ANALYSIS OF MOBILE TELECOMMUNICATIONS SECTOR IN TÜRKIYE ON THE EVE OF 5G TRANSITION

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ABSTRACT

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In today's global economic markets, countries compete based on knowledge and those that are more successful in terms of reaching, using and disseminating relevant knowledge will increase the well-being of their citizens. To this end, mobile broadband technologies such as 5G considered as one of the most important infrastructures of knowledge economy and lead to various transformations in both social and economic aspects. In this respect, the first part of the study covers the role and importance of mobile telecommunications technology (i.e., 5G and beyond) in the digital transformation process. Accordingly, specific features, costs & benefits of wide scale deployment and possible usage cases of this innovation are analyzed in detailed terms.

Having studied these issues and regulatory policies, second part proceeds with the analysis of Türkiye's telecommunications sector by adopting sectoral innovation system approach. The study aims to find (if any) fundamental systemic and structural problems that impede the effective functioning of this innovation system as the main research question. To this end, surveys and in-depth interviews are used to obtain experts' views and thoughts about the current state of the sector. Important actors, their relations (interactions), main activities of them have been defined and weaknesses

(bottlenecks) of the system have been identified to derive policy recommendations with the objective of increasing innovative performance of the sector.

Main findings of this work point out the need for restructuring of regulatory framework in several aspects. Above all other considerations, the study regards improvement of good governance principles including transparency, accountability, efficiency and effectiveness as a prerequisite for this restructuring process.

The thesis also emphasizes the importance of not only adopting foreign technology but also increasing the level of innovative, productive capability of the domestic sector together with increasing adoption levels (i.e., reducing digital divide) for the preparation of digital transformation challenges in the new era.

Keywords: Mobile telecommunication technologies, 5G, innovation system frameworks, telecommunication service and equipment production sectors, regulatory authority, public policy.

ÖZ

5G TEKNOLOJİSİ GEÇİŞ SÜRECİNDE TÜRKİYE'DE MOBİL
TELEKOMÜNİKASYON SEKTÖRÜNÜN ANALİZİ

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Günümüzün küresel ekonomik pazarlarında, ülkeler bilgiye dayanarak rekabet etmekte ve bilgiye ulaşmak, bunları kullanmak ve yaymak konusunda daha başarılı olanlar vatandaşlarının refah seviyesini artırabilmektedirler. 5G gibi mobil genişbant teknolojileri de bilgi ekonomisinin en önemli altyapılarından biri olarak kabul edilmektedir. Söz konusu teknolojiler hem sosyal hem de ekonomik açıdan çeşitli dönüşümlere yol açmakta ve tüm ülkeler rekabet avantajlarını sürdürmek için ilgili alanlarda yerli üretim yeteneklerini ve sürdürülebilir ekosistemlerini geliştirmeyi hedeflemektedirler. Bu çerçevede, çalışmanın ilk bölümü, mobil telekomünikasyon teknolojisinin (5G ve ötesi teknolojiler) dijital dönüşüm sürecinde rolünü ve önemini kapsamaktadır. Teknolojinin özellikleri, geniş ölçekli kurulumun maliyetleri ve faydaları ve bu yeniliğin olası kullanım senaryoları ayrıntılı olarak analiz edilmiştir.

Teknolojiyle ilgili hususlar ve düzenleyici politikaların incelenmesini müteakip ikinci kısım, sektörel yenilik (inovasyon) sistemi yaklaşımını benimseyerek Türkiye telekomünikasyon sektörünün analizine devam etmektedir. Çalışma, temel araştırma sorusu olarak ülke telekomünikasyon sektörünün (varsa) etkin işleyişini engelleyen

temel sistemik ve yapısal sorunları bulmayı amaçlamaktadır. Bu noktada, uzmanların sektörün mevcut durumu hakkında görüş ve düşüncelerini almak için anketler ve derinlemesine görüşmeler kullanılmaktadır. Sektörün inovasyon performansını ve etkinliğini artırma kapsamında politika önerileri oluşturmak için önemli aktörler, ilişkileri (etkileşimleri), ana faaliyetleri tanımlanmış ve sistemin zayıf yönleri (darboğazları) belirlenmiştir.

Çalışmanın ana bulguları, düzenleyici çerçevenin çeşitli açılardan yeniden yapılandırılması ihtiyacına işaret etmektedir. Çalışma, tüm diğer hususların ötesinde, şeffaflık, hesap verebilirlik, verimlilik ve etkililik gibi iyi yönetişim ilkelerinin geliştirilmesini bu yeniden yapılanma sürecinin ön koşulu olarak görmektedir.

Tez ayrıca, sadece yabancı teknolojiyi benimsemekle kalmayıp, aynı zamanda, yeni dönemde dijital dönüşümün getireceği risklere hazırlanması için yerel sektörün üretkenlik ve yenilikçilik düzeyini arttırmanın ve kullanımın yaygınlaştırılmasının (sayısal uçurumun azaltılması) önemini vurgulamaktadır.

Anahtar Sözcükler: Mobil telekomünikasyon teknolojileri, 5G, yenilik sistemi yaklaşımları, telekomünikasyon hizmet ve donanım sektörleri, düzenleyici otorite, kamu politikası.

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LIST OF ABBREVIATIONS

1G…5G:	1st… 5th Generation Mobile Network and Technologies
5G-PPP	5G Infrastructure Public-Private-Partnership
AC	Acquis Communautaire
AI	Artificial Intelligence
ARPANET	The Advanced Research Projects Agency Network (USA)
ARPU	Average Revenue per User
ASEAN	Association of Southeast Asian Nations
B2B / B2C	Business to Business/ Business to Consumers
BBU	Baseband Unit
CA	Competition Authority
CATV	Cable TV
CEPT	European Conference of Posts and Telecommunications
CIS	Commonwealth of Independent States
cMTC	Critical Machine Type Communication
COB	Chairman of the Board
COST	European Cooperation in Science and Technology
CTC	Communication Technologies Cluster (HTK in Turkish)
DARPA	Defense Advanced Research Project Agency
DIFC	Defense Industry Foundation Companies
DMS	Digital Multiplexing Switching System
DPAC	Defence Production Act Committee
DPC	Data Protection Commission (Ireland)
DTO	Digital Transformation Office
EC	European Commission
ECC	Electronic Communications Code
EFSI	European Fund for Strategic Investments
eMBB	Enhanced Mobile Broadband
ESB	Access Providers Association
ETSI	European Telecommunications Standards Institute

ESSY	European Sectoral Systems of Innovation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCC	Federal Communications Commission (USA)
FDI	Foreign Direct Investment
FTC	Federal Trade Commission (USA)
FTTx	Fiber to the X (e.g., FTTH: Fiber to the Home)
FWA	Fixed Wireless Access
GDC	General Directorate of Communication
GDPR	General Data Protection Regulation
GPT	General Purpose Technologies
GSM	Global System for Mobile Communications / 2G Mobile Network
GSMA	GSM Association
ICT	Information and Communication Technologies
ICTA	Information and Communication Technologies Authority (BTK in Turkish)
IEEE	Institute of Electrical and Electronics Engineers
IEP	Internet Exchange Point
IETF	Internet Engineering Task Force
IMT	International Mobile Telecommunications / Standards
IoMT	Internet of Medical Things
IoT	Internet of Things
IS	Innovation System
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ISP	Internet Service Provider
ISSAP	Information Society Strategy and Action Plan (2015-2018)
ITS	Intelligent Transportation Systems
ITU	International Telecommunication Union
KOI	Public Partnership Administration
KOSGEB	Small and Medium Enterprises Development Organization of Türkiye
KVKK	Personal Data Protection Board of Türkiye
M2M	Machine to Machine
MEUCC	Ministry of Environment, Urbanisation and Climate Change

METU	Middle East Technical University
MFSS	Ministry of Family and Social Services
MIAC	Ministry of Internal Affairs and Communications (of Japan)
MIIT	Ministry of Industry and Information Technology (of China)
MIMO	Multiple-Input Multiple-Output
MI&TECH	Ministry of Industry and Technology
mMTC	Massive-Machine Type Communication
MNC	Multinational Corporation/s
MNE	Ministry of National Education (MNE)
MOBISAD	Mobile Communication Devices and IT Businessmen Association
MOBILSIAD	Mobile Service Provider Businessmen Association
MT	Ministry of Trade
MTF	Ministry of Treasury and Finance
MTI	Ministry of Transport and Infrastructure
m-TOD	Mobile Telecom Operators’ Association
MVNS/O	Mobile Virtual Network Services/Operators
NBSAP	National Broadband Strategy and Action Plan
NFV	Network Functions Virtualization
NGA	Next Generation Access
NIS	National Innovation Systems
NMT	Nordic Mobile Telecom
NSF	National Science Foundation
NSW	The Government of New South Wales
OTF	Operator Affiliated Technology Firms
OECD	Organization for Economic Co-operation and Development
OFCOM	The Office of Communications (UK)
OSTIM	Middle East Industry and Trade Center
OTT	Over- the -Top (voice, media etc. services given over internet)
P&D	Production and Deployment
PTO	Public Telecommunications Operator
PTT	Postal, Telegraph and Telephone Company
RAN	Radio Access Network
R&D	Research and Development

RIS	Regional Innovation Systems
RTUK	Radio and Television Supreme Council
SBO	Presidency of Strategy and Budget Office
SDN	Software Defined Networks
SIS	Sectoral Innovation System
SMP	Significant Market Power
SOE	State Owned Economic Enterprise
SPO	State Planning Organization
SSM	Undersecretariat of Defence Industry
STIPB	Science, Technology and Innovation Policies Board
STIS	Swedish Telecom Innovation System
TBD	Informatics Association of Türkiye
TBMM	Turkish Grand National Assembly (TBMM-GNAT)
TBV	Turkish Informatics Foundation
TCP/IP	Transmission Control Protocol/Internet Protocol
TEDER	Telecommunication, Internet and Information Tech. Association
TELKODER	Turkish Competitive Telco Operators' Association
TESID	Turkish Electronics Industrialists Association
TIA	Telecommunications Industry Association
TIAA	Telematics Industry Application Alliance (China)
TID	Turkish Internet Association
TIS	Technological Innovation System
TMSF	Savings Deposit Insurance Fund
TOBB	The Union of Chambers and Commodity Exchanges of Türkiye
TPTO	Turkish Patent and Trademark Office
TRT	Turkish Radio and Television Corporation
TSI	Turkish Statistical Institute
TTGV	Technology Development Foundation of Türkiye
TUBIDER	Informatics Industry Association
TUBISAD	Informatics Industry Association
TUBITAK	The Scientific and Technological Research Council
TUTED	All Telecommunications Businessmen Association
TUYAD	Telecommunications Satellite & Broadcasting Business People Assoc.

TWF	Türkiye Wealth Fund
UDHAM	Transportation, Maritime and Communication Research Centre
UK	United Kingdom
URLLC	Low Latency Communications
USA	United States of America
UUYM5G	End-to-End Domestic National 5G Project
V2X	Vehicle to Everything (V2V, V2P, V2I)
VINNOVA	Swedish Agency for Innovation Systems
VPN	Virtual Private Networks
VR-AR	Virtual and Augmented Reality
WHD	Wearable Health Devices
WHO	World Health Organization
Wi-Fi	Wireless Fidelity (Wireless Broadband Networking Technology)
WTO	World Trade Organization
xDSL	(Family of) Digital Subscriber Line (DSL) Technologies.
YASAD	Software Industrialists Association

CHAPTER 1

1. INTRODUCTION

In today's world, information and communication technologies and services (ICT) including internet, mobile phones and broadband networks continue to spread very quickly. ICT become an indispensable part of both social and economic life and it is almost impossible to think of an organization and even an individual without internet, currently. Indeed, these technologies are beginning to alter nearly every aspect of daily life that some experts call these changes as digital transformation and even argue that people are witnessing fourth industrial revolution. This new phenomenon has been developing on the basis of a digital infrastructure that enables countless new applications and production processes in different sectors ranging from agriculture to healthcare, to name a few of them. In other words, there is no single definition or technology (e.g., artificial intelligence, robotics etc.) to summarize this digital transformation. Rather, several new technologies, processes and management methods should be utilized together in a new ecosystem approach to fully harness productivity and synergy effects. More specifically, this concept consists of several and constantly evolving sub-technologies such as artificial intelligence and intelligent systems, big data and analysis, artificial and vertical integration, cyber security, cloud, internet of things, robots and automation, additive production and augmented reality. What is more important, integrated use of all these new technologies brings significant synergy gains and further productivity increases to virtually every segment of economy. In turn, people also benefit from these more efficient services and productivity improvements.

In such a system, devices communicate with devices, in addition to humans and automatically fulfill various functions. Digital transformation aims to increase efficiency of decision-making processes by evaluating data obtained from numerous sources such as corporate and customer-based management systems. In fact, data is regarded as "petroleum" of our time (Economist, 2017) and experts believe near real time analysis of big data is one of the most important pillars in digital transformation

(Sharma S. , 2020). In this context, big data and cloud technology enable entities to analyze this data to the extent that never seen before. Moreover, intelligent automation, robotics, block chain, augmented reality coupled with other new technologies and process innovations play crucial roles in this transformation.

During this process, internet, mobile phones and other smart devices are gaining more importance and become an indispensable part of human life, largely due to development and dissemination of high-speed broadband (internet) access technologies. As a general-purpose technology[1], internet is a revolutionary innovation transforming (affecting) nearly all sectors of world economy as well. One can see internet as a catalyzer to other technological developments in ICT sectors. Internet (together with other ICTs) offers opportunities for all actors in the economy, including entrepreneurs, to reduce transaction costs at local, national and international levels, increase productivity, expand market coverage and enhance competitiveness. It is also recognized that ICT play key roles in reducing poverty and ultimately contributing to sustainable development by increasing productivity, efficiency and competition according to Clarke et al., (2015).

Before anything, as a starting point, an up-to-date (modern) and widespread telecom (data) infrastructure, transmission technologies- especially mobile- are prerequisites to implement digital transformation effectively (i.e., provision and adoption of these services like cloud computing, virtual reality). In other words, one can resemble internet as roads in today's knowledge economy similar to railroads in the first industrial revolution. Following this analogy that wider roads (e.g., highways) provide more fluid traffic flow, high speed (broadband) internet coupled with mobile usage further enhances the transformative effect of ICTs.

To this end, nearly all countries have devised policies to promote investment in these networks and technologies (OECD, 2017a, p. 28). These digital technologies and high-speed internet access networks in turn are increasing market efficiency by lowering the costs of search, (market) entry, transportation, and at the same time increasing information availability among other numerous benefits as well, (Goldfarb & Tucker,

[1] Rosenberg and Trajtenberg (2004) give characteristics of general-purpose technologies as 'general applicability', technological dynamism' and 'innovational complementarities.' In general, IGI (n.d.) considers GPTs as having many usage areas and applications, open to continuous innovations and has an effect on whole population.

2019). Within this context, development of mobile telecommunication (telecom)[2] technologies together with the expansion of high-speed broadband networks are among the main priorities of digital transformation process. Data production, which is an inevitable part of digitalization, and transmission of these data from one point to another point, require a strong communication infrastructure. Considering the amount of data produced each year and its growth trend[3], it is also important to transmit these data in the most efficient and fastest way. Previously dependent on fixed connections, the advent of mobile communications has further enhanced the role of internet and accelerated diffusion of (internet based) ICT applications to the extent that never seen before. Starting from first generation (1G) technologies that provide only voice communications, successive improvements have been starting to enable data communications, giving mobility to people in using digital applications. Especially, 4G mobile technology –for the first time- has given real mobility for people that are using their devices without a need for fixed connection in their homes or offices. What is more different for later generations in that these improvements can enable numerous connections between machines on a much larger scale and making it possible for fully automated vehicles, factories and smart cities etc.

As will be reviewed in the thesis, 5G and beyond technologies[4] make it possible many other uses and applications previously not available in different sectors. In other words, 5G has the characteristics to change the paradigms of nearly all aspects of economy by ensuring almost real time connection capabilities between machine-to-machine, along with human-to- machine and human- to- human forms. Indeed, it is estimated that there will be more than hundred billion (100 billion) connected devices by which human and machines interact and exchange information by 2025 (Huawei, 2018, p. 3).

These mobile technologies are increasingly used in almost all parts of the economy and have triggered innovation in sectors such as agriculture, health, energy, transportation, entertainment and finance. This technological development plays an

[2] Please note that telecommunication/s and telecom words are used interchangeably in the text. Cambridge dictionary defines telecom as a shortened word for telecommunications.

[3] It is nearly impossible to give exact volume related to data production. There are different estimations and one of them gives 64.2 ZB amount of data production for the year 2020. Furthermore, it is predicted that global data generation is projected to grow to more than 180 ZB by 2025 (Statista, 2021). In any case, the current volume and the growth rate indicate clear trend for enormous expansion potential in the near future.

[4] ‘Beyond technologies’ refer to successive generations of mobile telecom technologies (after 5G) such as 6G which is expected to be available in 2030s.

important role in strengthening digital transformation by increasing productivity, sustainability and overall prosperity.

Accordingly, as a continuation of broadband internet policies, almost all countries have started to undertake national action plans and strategies to develop new mobile technologies first, and then to enable widespread use in all segments of socio-economic life. Moreover, it is very important to develop 5G and future mobile communication technologies with national capabilities and to establish an ecosystem in order to make full use of opportunities brought by digital transformation. Connectedly, policymakers should give emphasis on establishing efficient cooperation between each actor (e.g., producer-service provider- university and civil society organizations) to extend the availability of these technologies nationwide.

Within this background and given the vital role of telecommunication technologies in digital transformation, the main objective of this study is to analyze Türkiye's telecommunications sector by using innovation system approach. This type of analysis is based on the assumption that economic, social and technological factors together determine development path of a sector[5]. Besides, historical evolution and resulting path dependency concept play decisive role in current outcome. Therefore, the study focuses on both historical evolution and current structure to determine barriers inhibiting more efficient functioning of the industry. Extensive interviews have been made with related actors to understand their perceptions and thoughts in this analysis. Finally, the study aims to derive policy implications for increasing innovative and economic performance of the sector as a whole.

1.1. Scope and Problem Definition

At the beginning, it should be stated that as a continuously developing and widening subject, it is very difficult to define the scope of ICT precisely. Firstly, ICT sector is composed of both hardware and software (i.e., both products and services), making it more difficult to limit the scope.

Moreover, it is both a pervasive set of technologies and at the same time subject to

[5] Sector, industry, market and the IS words are used in the same meaning and interchangeably in the text.

high rates of change and volatility (World Bank, 2009, p. 11).

Actually, the problem of definition and boundaries of ICT sector came to the agenda of OECD in 1997 and a consensus was reached in 1998 after several discussions between member countries.

Accordingly, information-generating industries, i.e., content industries, excluded from the definition and scope was limited to industries that process, transmit and show information electronically. In other words, OECD defined this as a composition of manufacturing and services industries that capture, transmit and display data & information through electronic means (OECD, 2005, pp. 4-5).

Furthermore, several inclusion criteria set for manufacturing and service sectors[6]. In line with technological changes, this definition revised several times in 2002, 2007 and 2008. One of the main updates has been the inclusion of various content and media sector products/services into this category. Following this last revision, current scope covers several sectors including ICT manufacturing, service and trade industries (Spiezia, 2008)[7].

From these definitions, it can be seen that ICT starts with the transmission and transformation of information in the first place. This information communicated through one-to-one, one-to-many, many-to-many and many-to-one by means of several communication technologies and devices.

These technologies and devices consist of several platforms including wired & wireless networks, voice telephony and the most important of all being (the) internet.

That is to say, a medium is a prerequisite to make any communication transfer between related parties, whether it is a machine or a person. For instance, mobile telecommunications necessitate existence of network infrastructures made up of many

[6] For the inclusion in manufacturing part, *the products of a candidate industry must be intended to fulfil the function of information processing & communication including transmission, display and must use electronic processing to detect, measure and/or record physical phenomena or control a physical process.* For the inclusion in services part, *the products of a candidate industry must be intended to enable the function of information processing and communication by electronic means* (OECD, 2002, p. 81).

[7] The complete sector classification is provided in the **Appendix-A**.

components like base stations and antennas, end user devices like mobile phones and a service provider who operates (runs) these networks. These are in general terms corresponds to network, end user hardware parts and to service parts of telecommunication subsectors, as shown in Table- 1.

Table 1-Telecom Sector Value Chain

Equipment Supply	Telecom Infrastructure	Service Development
• Telecom Equipment • Hardware • Software • Consumer Electronics *Market structure depends on the segment, (e.g., Presence or absence of sunk costs, free entry-exit in software etc.)*	• Fixed (e.g., copper, fiber etc.) • Mobil (e.g., 5G) • Other Wireless (e.g., Wi-Fi) *Monopoly/ Duopoly/ Oligopoly*	• Voice • Data • Internet • Database • Network Management • Video on demand • Broadcasting • Other newly developed services like Cloud, (4.5- 5G applications) *Market structure depends on the service type, (e.g., Internet service provision by using existing networks)*

Source: Melody (1999) and the author's own contributions.

As argued above, both service-based and production-based submarkets can be identified in telecommunications. Likewise, Malerba (2003) observes coexistence of various segments and different technology regimes & trajectories in this broad categorization.

Apart from the interactions between these sub segments, one should not neglect the role of demand in a telecom sectoral innovation system. Porter's (1990) diamond model points out that existence of sophisticated buyers (i.e., demand) bring in both product and process innovations to satisfy their needs, also increasing competitive advantage of these firms (as opposed to other markets where this type of buyers do not exist).

To give an example, it is sufficient to observe Apple's success in this field (e.g., iPhone coupled with many applications) that shows critical role of satisfying consumer needs (requirements). Of course, this phenomenal success should be analyzed within an ecosystem perspective, in which numerous factors such as existence of rival companies, availability of suitable support instruments and the role of universities etc.

have all played roles in the growth process of this company and other related market actors.

In the light of this argument, the scope of this study is limited to mainly telecom services and network equipment part, although standard classifications are increasingly blurring thanks to the concept of convergence, (Table- 2).

Table 2- Main Classifications and Convergence

Main Classification	Products (hardware)	Services and software
Telecommunications	Equipment (e.g., base station)	Voice, Internet services
Broadcasting	Consumer electronics (e.g., LCD TV)	TV and Radio services, programs
Computing	Hardware (e.g., Computers)	Software and services (e.g., OS and games)
Effects of Convergence	Telecom & Broadcasting & Computing from one device using one or different access technologies (e.g., Using a mobile phone -connected to mobile telecom networks- as a TV, computer, telephone, gaming device, camera, digital organizer and a credit card etc.)	

Source: Singh and Raja (2010), (Rouse, 2020) and the author's own contributions.

Prior to advent of internet, different communication networks used to provide distinct services such as television, radio and voice transmissions. Thanks to developments especially in internet technology, these different forms of information can be provided from many platforms and can also accessed by using many devices. As an example, one can use a mobile phone to obtain all these services from a single device or at the same time may prefer different mediums, like watching TV from conventional television sets.

In this respect, convergence can be defined in simple terms as the process of erasing barriers between previously distinct ICT services, networks and business practices along with market structures. Singh and Raja (2010, p. 10) categorize three forms of convergence. Two of them are technological and refer to service (e.g., voice, data and TV services from one telecom operator) and network convergence (e.g., VoIP). The other one refers to corporate convergence in the form of mergers & acquisitions and new market entries from other sectors.

In fact, corporate convergence has led to unification of previously separate markets like telecommunications and content provision. As a result, many companies started to operate in different segments simultaneously. Furthermore, mergers and acquisitions in the ICT sector have accelerated in recent years. OECD (2016a, p. 40) observed that especially convergence of services and the scale economies increased mergers and acquisitions between mobile and fixed telecom service operators in Europe. For instance, Hutchison and Orange (brands Drei and Orange/Yesss!) merged in Austria in 2013, Hutchison and Telefónica (brands H3G and O2) merged in Ireland in 2014, Telefónica and KPN (brands O2 and E-Plus) merged in Germany in 2014 to name a few of such market activities, (BEREC, 2018, p. 2). These type of market developments have been continuing all over the world with bigger firms aim to acquire capabilities in related and new segments of ICT. In particular, existing telecom operators and tech giants frequently resort to these practices such as Vodafone's acquisition of an IoT specialist Grandcentrix in 2021, (Bhadare, 2019) and Google's recent purchase of high-tech firms Pring, Dysonics and Neverware[8], (TADVISER, 2021).

For the study purposes, it is important to note that, convergence and digital transformation coupled with continuous technology development and rollout (e.g., 5G and beyond) necessity led to new policies and discussions on the need to regulatory framework changes. As will be argued, 5G network investment costs are also considerably higher than previous mobile technology rollouts.

These capital requirements trigger further consolidation in the number of mobile telecom operators in various countries (Taylor & Cervera-Jackson, 2020).

Apart from relatively small mergers involving acquisition of minor players, few of them have reached substantial amounts and attracted significant public attention. Among them, T-Mobile and Sprint merger is one of the biggest amounting to 26.5 billion USD and the approval process by federal courts took nearly two years, completed in February 2020. FCC, the regulatory authority of United States of America (USA) in telecommunications, also put some obligations[9] on T-Mobile

[8] Pring works on electronic payment, Dysonics is a 3D audio startup while Neverware is mainly in cloud services.
[9] These are coverage and quality of service requirements especially in rural areas. The company has to provide 5G services to 97% and 99% of the population in three- and six-years' time, respectively. In the rural areas, these rates are 85% and 90% for the same periods. Furthermore, the company has committed to giving at least 100 Mbps broadband service speed for the 90% of total population.

before giving its approval in this subject (Reardon & Cheng, 2020). Notwithstanding to these, few bigger operators (especially in USA) have withdrawn from some of their non-core businesses like Verizon and AT&T in 2021 to allocate (generate) funds for 5G network investments, (PwC, 2021).

In fact, operators in European Union (EU) consider further mergers are necessary in the continent to increase 5G investments and to compete with bigger companies in China and USA. Connectedly, these sector players have been trying to persuade EU decision-making level (politicians etc.) that advancement of next generation 5G technology and quick rollout is vital, since early comers will get the advantage over other competitors (e.g., USA, China) in several high (digital) technology areas including internet of things and artificial intelligence, (Fildes, 2018a).

In this context, it is evident that leading countries are engaging on 5G-technology (even starting on 6G) development race. Especially, USA and China followed by South Korea, Japan and EU compete by actively involving in standard-setting processes and supporting their companies by various policies in this competition. The importance given to this race highlighted by (former president of the USA) Mr. Trump’s comments that his country must lead the world in 5G and beyond (i.e., 6G etc.) technologies, (Martosko, 2019).

This argument stems from the objective of maintaining technological and economic superiority as well as protecting national security. Since, people are living in an increasingly digitalized world where virtually everything controlled by internet of things, artificial intelligence, cloud computing etc., security issues (e.g., network, data, cyber security) are becoming more and more crucial for any country in today’s world.

As noted, this digital environment produces huge amount of data transactions and whoever controls these processes can gain strategic advantages vis-à-vis others. Accordingly, countries intend to devise and control 5G networks depending on their technological capabilities. Besides, they strive to capture other country markets by exporting them (products and services), at the same time. Recently, in this struggle, Chinese telecom giant Huawei face with increasing opposition and even blocked from operating (equipment provision etc.) in several countries including Australia, New Zealand, UK and USA. Policy makers (of these countries) regard advanced mobile telecom networks as fundamental components of future infrastructure upon which digital ecosystem will function and safeguarding the security and robustness of these systems are deemed imperative to safe digital future (Ranger, 2019).

In the present situation, China seems to be leading the 5G technology development and network rollout and USA has started to implement policies such as banning use of this country's products to counter this position.

Japan, South Korea (in fact this country has the largest coverage rate of 5G in terms of base station numbers) and EU are also trying to compete with these forefront countries.

Even looking into the list of biggest telecom equipment producers, given in Table-3, reflects this observation.

As can be seen from the table, leading firms come from these countries even though they are all having global presence with their numerous branches and affiliates (subsidiaries) all over the world.

These seven vendors have above 80% market share in terms of total revenue of the sector (Pongratz, 2021). What is more striking, most of the other companies that are in the sector (i.e., sharing the remaining 20%) also come from these countries[10].

Table 3- Top Seven Telecom Equipment Producers Market Shares

Company	Origin	Market Share 2019 (%)	Market Share 2020 (%)
Huawei	China	28	31
Nokia	Finland-EU	16	15
Ericsson	Sweden-EU	14	15
ZTE	China	9	10
Cisco	USA	7	6
Ciena	USA	3	3
Samsung	South Korea	3	2

Source: Pongratz, (2021).

This competition between (technologically more) developed countries along with the need for increasing innovative capabilities and network deployment brings significant

[10] One can mention Fujitsu and NEC from Japan, Corning, Motorola and Juniper Networks from USA, LG from South Korea are among the largest ones in the remaining list.

challenges to other ones in several dimensions. Even though among the technology developing blocks[11], EU policy makers as well think that they are relatively in a backward position to China and USA in this subject.

Consequently, they have started implementing new programs, regulations to speed up their advancement in the field and to accelerate adoption of these services, i.e., deployment and adoption of 5G and vertical usages like autonomous vehicles, fully automated factories etc.[12]

Developing countries are in a more difficult position to respond these changes in this very competitive (but between few countries) setting. In general (and historically), they have been in the position of importing telecom technology embedded in network equipment in return for sizable amount of foreign currency.

Moreover, in some of these countries service providers[13] that use these networks are also foreign and multinational companies like Vodafone, Telefonica and T-Mobile. Within this context, countries can be put (roughly) in technology user and producer categories in the first stage. Of course, telecom equipment category covers many products and software types. Countries can produce some of them depending on their technological capabilities. Naturally, being a producer country contains user category as well.

In sum, governments (of different countries) may have several objectives in both service provision (part) & hardware production part of the sector and devise policies to achieve them.

As the main focus of this study, Türkiye[14] is mainly a user of foreign technology in mobile telecommunications and has aimed to raise indigenous production capabilities of these technologies.

In other words, while telecom services sector actors have mainly worked on expanding

[11] This word is used in the meaning of 'group of countries' especially against China.
[12] Some of these strategies and policies are examined in a more detailed manner in the study.
[13] Telecom service providers, service providers and operators are used interchangeably and in the same meaning throughout the text.
[14] The country and the/this sector words are used in the meaning of Türkiye and her telecom sector in the text.

coverage of these services, the actors in the production part have worked on producing this network equipment.

As the study shows, policy makers have especially focused on increasing domestic production capabilities of the sector starting from 3G technology introduction to the country.

In line with 5G technology development and adoption process (also in early phases along with other technology developing countries), the country may capture some opportunities to raise her indigenous technology capability and provide more coherent, secure infrastructure on which digital services (and ecosystems) will function efficiently.

Apart from security and reliability necessities and possible future gains (increasing innovation capability etc.), the sector produces a considerable amount of revenue each year. In this regard, it may be better to look into the composition of this figure and contribution to the economy as a whole. Informatics Industry Association (TUBISAD[15]) has conducted market analysis research in the country, since 2012. This study divides ICT sector into two main subsectors, communication technologies and information technologies. First subsector is composed of equipment-hardware (computers, servers etc.), software (data base systems, desktop applications etc.) and services (consultancy, outsourcing etc.). Electronic communications and equipment-hardware parts constitute second subsector.

Table 4-ICT Sector Revenues in Türkiye (Billion USD)

Year	Communication Tech.	Information Tech.	Total
2013	22.5	9.4	31.9
2014	21.5	10.1	31.6
2015	20,4	9,5	29,9
2016	21.4	9.8	31.2
2017	20,8	10.5	31.3
2018	18.1	9.3	27.4
2019	17	9.9	26.9
2020	17.1	9.8	26.9
2021	17	12.9	29.9
2022	12.9	11.8	24.7

Source: (TUBISAD, 2023) and compilation of previous TUBISAD ICT reports.

[15] This is the official abbreviation of 'Bilişim Sanayicileri Derneği' in Turkish.

These market analyses show that total revenue is fluctuating between 32 to 25 billion USD, (Table-4). There is no material growth in real terms and the volume has been decreasing in line with the depreciation of domestic currency in recent years.

Table 5-Composition of Products (in terms of domestic shares)

Year	**2020**		**2021**	
Categories	**Domestic share (%)**	**Import share (%)**	**Domestic share (%)**	**Import share (%)**
IT Services	76	24	69	31
IT Software	71	29	82	18
IT Hardware	19	81	26	74
CT Hardware	15	85	16	84

Source: (TUBİSAD, 2022) and compilation of TUBISAD ICT reports, (this analysis is not present in the latest report)
(*) Please note that this analysis has divided ICT in two main parts as information and communication technologies. The table does not show electronic communication services (e.g., cable tv, mobile telecom services), since they are provided by authorized companies in the country. **IT services:** Consultancy services, support, maintenance and training services etc., **IT Software:** Operating systems, database management, desktop applications etc., **IT Hardware:** Computers, Servers, storage units etc., **CT Hardware:** Mobile telephones, network hardware etc.

In fact, there are other factors that have played parts in this unsuccessful performance, as analyzed in this study, including failures in regulatory policy making framework. If one looks into foreign trade part, the situation is not satisfactory, either. When the breakdown of ICT equipment trade examined from Table- 5, it can be seen that 84% of the communication equipment spending comes from imports of this hardware. While information technology software category has the highest domestic content ratio with 82% according to this research study. From this analysis, it is understood that the country's (telecommunications) hardware sector is not capable of satisfying[16] the requirements of (telecommunications) service part (i.e., domestic service providers).

This deficiency and/or weakness in the wake of 5G-transformation period constitute one of the main problems related to the IS. On the other side of the coin, telecom service providers play crucial roles in rollout of new generation technologies. At this point, supportive regulatory policies, macroeconomic stability are deemed as necessary to give incentives to market actors. Obviously, this is (i.e., widespread

[16] Not necessarily in the meaning of supply capacity, it is equally possible that operators can prefer foreign equipment because of price and quality considerations as well.

coverage and availability of affordable services) vital for any society (country) to benefit fully from digital transformation process. In short, a telecom sector institutional framework should support investments both in the mobile (e.g., 5G technology and components like base stations etc.) and fixed (e.g., fiber connections) networks to establish wide coverage rate and acceptable quality of service levels.

In this respect, as a measure of internet adoption, OECD (2022)[17] statistics is the most widely used quantitative indicator by policy makers across the world. Indeed, countries often use them to compare their rankings in different categories. According to these statistics[18], Türkiye ranks 35th among 38 (OECD) countries in the fixed broadband adoption category. While OECD average is 34,69%, the country has 21,99% penetration rate and people (e.g., experts, politicians) has criticizing this situation along with some other indicators used in (internet) comparisons like the ratio of fiber connections and download/upload speeds.

For the mobile broadband category, Türkiye ranks (again) 36th (in the OECD list) with 84,4% as opposed to OECD average of 128,2% penetration rate[19]. It should be accepted from the start that internet access and usage become an essential right in today's world to benefit from digital transformation.

In fact, unavailability of internet lead to economic, educational, and social inequalities, what is called a 'digital divide' problem. Accordingly, this study also regards increasing internet access as one of the major objectives of a sectoral innovation system.

From a technological point of view, fiber technology and infrastructure are regarded as the main component of 5G. The reason for this lies in the fact that fiber is the most capable medium to transmit huge amount of data, some of which sensitive to time-delay. The importance of increasing fiber coverage can be seen in various policy papers and statements of politicians. For instance, high-level policy papers such as 11th

[17] Please note that this is Jube 2022 data. OECD is updating the data portal continuously.
[18] It may be helpful to show previous OECD statistics in this subject. According to 2020 figures, Türkiye ranked 34th among 38 (OECD) countries in the fixed broadband adoption category. While OECD average was 33,6%, the country had 20,7% penetration rate. For the mobile broadband category, Türkiye ranked (again) 34th (in the OECD list) with 78,7% as opposed to OECD average of 117,5% penetration rate.
[19] These statistics are evaluated in more detail in the case study part.

Development Plan aim to increase fiber internet subscriptions and telecom regulatory authority (ICTA[20]) puts developing this infrastructure as one of the main strategic aims in the digital transformation process.

In a recent interview, Deputy Minister of Transport and Infrastructure Ministry (MTI) Mr. F. Sayan has pointed out that the amount of data usage will increase even more by switching to 5G and that fiber communication infrastructures will need to be used in the main network and the connection of base stations. He has added that fiber investments in the further enhancement and better planning of the future will be one of the most critical issues, and they are making every effort to pave the way for infrastructure operators authorized in this regard (Şan, 2019).

Within this background, the study has focused on the more problematic areas of telecom service part, which hinders more inclusive, widespread internet access[21] and the need for raising indigenous technological capabilities in the sector. By considering these problems, the study emphasizes both economic and social benefits of a well-functioning sectoral ecosystem.

1.2. Objective and Research Questions

As discussed in the previous part, the research aims to study Türkiye's telecommunication sector by adopting innovation system (IS) approach. In general, this type of analysis has firstly focused on determining barriers that are inhibiting (innovative) performance of any sector in question. Having specified these problems, appropriate policy suggestions can be made to improve performance of an IS. In parallel to this setting, the main objective of this research is to put forward policy proposals to reduce (or eliminate) obstacles in (more) efficient functioning of the whole system. Above all other factors, knowledge and learning processes are at the core of innovative performance of any sector in IS framework. Furthermore, there

[20] Information and Communication Technologies Authority. Regulatory authority, telecom regulatory authority words and ICTA abbreviation are used interchangeably in the text. Although Turkish abbreviations are used for some organizations that are well known (by abbreviated words) like TUBİTAK and TUİK, Turkish abbreviation of this organization (BTK) is not used in the text, due to the reason that this (name) is used more often than any other organization throughout the study. The same procedure is also used in other organizations like Ministries, which are not widely known by Turkish Abbreviations, e.g., Ministry of Transport and Infrastructure (MTI).
[21] Access term is used in the meaning of 'Access and Usage'.

exists differences between sectors with regard to these processes depending on accessibility, opportunity and cumulativeness of the knowledge base (Malerba, 2006).

In telecommunications sector, it can be said that each of these dimensions have influenced development of related markets.

To start with, both equipment and infrastructure markets exhibit high degree of cumulativeness and opportunity conditions.

For this reason, many countries have designed national programs to develop their domestic capabilities (of their firms) in these sectors to get competitive advantage over other countries. EU, USA[22], China and South Korea[23] have all worked on 3G standards to compete in the international markets and promoted both equipment producers and infrastructure providers to this end.

It is evident that, once disruptive effects of a new technology (Utterback, 1994) ends, then other factors such as learning curves, first comer advantages, economies of scale and other barriers to entry become decisive for later market developments.

As it will be shown in the following parts, Türkiye has not faced with such experience (e.g., advancing a new or emerging technology) due to her technology follower status and the latter mentioned factors such as scale economies, first comer advantages have largely determined the market structure and competitive level of the sector.

Global hardware vendors have become main suppliers of domestic telecom service providers by using their scale economy advantages.

On the other hand, first comer advantages and higher investment costs (sunk costs) have affected services part (especially mobile telecommunications) market structure extensively. Notwithstanding to these, some segments of services (part) resemble to software sector in that both accessibility is high and start-up costs are relatively less than the other market segments. For instance, call centers, application developments

22 Though some differences exist between these two, since EU deliberately promoted one technology, namely GSM, whereas this was not the case in USA.
23 A centralized and top-down policy in a sense but at the same time collaborative effort of all related actors.

(programs, utilities etc.) and internet content provision are all relatively easy to establish, but success (outcome) will also depend on country-specific factors.

In the light of these discussions and taking into account the fact that all developed countries are in the process of utilizing new digital technologies (even 6G) and related applications, main research questions for policy perspective given as:

- What are the fundamental systemic, structural problems that impede the effective functioning of the Turkish Telecommunications Sectoral Innovation System? Relatedly and more specifically, is the regulatory framework conducive to solution of these problems?
- What is the production- innovation capability of Türkiye’s eco-system in the field of 5G Technology?
- In this regard, what kind of policies- programs can be devised to develop these capabilities?

Apart from these policy objectives, the study has additional objective of contributing to IS literature by applying this framework to one of high technology sector in a developing country context.

Since, IS studies have been mainly conducted in developed country cases, some authors criticize lack of application in developing country cases and advocate modifications to this approach, e.g., (Edsand, 2016).

Accordingly, to reiterate, it is aimed to enrich the use of this approach in different contexts.

1.3. Organization of the Thesis

The rest of this dissertation is organized as follows.

After the introduction, second chapter deals with discussion on the methodology of the dissertation. In this context, steps of functional analysis are stated along with main methodological framework of the study. In the study, several findings (assertions) are mainly derived from historical observation and (from) reviews of policy papers, sectoral reports and news articles. Most of them can be put in weaknesses/failures (in the functioning of the sector) category. While some others are oriented for future policy directions, most notably related to 5G technology deployment process.

Apart from these derived findings and observations, the study aims to put forth sectoral problems (failures) through interviews conducted with related actors, mainly firm & other organizations representatives and (sector) experts. At the same time, the research will endeavor to find solutions to these problems by using suggestions and thoughts of these actors, along with examination of other studies and country experiences. Chapter three presents background information about evolution of mobile telecom technologies[24] starting from first generation (1G)[25] standards[26] and the expansion of mobile broadband internet usage throughout the world. Afterwards, 5G technology is analyzed in terms of its role in the digital transformation process and its new usage applications in vertical sectors.

After looking into effects of 5G technology in telecom operator structures, this part continues with the examination of risks and problems related to deployment of this technology. This chapter end with some observations on the successive generations of mobile telecommunications (i.e., 6G) to indicate evolutionary nature of these technologies and the need to continue works on this subject.

Fourth chapter covers evolution and examination of different types of IS approaches. In this context, mainly national, sectoral, regional and technological IS frameworks are analyzed to get commonalities and differences between them. The study especially focus on the determination of systemic problems upon which policy recommendations are prepared in IS context. Having examined the related literature, several studies and projects (covering separate aspects and levels of the sector) are summarized to show different applications of the framework in telecommunications sector.

Evaluation of Türkiye's telecom sectoral innovation system forms the topic of fifth chapter.

The analysis has two main parts, service provision and equipment production

[24] Technologies and network devices are analyzed in terms of their benefits and features without going into detailed technical descriptions (e.g., working mechanisms, structures etc.) of these terms.
[25] Numerical abbreviations like 1G, 2G etc. are used to indicate successive generation of mobile technologies.
[26] 'Technology' and 'network' terms are used interchangeably in the text, instead of 'standard' word, e.g., 5G technology and 5G networks.

respectively. It consists of historical evaluations, examination of sectoral boundaries, main actors and institutional setting, among other topics. Here, the study also focuses on related EU policies to make some comparisons between these different settings. Chapter six covers analysis of the sector in the form of interviews with sector experts. After making inferences about sectoral problems, these are discussed extensively with stakeholders in interviews.

Although a specified questionnaire set is used in these interviews, participants' interests and their particular stances have shaped these discussions.

Their opinions have provided clearer picture of sectoral problems and form basis for possible policy recommendations to minimize them. In conclusion, chapter seven gives brief summary of research findings and policy prescriptions.

Limitations of the thesis and possible study areas to enrich knowledge base of these topics are stated for future research at the end of this part.

1.4. Contribution of the Research

To begin with, as emphasized by various researchers, increasing number of this type of studies will contribute to the advancement of IS concept since there is no optimal innovation system to be used as a benchmark.

What is more specific is the fact that IS analysis related to catching up country industries are even fewer to understand working of the framework in these contexts.

Apart from these benefits, main contribution of the (thesis) study comes from the analysis of a TIS that is in a formative stage, coupled with a more developed (but problematic in several dimensions) service sector IS analysis.

In fact, as Jacobsson et al. (2006) indicate such studies (i.e., TIS case analysis) have been mainly limited to ex-post functional evaluation and analysis of a IS in a 'catching up' phase would be a useful addition to this strand of research.

Furthermore, the research includes ex-ante policy appraisal for 5G technology development and deployment process in the country. In sum, the study aims to research closely related sub sectors of telecommunications industry by employing IS framework in a developing country setting. In other words, as noted above, both service and equipment production segments are evaluated by emphasizing the regulatory framework of the whole sector. Indeed, the importance of these sub sectors in digitalization process necessitates the examination of each without neglecting the other. In today’s increasingly digitized world, any country should have some infrastructure capability and capacity on which related services can be provided to all segments of her citizens with an affordable cost, good quality and reliability to solve (at least minimize) digital divide problem.

Accordingly, the study’s importance comes from the fact that development of both services and equipment production segments should not be neglected in any country ICT and economic development policies. Furthermore, the research aims to enrich literature on the application of IS framework in a developing country context and at the same time build upon the knowledge base of both academic and policy studies in the country. Indeed, many leading scholars in this subject recommend application of this approach not only to emerging economies but also to other country contexts and to different sectors as well.

As an illustration, Bergek (2019) points out to the fact that there is a need for further research to better comprehend formation and working of several functions such as market formation and entrepreneurial experimentation.

Continuing this discussion, she has further emphasized that the field requires more in-depth qualitative studies apart from just using indicators to analyze relationships, interactions between functions and events. In this context, the study provides a detailed analysis of interactions between sector actors and the regulatory framework (i.e., mainly regulatory authority) and endeavors to explain how the implementation of this framework in practice, has shaped the evolution of the sector.

Another novelty of this study comes from combining analysis of current market structure to a related market formation activity (i.e., 5G technology introduction) and (as mentioned above) provision of some policy recommendations for this transition process. The study shows that just introducing a new technology, from which high expectations exist, may not bring intended benefits unless necessary conditions and preparatory works are not completed in a more transparent and participatory decision-making environment. This is especially critical for the public organizations and they should consider a more innovative license policy along with other improvements, revisions in sector specific regulations as detailed in the study.

The other contribution of the study can be seen in its attempt to propose a thorough structural and organizational revision of public organizations that are in the regulatory framework.

Although, some studies exist to indicate sectoral problems, none (to the best of author's knowledge) evaluates this structure in depth and recommends changes in several aspects.

In fact, one of the reasons for emphasizing the increasing role of digital applications, vertical sector usages and convergence in ICT fields (in the study) is also to indicate necessity in the restructuring of this framework.

Hence, the study advocates this reform together with more adherence to good governance principles as a starting point (prerequisite in a sense) for a comprehensive sectoral development policy.

In the end, this suggestion can be considered as main contribution of the study (especially taking into account lack of such studies in this regard), above other topics.

CHAPTER 2

2. FRAMEWORK OF RESEARCH & METHODOLOGY

2.1 Introduction

This chapter gives information on the research method and analytical framework of the study. The first part summarizes this framework without going into details, since these are evaluated in chapter 3 on innovation system analysis. Topics related to methodology are stated in the second part. This part includes some explanations for selecting a qualitative research technique and interview making process. Qualitative semi-structured (face to face) interview method has been used in these conversations. Questions related to interviews are provided in **Appendix- E.**

2.2 Framework of Research

The study, first of all, plans to determine main actors, interactions between them and the role of institutions in the IS. Following this, the research aims to find main problems that block attainment of desired objectives and/or simply development of the sector. For policy purposes as well, it is imperative to diagnose these problems before prescribing some sort of improvements (or recommendations).

In essence, the framework consists of both SIS and TIS methodology in general terms. More precisely, the study follows the frameworks developed by Edquist (1993) and especially by Bergek and Jacobsson (2006), Hekkert et al. (2011), Hekkert and Wieczorek (2012), to name important ones. These studies prioritize functions rather than only examining structure of any system.

In other words, while observation of structure gives information about the active organizations in any system, functional analysis further examines the roles, performance levels of these actors.

What is more crucial, functional analysis can provide more insights for policy makers in determining whether these performance levels are sufficient or not for successful outcomes. In fact, this does not mean that structure is not important or are not analysed. On the contrary, the framework starts with the analysis of structure as a first step. Having analysed the main elements, the study proceeds with examination of functions and observed problems in this setting[27].

2.3 Methodology for the Analysis

Bibliometric analysis constitutes one of the main methodologies of this study. In other words, publications, public policy papers (plans, programs, activity reports etc.), news and internet sources are searched in the first place to describe the main elements of the innovation system such as organizations and institutions. Besides, sector related events like workshops and seminars are valuable source of information regarding these actors and working of the industry. Collection and analysis of different source material have also been used to derive main problem areas in the form of assertions that are written as statements for discussion purposes in the later stage of the study. As an example, attending a conference related to IS can provide valuable information for observing important issues on the agenda of the sector and at the same time provide meeting opportunities with important people who are involving in some part of sectoral activity.

Apart from forming the basis for structural analysis, this collected information and literature survey are used to support (triangulate) the validity and reliability of data from the questionnaires. Furthermore, several statistics are employed to analyse evolution and development trends of the sector, although main methodology of the study is based on qualitative research.

Before passing to details of these, it should be mentioned that the study has made use of triangulation whenever possible. As indicated by Olsen (2004), this method necessitates combining both different data sources, use of both quantitative and qualitative tools that can be called methodological pluralism. Moreover, Yin (2011) recommends use of triangulation to substantiate a description, observation by employing different kind of sources in a qualitative research framework. In line with these, this research has attempted to make triangulation by utilizing written material

[27] As indicated above, some of the details concerning this topic is given in Section 3.3 and 3.4.

(reports, policy papers etc.) sources with statistics (including market development and usage trends etc.) and with sector experts (that have been participated in the interviews) opinions in certain subjects. For instance, before making a generalization on the competitive structure of the sector, current situation and related complaints about market competition levels have been analysed by looking in policy papers, journals and examining some data regarding market developments together with obtaining participants' opinions in this topic.

In this respect, the range of statistical analysis has started from (mostly) the beginning of 2000s to the present. In some categories, later years are available owing to the reasons of data availability and starting date of these (service) offerings like mobile broadband and fiber optic connections (capacity). Historical evolution has begun from roughly same period when the country observed first attempts of market liberalization in the sector[28]. Before passing to discussion of analysis methods, it should be noted that some main developments of telecom sector like liberalization and (historical) development of mobile technology generations are given by examining different studies and projects in chapter 4.5.2.

In this way, both related study examples (together with their methodologies) and general developments in the sector can be given at the same time.

The reason for the adoption of qualitative research stems from the relevant features of this methodology to IS analysis. In essence, it has an inductive approach that depends on firstly data collection to make empirical observations. Besides this, the holistic and dynamic perspective of this research methodology can be utilized to study relational structure of a social system constructed by collective actions and perceptions of system components, (Patton, 1980, p. 40). Indeed, as seen from different studies, which are used for examples, any innovation system has its unique evolution path and requires extensive meetings with different actors who not only have different roles but also have different interests to understand these socio-economic interactions embedded in a dynamic setting.

Accordingly, qualitative interviewing is used as the main research method. For the functional analysis, mostly semi-structured and face-to-face interviews are conducted

[28] Liberalization process in global telecom markets have been examined in related example studies part.

with people from companies, public organizations including universities and other sectoral associations[29]. In other words, the study utilizes semi-structured interview type to focus on specific issues and to ask similar questions to each interviewee to make generalizable inferences from these observations, (Bryman, 2012, pp. 471-472).

Sampling: The study has utilized snowball and purposive sampling in the determination of relevant interviewee portfolio. In the first step, several important actors are identified from public sources like news and social events. Secondly, other relevant actors are obtained from initial interviews.

That is to say, snowball sampling has been used especially in the conferences and meetings (conversations after the formal event etc.) and several references have been obtained from these initial talks with attendants of these events.

In any case, purposeful sampling has constituted the main (sampling) method of the study. At the first step, the sample environment is bounded by sectoral limitations and also by geographical definition as well. In more detailed terms, sectoral boundary means selection from sector related firms that have (working) authorizations, licenses from regulatory authority in services segment and have memberships in CTC (HTK) cluster, which was established for the purpose of producing telecommunications equipment (including software) in hardware segment of the IS. On the other hand, these interviewees mainly come from Ankara and İstanbul based organizations, which are also in line with the importance of these (geographical) locations for the overall sector. It should be mentioned that, similar situation also exists for the fact that headquarters of related public organizations are also in the capital city, as well. In the end, the selection has been made to ensure that interviewees are part of the sector in different aspects from policy making roles to producing end user services.

Connectedly, it is evident that (in addition to sampling) sample size is important for achieving data saturation. Although there is no definite sample size, several researchers agree on some threshold levels. While Warren (2002) regards sample size of between twenty to thirty interviews as satisfactory, Gerson and Horowitz (2002) consider minimum sample size of sixty to derive conclusive inferences. In line with

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[29] Interview list is given in **Appendix-E.**

these arguments, the author has planned to achieve required variety and numbers in the selection process. Accordingly, main actors are identified in terms of profit vs. non-profit organizations and economic activity categorizations. Companies and sectoral (industry) associations constitute profit- oriented actors in the market. As in (all) other IS studies, companies (firms) occupy key positions in the analysis, as well. Sectoral associations have indirectly tried to achieve their members' main objective, i.e., profit maximization, by lobbying and making other efforts to influence public policy making process. Public organizations like regulatory authority, academic actors and other non- governmental agencies constitute main establishments in non-profit part of the industry.

On the other hand, these actors have different kind of economic roles in the system. These are hardware production and supply, service provision, consultancy services, regulation including sector specific issues like spectrum management and more general ones like taxation, education policies etc.

Data Collection and Interview Process: Following these arguments, as mentioned, the author has tried to select a comprehensive interviewee list covering different segments of the sector. The interviews took place between December 2022 and May 2023.

There are 23 people in the list from companies, public organizations, sectoral associations and experts involving in consultancy services and working as journalists. **Appendix-G** gives a more detailed list of interviewees.

It should be mentioned here that, these interviews have been generally conducted with more than one person, although it is counted one in this list.

Hence, more people's opinions have been received than this number in reality. For instance, when visiting a company, the author has met with at least two people in many circumstances.

Not all these questions were asked to everyone, more specifically participants selected which questions to discuss and they generally responded as “I don't know the subject” or “I don't want to comment on this”, whenever they wanted to skip a question. Secondly, there are two main categories of questions that have been asked to participants in different segments of the sector. More specifically, questions between 1-28 (in the detailed analysis of sector-specific problems part) have been directed to participants from service sector while questions between 29-40 (in the detailed analysis of sector-specific problems part) have been directed to participants representing equipment sector segment. As a matter of fact, more time has been given for the discussion of these questions that are directly related to assertions of the study. Questions in the first part of the study have not been discussed as deeply as the above-mentioned category. Notwithstanding to this, they have emphasised similar kind of issues during conversations. In other words, they show more willingness to discuss more pressing problems such as tax burdens, non-transparent practices in some regulations etc.

Finally, the questions in the first part (more related to firms) have not been discussed with participants from public organizations, academicians and journalists. They have been consulted with the topics related to sector-specific part such as the situation of fiber access coverage in the country. By this way, the length of interview times has been reduced depending on the interest and availability of respondent time. That is to say, respondents, in some cases, increased their planned times for these interviews due to the fact that (at least the author thinks in that way) they have complained about their problems. In any case, the average duration of these meetings became approximately 3 and 3,5 hours with the exception of an initial interview that lasted nearly whole afternoon, in the form of a pilot study.

Ethical Approval and Privacy Issues: The study has obtained ethical permission from the METU Human Research Ethics Committee with the protocol number 0398-ODTUİAEK-2022, **(Appendix- H)**. Accordingly, the author strictly followed ethical principles including protection of privacy, confidentiality, and anonymity of interviewees.

It should be especially emphasized that the author has not given much information about the identity of participants to ensure anonymity.

Because of this reason, a firm representative or a company opinion word is used for interviewees with business people, and a specific reference is not made to participants from public organizations. In this respect, respondents had been informed about the objectives of the research and about how to use their opinions beforehand.

One copy of interview guide has also been provided to participants before starting related interviews, to facilitate the process and ensure transparency.

Data Analysis: The research has mainly utilized a case study approach in making and analysing interviews. Simons (2009) defines case study as a detailed exploration of the system from multiple perspectives and it is particularly suitable for industry analysis. In fact, Aithal (2017) considers government policy evaluation in this setting. According to him, government policies can affect development of a sector in various aspects like competitiveness and a case study should focus on how these policy tools support or block performance and efficiency levels of any industry. The study has also put a sector in its main focus and has analyzed it by looking historical developments and making detailed discussions with sector actors about the current outcome and problems of the IS.

Within this context, the study aims to test some findings (assertions) derived a priori from observations and analysis of the author, in a qualitative research setting. These include evaluation of policy papers (e.g., strategy and action plans), journal articles and other information sources. The stated assertions (mainly outcome of analysis in chapter 5), which are given in Table-47, mostly correspond to sectoral obstacles and unresolved topics (for a long time) that can be observed in such sources with a follow up examination of policy outcomes. Accordingly, the study has utilized questions given in **Appendix-E** for respective assertions in each part. As a matter of fact, the author has made use of participants' views on these issues together with the secondary sources to evaluate each of them. Moreover, these findings are examined within appropriate function categories. For example, problems related to policy papers **(Assertion-2)** have been discussed in 'Guidance of Search' function category.

These discussions have been noted extensively during the interviews for later use and some topics have been rediscussed again if some ambiguous (or unclear) points occurred during these meetings. Indeed, these notes are extensively analysed and combined in terms of function and sector specific assertions headings.

The latter part is more important for this study purposes due to the fact that they, in a sense, represent each functional category and at the same time indicates problematic areas of the sector, which are necessitating new policy recommendations.

As an example, after analysing answers related to Assertion-1, similar responses have been put together to derive conclusions, representing majority opinion of the population.

In this regard, it should be stated that same procedure has been applied to each question group within these higher-level statements.

As a supporting tool, most repeated and/or emphasized words have been noted to make some basic coding in each category, as well. In any case, it is evident that these words are all related to sector jargon and/or have important meaning that embodies main topics, problems encountered in the sector.

These are given as a summary form in Appendix-I.

As a last remark on the methodology, the study has adopted some measures to increase what is called ‘trustworthiness’ of the research. This concept has several criteria and most importantly include credibility, transferability, dependability and confirmability, Bryman (2012).

As stated above, various data sources have been used to support research assertions. It can be said that this triangulation increases confirmability and credibility.

At the same time, consultation with the thesis advisor has definitely contributed to this process as well. For dependability and transferability criteria, the study provides a detailed questionnaire set, a general description of interview sample (for privacy reasons in general level) and some explanations of (interview) processes.

With the background information given in the study (e.g., this chapter and chapters 5-6), it can be said that other researchers may utilize the whole framework or some parts of it to conduct further studies in this regard. In sum, although the study has attempted to analyze functions of the IS, main objective is to look for problems and possible policy options to increase efficiency and performance (e.g., coverage expansion, better quality of service, more transparent universal service and domestic production regulations etc.) of the sector in the context of these stated findings. This does not mean that, these cover exactly all problematic issues of the IS and whenever participants mention other issues, they have been discussed as well.

2.4 Limitations and Strenghts of the Methodology

Since the study follows IS framework, it has similar difficulties in application. Without going into repetition, for instance, as common to other IS studies, a specific boundary set has been defined to make the analysis scope more manageable. As mentioned, convergence in ICT makes this issue even more problematic in a dynamic perspective. Having stated these topics (related to IS) in the other parts of the study (especially in chapter 3), it may be useful to indicate some limitations of the selected methodology. These comments can also be beneficial to see some parts of the study which needs to be improved (revised) and/or supported by other researches in this field.

As in almost all qualitative study methods, this work has some methodological limitations likewise. It can be argued that sample size is not large and representative enough to make generalizations. While one should accept the fact that population sample is not large compared to quantitative analysis, time consuming interview process has made this an unavoidable consequence of qualitative research. Here, the author has tried to reach relevant people in different segments by focusing on their experience and involvement in sectoral issues. That is to say, purposive sampling has been used to obtain variation in the analysis process. Here, some participants did not even want their groups (e.g., from public organizations etc.) to be disclosed and these anonymity considerations has introduced some complications in presenting research outcomes.

Apart from sampling size considerations, the length of interview period has given rise to some management problems during meetings. It is natural that all the participants haven’t got much time for interviews (due to their professional occupations) and this fact sometimes necessitated acceleration of discussion process. Another criticism of a qualitative research is the possibility of manipulation by both researcher and/or participants.

The author has tried to minimize this tendency by asking questions in a neutral way like "what do you think about the subject" without adding his own views etc. Furthermore, it can be said that, nearly all the participants have a long period of experience in the sector and have specific opinions in these matters, which minimizes this possibility. On the other hand, it can be said that the degree of variance (i.e., people from different groups) has ensured some kind of plurality that also reduces domination of one particular participant and/or group.

Above all these considerations, the author has tried to validate findings/observations in each subject with other quantitative and/or qualitative data and information, i.e., triangulation with use of journal articles, press releases and related data etc.

In sum, before concluding this chapter, it may be suitable to summarize main strengths of the qualitative methodology briefly.

First of all, the study has analyzed historical development of the sector to account for the current structure and present problems by employing such methodology.

In other words, evaluation of important events and policies in depth has made it possible to derive various main assertions and construct statements that can be discussed with sector experts in the end. Secondly, the participants have added valuable contributions and shared their experiences in the actual working of the sector that could not be done in a quantitative analysis.

Furthermore, although the study has mainly employed a qualitative methodology, statistical data has been used to support observations made from discussions with participants. In the end, it can be said that these methods form two sides of a coin and should be used to complement each other in analyzing any subject whenever possible.

CHAPTER 3

3. EVOLUTION OF MOBILE TELECOMMUNICATIONS & IMPORTANCE OF 5G TECHNOLOGY

As pointed out in the introduction, it is evident that ICTs have permeated to all aspect of socioeconomic life in every country, resulting what is called digital transformation or digital revolution. However, the level of diffusion varies between countries and even within one country, there exists big differences between segments of population, e.g., people living in rural areas, low-income households. Without going into details of these differences at this stage, the chapter attempts to look into importance and role of mobile telecom technologies in this digital transformation process.

3.1 Digital Revolution and Beyond

Throughout the history, major changes in economy fueled by innovations have been summarized as industrial revolutions. These revolutions have also deeply influenced status quo of societies leading to social changes as well. Although, many factors played roles in these socioeconomic transitions, it is customary to bring a few distinct technologies to the fore for indicative purposes. In line with this argument, the below Table-6 shows main technologies associated with successive stages.

Table 6-Industrial Revolutions and Main Technologies

Stages	Main Technology	Applications	Time Period
First	Steam Power	Mechanized manufacturing equipment	End of 18^{th} c. to early 20^{th} c.
Second	Electricity	Mass production with the use of electricity	Beginning of 20^{th} c. to 1960s
Third	Computer-Automation	Electronically based production automation worldwide using ICT such as robotics use in manufacturing	1970s
Fourth	Cyber-Physical Systems	Real materials and virtual processes interconnected leading to smart factories.	Today and near future

Source: (Bosch Group, 2018), (BCG, 2021)

Before anything else, it should be stated that all these stages are closely linked with each other because of the cumulative nature of technology and knowledge. Notwithstanding to this and in general terms, steam power enabled mechanization of production in the first industrial revolution. Afterwards, electricity made possible transition to mass production.

Lately, use of ICT in automated production prepared the base for third industrial revolution and further advancement of different technologies in ICT domain led to combination of physical, digital, and biological spheres in the current stage. What is more distinct in this phase that it is difficult to present one or two technologies even for indicative purposes. Scwhab (2016) mentions *artificial intelligence (AI), robotics, the internet of things (IoT), autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing* as main technologies that have roles in this process. Above all, BCG[30] (2021) underlines that joint use of these technologies[31] are more important to achieve transformative and synergy effects.

In fact, confluence and use of these technologies in an ecosystem (i.e., synergy effects) is considered main driver of new era. OECD (2017b, p. 27) defines fourth industrial revolution[32] as the utilization of interconnected digital technologies[33] contributing to more efficiency in both production and service processes, at the same time yielding new services and products in different markets.

At the core of this transformation lies ‘data’. The usage (e.g., transmitting, processing, analyzing) of more and more data is changing virtually all aspects of people’s socio-economic life. Businesses need continuously increasing data capability due to use of digital technologies. They mainly utilize data to gain competitive advantage by reducing costs and increasing consumer satisfaction. Furthermore, people all around the world feel themselves addicted to digital world, leading to exponentially increasing

[30] Boston Consulting Group.

[31] Similarly, BCG mentions *additive manufacturing, augmented reality, autonomous robots, big data and analytics, the cloud, horizontal and vertical system integration, industrial IoT, simulation and cybersecurity* among major innovations of this era.

[32] Digital revolution and digital transformation are used interchangeably in the text.

[33] This set includes not only technologies like internet of things (IoT) but also- as stated above- new materials such as bio- based and new processes like artificial intelligence, additivite manufacturing that uses 3D printing.

data consumption. It is predicted that more than 6 billion consumers will interact with data every day together with 22 billion IoT devices (Lueth, 2018), leading to global datasphere size of 175 ZB in 2025 according to Reinsel et al. (2018).

Table 7-Mobile Telecom & Internet Subscriber Numbers in the World

Year/Category*	2005	2010	2017	2018	2019	2020	2021	2022
Mobile tel. subs.	2.205	5.290	7.724	7.997	8.181	8.233	8.391	8.586
Active mobile BB subs.**	N/A	807	4.723	5.312	5.723	6.065	6.459	6.909
Fixed BB subs.	220	526	1.020	1.076	1.134	1.224	1.322	1.399

Source: (ITU, ICT Statistics, 2023), (*) Million. (**) Stands for broadband subscriptions.

Table-7 also shows the tremendous rise in the number of internet users, especially in the mobile telecom and broadband internet category. It is interesting to note that people are making more than one subscription for mobile telecommunication services and this leads to above hundred percent (100%) penetration rates[34] in many countries. The reason for this is that it is relatively easier to deploy mobile telecom networks than fixed ones (especially fiber or cable networks) although they have more inadequate internet connection capabilities, at least until the advancement of 4G technologies.

As the number of mobile telephone subscribers surpasses 8 billion range, mobile communication devices, most notably phones and increasingly smart phones are becoming most widely used equipment in the history of humankind. Apart from this, many people (almost certainly all of them in near future) see these devices as indispensable part of their lives. Harris and Cooper (2019) illustrate this phenomenon with some examples by indicating (USA) Supreme Court decision that accepted mobile phone as an integral part of an individual and by referring some surveys showing people attitudes. According to these, people prefer to eat less rather than leave their phones or they return home if they forget their phones but do not do this in case of forgetting their wallets. Within this increasingly digital world (environment), as mentioned, if data is resembled to cars, telecom networks are the roads on which these vehicles travel and reach intended destinations (i.e., data transmission, analysis and content provision). Like a ‘chicken or egg’ paradox, data requirements and telecom technologies along with related equipment (e.g., smartphones) push each other to

[34] Number of a service subscribers (e.g., mobile telecom subscribers) divided by total population.

higher levels in terms of capability, capacity and transmission speeds etc. In other words, growing demand for data services necessitate advancements in telecom technologies (especially mobile) to deal with these market needs and vice versa.

3.2 Evolution of Mobile Telecom Technologies

After the invention of (fixed) telephony, the second radical innovation in this field (i.e., telecommunications) is mobile communications, which can be described as the adoption of several technological systems to communicate regardless of a fixed location.

In simple terms and taking into account the fact that any innovation takes time and requires numerous modifications (revisions) to be available for mass-market usage, evolution of mobile communications normally categorized as successive generations.

As below Table-8 shows, this technology has been improved continuously since its inception in the late 1970s.

These advancements are later categorized in ‘X generation’ wording. Each generation has distinct technological characteristics and specifications like data transmission capabilities. First generation (1G) used analog transmission technology to provide voice calls.

Naturally, it had limited capacity and communication devices were heavy and expensive for mass-market usage.

Starting from only capable of providing analog voice telephony, each generation almost evolved in every decade, adding more and more features to the technology. In the second generation, use of digital technologies increased capacity and led to production of more cost efficient and portable devices that were fostering the growth of user base. 2G enabled sending of text (SMS), multimedia (MMS) messages and low speed data transmission (up to 64 kbps).

However, it can be said that mobile broadband experience has practically started with 3G technology in the beginning of 2000s.

For the first time, increased bandwidth and data transfer speeds enabled consumers to use audiovisual files and internet applications. Starting from 2010s, 4G has upgraded the previous one in terms of high data speed capacity between 10 Mbps to 1Gbps (Quallcomm, 2014). On the other hand, network deployment costs of these new generation technologies have been rising, making widespread infrastructure investments more expensive as well. In this (unending) journey, 5G becomes the latest technology, which is in the commercial usage (currently in some parts of the world).

Table 8-Evolution of Mobile Communications Technology

Features	1G	2G	3G	4G	5G
Deployment	1970-1980s	1990-2000	2000-2010	2010s	2020s
Technology	Analog Cellular	Digital Cellular	CDMA, UMTS, EDGE	LAN, WAN, WLAN, LTE and Wİ-Fİ	5G, LTE Advanced, OMA and NOMA
Multiplexing	FDMA	TDMA/ CDMA	CDMA	CDMA	CDMA
Core Network	PSTN	PSTN	Packet Network	Internet	Internet
Switching	Circuit	Circuit, Packet	Packet except for air interface	All Packet	All Packet
Service	Analog voice	Digital voice, SMS, MMS, Data	Integrated high quality audio, video and data, multimedia	High quality VOIP, HD Multimedia Streaming, 3D Gaming, dynamic information access	Super-fast mobile internet, AR/VR, self-driving tech., smart city and smart factory solutions etc.
Av. Download S.	2-14.4 kbps	15-200 kbps	5-8 mbps	50-80 mbps	150-200 mbps
Peak Download S.		384 kbps	40-56 mbps	1-3 gbps	10 gbps
Bandwidth	2kbps	16-64 kbps	2 mbps	200 mbps	>1 gbps
Av. Latency	N/A	500-1000 ms	200 ms	100 ms	<1 ms

Source: (Talukdar & Saikia, 2014), (RF Page, 2021), (Su-hyun, 2019), (Ghayas, 2020)

Experts consider this technology as an evolution of previous generations but at the same time see capacity increases as a revolutionary change from even 4G environment (IBM, 2021).

In two main indicators, 5G provides 10 to 100 times more data speeds (ranging from 10-20 Gbps) and much lower latencies than 4G. GSMA gives this latency differential as 10 times whereas one ITU document indicates as large as near 100 times differentials, i.e., 60-98 ms[35] in 4G versus lower than 1 ms in 5G[36]. Besides, the new technology uses less energy, has more battery life for sensors and has 10 to 100 times more device connection capacity compared to the previous generation.

As an international standard setting institute, International Telecommunication Union (ITU) published International Mobile Telecommunications (IMT) Vision for 2020 and beyond.

The report stated important milestones as vision determination until 2016, requirements determination until mid- 2017s, standard development until 2020 and deployment phase after this date.

This organization likewise considers mobile communications will form one of the vital infrastructures of digitalized life on which several services provided in the near future. In line with this, more data traffic, many more devices with diverse service requirements such as better service quality and better affordability will require considerable amount of network investments and innovative solutions by mobile telecom operators.

Any case, 5G stage considered as a milestone in that not only people connected as in previous technologies but also machines will be connected to each other, to the extent that never seen before. That is to say, 5G technology forms one of the key factors to more efficient and widespread use of internet of things (IoT), leading to many usage cases (applications) ranging from autonomous vehicles, virtual reality, robotics to smart industries and cities to name a few of them. In line with these arguments, many governments have begun establishment of 5G networks in their countries (via telecom operators). In this context, **Appendix-B** shows more detailed picture of different

[35] Millisecond: 1/1000 of a second.
[36] These specs can vary between test environments and normal usage cases, most of the time best ones are given in ideal environments. What really matters is that 5G makes a significant difference in these comparisons.

countries' network development status.

3.3 Role of 5G in Digital Transformation (Usage Cases)

As indicated above, digital technologies support continuous innovation across several industries, service sectors and social life. ICT (itself), banking, finance and insurance, media and automotive sectors are among the first comers in this digital transformation.

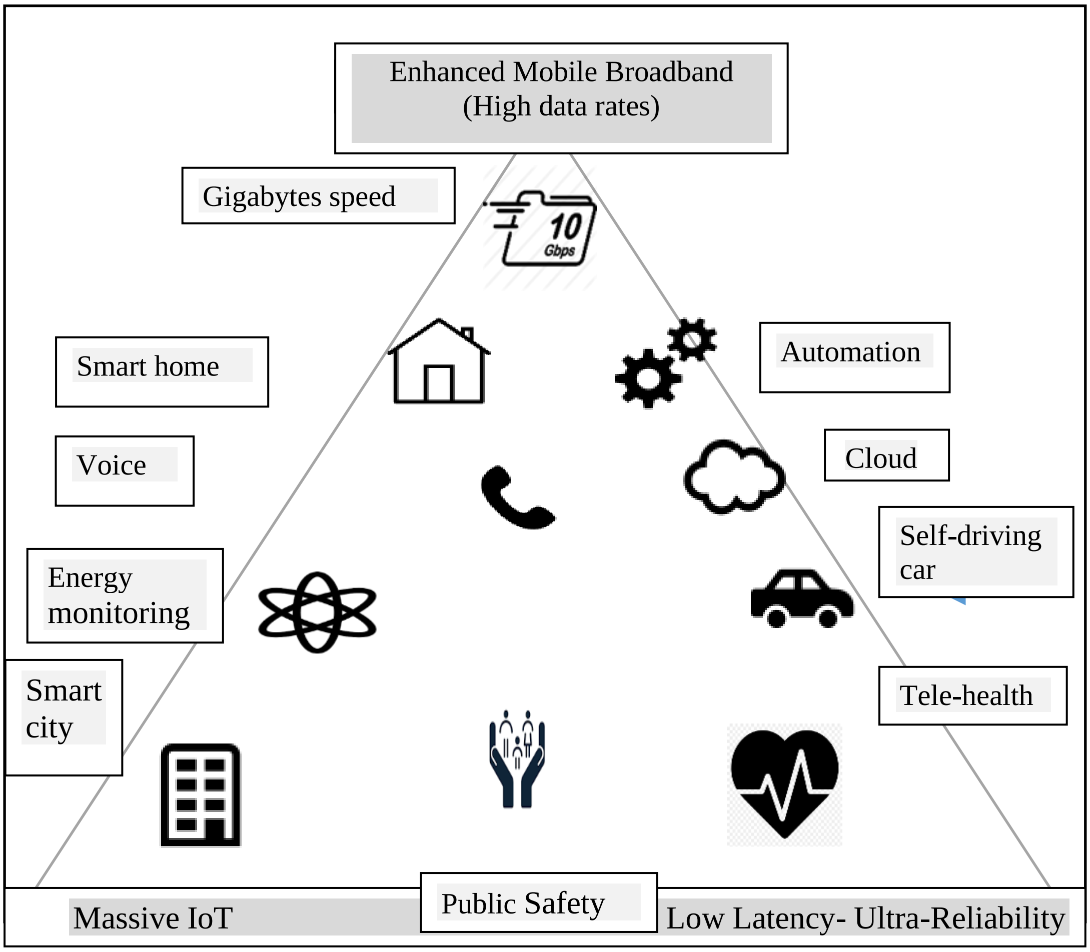

Figure 1-Usage Cases of 5G

Source: (ITU, 2015a), (5GWorldPro, 2019)

In essence, 5G technology consist of three main pillars (Fig-1); enhanced mobile broadband, massive machine communication and ultra-reliability, low latency. Enhanced mobile broadband means evolution to gigabytes speed in uploading/downloading of high definition, 3D videos. Massive amount of machine-to-machine communication make it possible to build smart homes, cities and industries on these networks. On the other edge, ultra- reliability and low latency (i.e., as low as 1 millisecond) bring in widespread use of autonomous cars (self-driving), industry automation, telehealth services, even including remote surgery and full autonomous vehicles (ICTA, 2018).

From this perspective, development (product development, testing etc.) and deployment (infrastructure- network availability, penetration etc.) of 5G forms one side of the coin. Development of usage cases (usages-applications) in vertical sectors are equally vital to generate more value added in other industries. Determination of the needs of other sectors and mapping them in 5G network design process is very crucial for eco system sustainability and growth in later stages. Related to this, it is important to establish cooperation between network providers and vertical sector users.

Government initiative and guidance is necessary for the establishment of this cooperation and traditional sector's needs such as agriculture should be taken into account for more widespread realization of digitalization benefits.

Within this context, it should be noted that usage cases are also developing both in numbers and in sophistication in line with the availability (i.e., deployment levels, technological upgrades etc.) of 5G, as shown in the Table-9.

Table 9-Stages of 5G Use Cases

Stages	Technology	Some Cases
Early Use Cases	Fixed Wireless Enhanced Mobile Broadband	Internet access to homes High speed internet
Later Use Cases	Massive Machine- Type Communications Ultra- Reliable Low Latency Communications	Industrial IoT, Smart Cities Robotics, Drone Control
Near Future Use Cases	Revolutionary Changes	Healthcare, remote industrial machine operation, virtual sports attendance etc.

Source: (Sdx, 2017)

In the early development phase, there is not much difference from the previous generation (i.e., 4G) in terms of use cases, although users get more satisfaction because of higher internet speed and upload- download capacity. In other words, enhanced mobile broadband (eMBB) seen as a continuation (evolution) of existing 4G services and has been introduced for commercial usage starting from 2019.

This technology not only provide higher download/upload speeds and better quality of service but also begin to surpass fixed broadband technology in terms of these capabilities. Initial eMBB use cases focus on consumer markets to satisfy demand for higher quality video transmission, streaming everywhere, eliminating need for a connection to Wi-Fi networks or hotspots.

Due to vast increase in use of these mobile devices, mobile data usage will exceed the fixed broadband consumption in the near future throughout the world.

Starting from 2017, mobile devices (excluding tablets) has been generating nearly 50% of global website traffic and this rate has reached to around 55% in the first quarter of 2021 (Clement, 2021). In addition to this, composition of data is also changing very rapidly. Broadband video usage is continually increasing in line with increasing access speeds, from nearly 60% in 2017 to 80% of the total data usage prediction in 2022 (Bhattacharjee, 2019).

These developments coupled with increasing popularity of immersive applications (VR-AR) and migration of data (e.g., mobile office applications, gaming etc.) to cloud, put enormous requirements on networks in terms of latency, capacity and throughput.

In this respect, 5G networks must satisfy higher capacity, enhanced connectivity and higher user mobility requirements.

Firstly, broadband access should be present in urban areas both indoor such as conference centers and outdoor like sport facilities, campus sites etc. Secondly, satisfactory user experience requires quality of service in terms of enhanced and uninterrupted connectivity. Thirdly, passengers in mobile vehicles like trains, buses should also use these services uninterruptedly and with acceptable quality of service.

eMBB enable virtual and augmented reality (VR-AR) applications and 360-degree video streaming among others (Kavanagh, 2018). Virtual reality applications include entertainment and games, tourism and advertisement, live sporting events, among many other sector and usages[37]. On the other hand, augmented reality applications also

[37] For instance, one expert gives at least twenty-one industries and areas that are currently using VR applications. This list includes automotive, healthcare, retail, tourism, real estate, architecture, gambling, learning & development, recruitment, entertainment, education, sports, art & design, events & conferences, well-being, social, charity, marketing, recreation, law enforcement, news & journalism. One can also include military uses of AR & VR as well (Thompson, 2020).

comprise of intelligent navigation, sightseeing, education and training, maintenance and repair, military uses such as head mounted display. 5G allow VR and AR to establish the infrastructure for next generation mobile social platforms.

These services and related software- hardware are particularly important for the development of 5G eco system. In other words, both hardware (like terminals, chipsets) and software (like gaming, educational programs) give opportunities for the firms in related sectors. Indeed, AR and VR start-up valuations[38] had already reached 67 billion USD in 2019 (Merel, 2019).

In any case, as technology becomes more mature and with increasing availability, it is observed that usage areas enlarge and even traditional sectors are starting to adopt many other applications depend on 5G infrastructure. In this regard, some of the main sectoral uses (shown in Figure-1 with symbols), are summarized below.

Since these vertical sector usages gain more prominence and play critical roles in digital transformation, a more detailed evaluation is given in the **Appendix-C**.

In fact, any policy for 5G technology development and deployment process should definitely prioritize advancement of these applications.

Although the number of sectors (industries) that are adopting 5G based digital applications is increasing day by day, several reports indicate some of the main ones that attracts more intention by stakeholders.

Among them, Huawei (2019) emphasizes telecom, media, manufacturing, transportation and public services as emerging areas for these applications. Similarly, GSMA (2019a) points out automotive, media & content, smart city, healthcare, manufacturing and energy as among main opportunity areas for mobile operators and other service providers.

Transportation and automotive sector have been among the pioneer users of these (digital) technologies. With the advent of mobile communications, firms have begun to install infotainment systems in the first place. Starting from (especially) 4G, eMBB

[38] Including firms that have other fields of activity as well as AR & VR. The figure for a more restricted scope of firms were 45 billion USD in that year.

and ultra-low latency enable more (radical) innovations like autonomous driving and remote vehicle maintenance services. 5G technology with superior features like network slicing will further upgrade vehicle- to- everything communications (V2X) to speed up development and diffusion of this usage. Network slicing provides multiple dedicated networks on a single network. This feature of 5G enable operators to provide different type of services for customers, (GSMA, 2017). For instance, full autonomous driving requires very low latency and for media applications one does not need such kind of stringent specs.

Moreover, this market growth (trend) facilitates new data-based business models for the use of (other than automotive) companies such as insurance firms and application of similar technologies to other modes of transportation like railways.

On the other hand, this application type demands non-interrupted service quality (i.e., connectivity between countries) and cooperation with vehicle producers for mobile telecom operators.

Media, entertainment and content sector forms other potential areas for extensive adoption of usage cases like ultra-high-fidelity media, on-site live event experience, user & machine generated content, immersive media, cooperative media production and collaborative gaming (5G-PPP, 2016).

In this setting, 5G benefit service/content providers by enabling very high transmission capabilities for HD videos and drone images etc. Huawei (2019) underline gaming, which use AR technology as one of the most attractive growth areas with annual revenue predictions of 100 billion USD in a seven years' time.

These new services (with more recent ones like tactile feedback) will undoubtedly increase the burden of network management by mobile operators. In parallel with this, demand (need) for cloud services is generating new businesses in this field.

Overall, mobile telecom operators are starting to diversify into media & content services by either establishing their platforms or collaborate with other players.

Another area that receives much interest in recent years is smart city applications, all of which together are used to increase quality of life for its inhabitants. Some of these include smart traffic management, smart energy management, safety and early warning systems.

Likewise, several technologies used in combination to give these services. IoT, AI, cloud computing, machine learning, M2M and mesh networks are among the main components of a whole system (TWI, 2021). Needles to mention that, a good functioning smart city needs a reliable telecom network to meet all these data requirements.

Healthcare sector increasingly use applications enabled by mobile communication technologies. Ericsson (2021a) categorizes these into patient, hospital applications and medical data management along with applications (shown in the other category) that simplify access to medical support like ambulance drones and 3D printing.

Patient applications include services that are given out of hospitals and cover precision medicine, remote monitoring devices. Hospital applications can be defined as services that are used in this location like telemetry and AR/VR aided training for surgeries.

On the other hand, medical data management applications mainly focus on storage, analysis and real time delivery of medical data. As hospitals are becoming data centers as well, telecom networks (in turn mobile operators) must satisfy availability, reliability and security requirements. With the help of 5G technology, Ericsson (2021a) predicts operators' revenue potential of 75.7 billion USD by the year 2026.

It is evident that manufacturing is an essential part of digital transformation process. In fact, digital technologies used in a factory environment can be considered as the birthplace of industry 4.0 concept.

Bosch (2021) company became the first organization to mention this by referring to a factory managed by machines in 2011. Currently, smart factories are using digital technologies virtually in every segment of production process in a combined manner.

5G-PPP[39] (2020, p. 49) categorizes these as applications related to time-critical

[39] The 5G Infrastructure Public Private Partnership (5G-PPP). It is a collaborative organization founded by the European Commission and stakeholders from European ICT sector including producers, operators, research agencies and SMEs, (5G-PPP, n.d.-a)

process optimization inside a factory, non-real-time critical in-factory communication for large number of devices, remote operations and massive information exchanges.

In these categories, there exists hundreds of specific equipment including robots and mobile cranes, all of which undoubtedly bring heavy loads to communication infrastructure of these factories.

Similar to the above-mentioned sectoral usages, private area 5G networks are facilitating these processes by enabling ultra-low latency and reliability capabilities.

Energy and other utility sectors are also benefiting from digital applications, which are using 4G and (increasingly) 5G networks.

These usage cases reduce utility providers' costs and promote energy efficiency to minimize environmental effects. Industry actors state smart grid management, smart meters and remote monitoring among commonly used applications in this context.

Huawei (2017a) emphasizes feeder automation[40] as one the most relevant use case benefiting from 5G enabled low latency (lower than 10 ms) capabilities to reduce energy waste from power stations.

In sum, one can indicate several different usage areas and applications enabled by advanced mobile telecom networks, but -in this case- the list may cover virtually all sectors in the end[41].

However, one industry can be differentiated from the others in certain aspects and this is telecommunications sector itself. While providing essential infrastructure base for the provision of many data-oriented applications, this sector has also been subjected to change because of its growing role in this setting.

On the one hand, network investment costs are increasing and at the same time, related business opportunities are expanding as well.

As will be discussed later, mobile telecom operators are now buying start-up firms that

[40] It provides ability to remotely monitor and control networks by collecting information, and delivering useful & on-time information to related parties, (ABB, 2000).
[41] As indicated, a more detailed discussion about some of these usage cases is given in **Appendix-C**.

are in the digital technology domain and/or establishing partnerships with other ICT firms to enter different business segments related to these usage cases and services.

3.4 New Paradigm for 5G Technology Policy

In essence, the above discussions (together with more detailed evaluations in the appendix part) serve to indicate the vital role of broadband internet access and usage throughout the globe.

Before continuing with other topics in this context, it is worth mentioning the assumptions of this study. First of all, 5G should not be seen as a single technology that comes immediately to operational/ commercial usage by people.

It has antecedent generations and will have forthcoming ones like 6G in the next decade. Here, one can say that ‘internet’ as a general- purpose and revolutionary technology has started the evolutionary road to digitalization of everything.

In short, the study uses 5G word for indicative purposes, covering advanced mobile telecom technologies (e.g., 6G) along with complementary fixed access types such as fiber-based networks.

Secondly, the study accepts the trend of digitalization as an inevitable process and concentrates on sectoral impediments blocking dissemination and widespread adoption of these technologies.

It is certain that these technologies have several negative side effects including internet addiction, gaming disorder, cybercrime and privacy breaches, to name a few of them (Quaglio, 2020).

Public policy has critical roles in reducing these negative effects but they are not covered in depth in this study with the exception of some general evaluations in the policy paper section of the case study part.

Notwithstanding to this (and it is not a negative effect of use but lack of access & use), digital divide and universal service issues are analyzed as problems of the sector. Furthermore, cybersecurity has become an important business segment and increasing number of both service and equipment producer firms are entering in this market part.

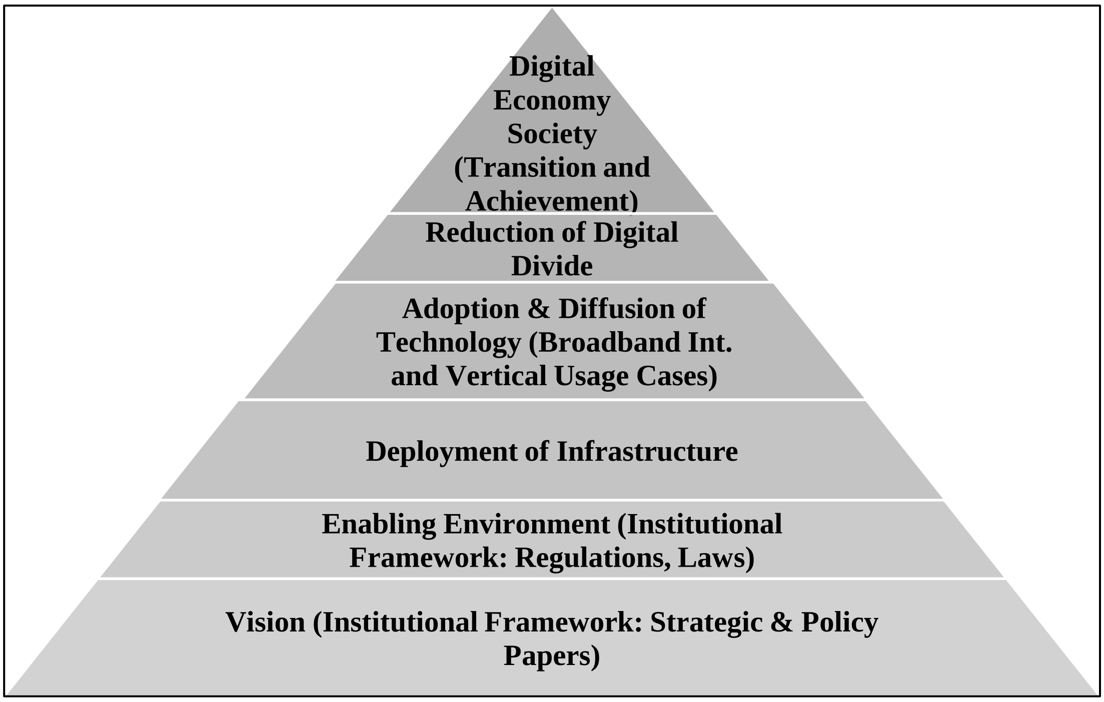

Figure 2- 5G Technology Deployment Steps

Source: Huawei (2019), ITU (2018), GSMA (2019a) and the author's contributions.

These points lead to main argument of 5G-technology policy adopted by this study (Figure-2).

In particular, the policy should not only cover technology development but also address issues related to widespread adoption (dissemination) of these technologies and related applications.

What is more, countries should consider data security as another critical component of this technology policy.

In sum, all these considerations necessitate a certain level of indigenous technological capability, widespread availability of advanced telecom networks (i.e., fiber and 5G), affordability of access and use of these services and finally establishment of a transparent and well-functioning universal service policy to reduce digital divide problem.

In line with these arguments, the study will focus on dissemination of technology (i.e., service provision part) and increasing indigenous production capabilities (i.e., hardware production part) of the sector. At the same time, the need for reducing digital divide problem is considered as an integral part of the analysis to achieve digital economy and society objectives.

Having considered the role of 5G and need for an inclusive policy approach, the study continues with a more detailed review of sectoral trends and problems related to this technology deployment process.

3.5 Telecom Sector Trends and New Business Opportunities

The above discussion shows that mobile telecom operators[42] have opportunities in different (vertical) sectors as infrastructure enabler and technology provider alone or in collaboration with other ICT firms and start-ups. On the other hand, they face with risks and problems such as increasing competition from other sectors, stagnating growth and consumer demand, need for considerable infrastructure investments and regulatory obligations. Consumers (both individuals and organizations) demand more data capacity and speed, bringing necessity of network upgrades and new investments. At the same time, traditional voice service revenues have been declining due to substitute products such as over the top (OTT) applications like WhatsApp and voice over internet protocol services since nearly a decade (Massaed, 2014). Indeed, international over-the-top (OTT) voice traffic surpassed 1 trillion minutes in 2019, as opposed to approximately 430 billion minutes of international carrier traffic. Experts accept that this trend will continue taking into account free services (included only in internet usage costs of course) provided by these firms (Bannerman, 2020).

To reiterate, in this challenging environment, operators need to increase their infrastructure investments to stay competitive and to meet user demands both in individual and in business bases.

Fiber upgrades in fixed network and new generation mobile network rollouts make up the main cost categories.

Mobile operators have performed 5G technology trials, tests and in some countries,

[42] Mobile telecom operators, mobile telecom service providers/firms are used interchangeably in the text. It should be mentioned that these firms occupy central role in the analysis of telecommunications sector as a whole, especially in our country case. They have almost entire market share in service provision (i.e., voice and data services) and at the same time major customers in telecom equipment segment, where there is no major domestic producer available.

they are already making major investment expenditures, starting from (beginning of the) 2020s. In addition to investments in network components (e.g., base stations, antennas), telecom companies main concern comes from possibility of (or already incurred) excessive spectrum fees[43].

Apart from this, communication between machines (M2M, IoT) will constitute major part in future operations of mobile telecom operators. Similarly, cloud market to store and analyze big data display similar patterns. Gartner (2020) predicted worldwide public cloud revenues to grow more than 6% in 2020, reaching nearly 258 billion USD from 242.7 billion USD in 2019. While, Statista (2022) estimated the market to surpass 525 billion USD in 2023.

In any case, the market is expected to grow considerably in the coming years. Expert predictions for market size are in the region of 1.250 billion USD by the year 2028, (Businesswire, 2021). Currently, Amazon Web Services, Microsoft, Google, Alibaba, and IBM together have half of the market share, (Jones, 2022). For the other half (of the market), telecom operators are also competing to gain market share along with other ICT firms.

Moreover, many experts see cloud computing as a disruptive innovation for changing business operations. Experts (PwC, 2013) state that consolidating infrastructure in the cloud increases productivity and reduces expenditures by enabling elasticity and accessibility of using these platforms from any place at any moment. For this reason, telecom operators have begun to enter this business segment by making substantial investments in data centers and establishing partnerships with other firms in the market. They aim to use this technology to virtualize their networks and to widen their scope of innovative solutions in IoT ecosystem like cloud-based communications and infrastructure as a service, platform as a service and software as a service (Chowdhury, 2019).

Sector analysts argue that telecom operators are not able to compete with tech giants like Amazon, Microsoft and Alphabet in global arena due to their large-scale undertakings. However, they have comparative advantages in local markets to give

[43] The role and importance of spectrum fees is analyzed in the next section.

private cloud services for firms offering vertical applications, (ADL, 2013). Besides this, one can see the role and importance of public policies in supporting ecosystem by observing some examples.

In EU, where data protection regulations enforce data storage in the member countries, domestic operators are trying to become dominant players of the market. Deutsche Telekom and OVHcloud (a French company) have been cooperating on the provision of cloud computing platform (as an alternative for global companies such as Google, Amazon and Microsoft) for European firms and public organizations (Rosemain, 2020).

Besides, European Commission (EC) has started a collaborative project called Gaia-X to develop European cloud platform in June 2020. One of the main aims of this project is to support data protection and governance capability of the member countries, (European Council on Foreign Relations, 2020).

Telecom operators and IT firms have already provided digital and in most cases mobile services but as indicated before, 5G with the much superior technological capabilities, expected to bring disruptive transformations across virtually all sectors by coordinating IoT, cloud, big data and other digital services simultaneously.

In this environment, these operators will be able to facilitate vertical usages either by establishing partnerships or by themselves, (Huawei, 2016).

As digital transformation is spreading not only to industries but also to almost every dimension of daily life, digital revenue for ICT players expected to reach approximately. 3.5 trillion USD by the year 2026.

Analysts forecast above 700 billion USD revenue opportunity for telecom operators targeting digital transformation services using 5G technology by the year 2030[44]. In

[44] Main industries supposed to generate this amount includes manufacturing (19%), energy and utilities (12%), public safety (10%), healthcare (21%), public transport (5%), media and entertainment (10%), automotive (12%) and financial services (5%), retail (4%) and agriculture (2%) according to estimations of Ericsson (2019). Percentage figures in parentheses refer to shares of the corresponding category in the total revenue forecast. As in the case of other predictions in the ICT industries, there exist other estimations related to these trends. In this category, some of the recent additions are mainly agriculture and retail. The important thing is that these trends are indicative for the growth potential of related markets.

the competition for capturing from these revenue streams, operators can play different roles in the 5G value chain. The first role consists of service (voice, data) provision to end users.

This is indeed their core business in line with historical developments, i.e., voice and later data with the emergence of internet. With 5G rollout, operators continue providing previous services like communication, messaging and mobile internet usage. However, the user experience will be different in terms of data speeds, low latency and other quality of service criteria. As stated previously, enhanced mobile broadband (eMBB) with data transfer capacity of downlink speeds approaching one (1) Gbps levels indoors, and three hundred (300) Mbps outdoors will further increase the use of mobile telephones, tablets and wireless computer connections reducing the necessity of fixed internet availability (Goodwins, 2019). Moreover, fixed wireless access (FWA[45]) services can replace much of the traditional wired broadband connections in the near future. FWA is not a new service and operators has used this technology to substitute fixed internet access (i.e., ADSL, fiber, cable). However, it has becoming competitive to fixed solutions with the advancement of mobile communication technologies starting from 4G (LTE). This competitive pressure will increase especially after the introduction of 5G based FWA with a fiber equivalent performance[46] and with more affordable tariff structures, (GSMA, 2018a). That is to say, operators need to satisfy performance and cost requirements of consumers in the end user segment. In UK market, Ovum stated 5G enabled FWA could replace up to 85% of nearly 26 million fixed line subscribers by providing equal or better speeds with more suitable prices. At the same time, deployment of this network technology could be made at a half cost of fiber infrastructure investments in same location, (Three press release, 2018). For cost considerations, 5G-FWA has advantages over fiber investments in comparable locations. Fiber rollout in urban areas especially connection to homes is an expensive undertaking in which civil work, permission procedures, involvement of different stakeholders constitute main cost items in total expenditures.

[45] Fixed wireless technology provides a high-speed internet connection access through airwaves from towers to receivers in users' premises (Schell, 2019).

[46] Here, performance specs follow evolutionary path, from copper (like Xdsl connections) to cable and fiber reaching above 10 Gbps speeds. Starting from 4G FWA with 50-150 Mbps speeds, 5G enabled FWA can provide 10 Gbps speeds, becoming a competitive service vis a vis fiber access (Wik Consult, 2020, pp. 9-11).

In essence, 5G- FWA is a cost-effective solution for mobile operators, which do not have widespread fiber network, and for the areas where broadband infrastructure is not enough to provide satisfactory service for users.

This concept is also significant for public policy considerations. It is widely accepted that digital transformation should cover each segment of any society to realize its benefits.

Otherwise, some people may not be able to use and benefit from digital technologies[47].

Here, 5G-FWA rollout can be vital in closing the gap by providing advanced internet (e.g., multimedia, real time applications) services to disadvantaged people (e.g., in lower income categories, unemployed etc.) in a country. In any case, this does not mean that fiber network and related investments will be unnecessary and the important thing for the operators is that with 5G- FWA, they have other alternatives to use in a complementary way to optimize their infrastructure related expenses and upgrades (GSMA, 2018).

Starting from the previous generations of mobile technologies, an ecosystem has already developed to support rapid diffusion of this technology. Many countries see commercial trials and operators are establishing partnerships with global vendors in widespread deployment of 5G-FWA. Some of these are given in the Table-10 below[48].

In line with their expansion strategies, global telecom vendors aim to enter this market segment by making investments in new equipment and technology. Technology analysts indicate the fact that 4G has initiated this path and major equipment providers will support technology development and diffusion by making trials, tests and partnerships with major operators. That is to say, an ecosystem is ready for 5G-FWA (evolutionary path) and market players see this technology as a real opportunity to

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[47] In fact, digital exclusion has become a social problem (i.e., not reaching and using information in the information age) called digital divide. According to Molinari (2012)) digital divide is the disparity between people and societies that gain access to ICT and those do not access to these technologies. It is clear that in today’s environment, simple definitions of universal service are not enough to respond the needs of information society. Hence, the concept should cover lack of access (due to affordability), lack of knowledge on how to use the technology and lack of knowledge on the benefits of the technology (Molinari, 2012).

[48] This list is given for indicating widespread adoption of the technology and one can add many other projects throughout the world.

enrich their business portfolios (McCaskill, 2020).

Table 10- Main FWA Operator & Vendor Partnerships

Mobile Operator	Vendor	Country (of the operator)
Verizon	Samsung	USA
U.S. Cellular	Nokia	USA
Orange	Samsung, Cisco	Romania
Swisscom	Ericsson	Switzerland
Arqiva	Samsung	UK
Optus	Nokia, Huawei	Australia
NBN	Ericsson	Australia
Comsol	Samsung	South Africa
Globe Telecom	Huawei	Philippines
Zain	Nokia	Saudi Arabia
TIM	Ericsson, Qualcomm	Italia
Ooredoo	Nokia	Oman

Source: (Telecoms, 2021), (Waring, 2019), (Chamberlain, 2019)

Regardless of this fact, it is natural that the level of commitment (or enthusiasm) varies from operator to operator depending on their legacy infrastructures, business plans (in general a path-dependent process) and future expectations. Although many operators backed by vendors started to invest in 5G-FWA[49], for instance AT&T decided not to

[49] Technology provider's (vendors) efforts has contributed to the rapid development of 5G-FWA in world markets. Samsung has launched first commercial 5G-FWA solution system in the world. This system consists of *first* commercial 5G modems and mm Wave RFICs, commercial 5G home routers (CPEs) for both indoors and outdoors, 5G Radio Access Network (RAN), a next-generation core, AI-powered 3D radio frequency planning tools, services and all these equipment got authorization from regulatory authority FCC of USA (Samsung, 2018). With this partnership, Verizon became the first operator to begin deployment of 5G-FWA services but service availability is still limited to some cities. This operator planned to cover 30 cities in 2019 initially beginning with FWA at home then expanding mobile 5G availability in these areas and currently covers 60 cities- but with only some specific parts of them (Fisher, 2021b). Nokia, Ericsson, Huawei and ZTE are all following this trend and trying to capture market share in the global arena. Nokia using the market forecasts, expect FWA to reach approximately 27.5 million households by 2022. According to the company, operators will utilize 5G technology increasingly to commence new business opportunities. In parallel to this line of reasoning, Nokia introduced a new technology (FastMile 5G Gateway) that enables operators to enhance their 4G (LTE) network capabilities up to 10-25 times faster than this platform (Nokia press release, 2019). In a similar fashion, Ericsson has given priority to this technology by underlining low capital-intensive rollout, flexible capacity deployment, spectrum efficiency and ability to address both fixed access and mobility for homes and businesses (Ericsson, 2021a). The situation for Huawei and ZTE is somewhat more confusing if recent developments taken into account. They have made considerable investments in 5G technology and established partnerships with operators not only in Asia but also in Europe and USA. USA government ban effected these vendors businesses in various countries, showing the role of public agencies (rules, regulations etc.) in technology development policy and programs. For example, besides US operators, Optus (Australian based) cancelled the agreement with Chinese vendors on the ground of technical security concerns, i.e., national security decision of Australian Government (Reichert, 2018). However, it seems that some operators (or countries) are not taking into account USA's efforts to ban these companies and proceed with their own business plans. More recently, Huawei and Swiss telecom operator Sunrise established a strategic partnership in smart farming with

enter this market segment by bringing its extensive fiber network to the fore. CFO of the company argued that if the fiber were already available then there would be no need to search other alternatives because of the quality of service that provides to end users (Goovaerts, 2018).

In sum, 5G-FWA brings cost effective network alternative for operators, especially with decreasing costs as a result of continuous technological developments, support of global vendors and economies of scale. Operators see opportunities especially in capturing consumers that are cost sensitive in the first place.

Secondly, it may be possible to substitute old legacy technologies like xDSL in terms of service quality. Thirdly, operators can utilize this technology to meet temporary or seasonal demand (e.g., holiday places etc.) instead of more costly fixed line investments and/or upgrades.

Fourthly, 5G-FWA provides cheaper connection between IoT applications requiring less rigorous specs in terms of latency.

Lastly, but more importantly for public-social policy purposes, this technology may play a role in addressing digital divide problem. Policy makers should consider this role when devising license and incentive mechanisms for mobile operators undertaking 5G network investments.

As the role of knowledge and digital services becomes integral to society, even basic access to the internet is not enough to support disadvantaged people in taking advantage of digital transformation such as e-learning and e-farming among other examples.

Further to the previous arguments, 5G technology can improve the functioning of digital ecosystem by connecting each element (IoT, cloud, robots etc.) in a more efficient manner.

Enhanced mobile broadband, massive machine type and critical machine type communications can provide connectivity to different needs of usages in every layer

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5G technology (Reuters, 2019a). As another case, Philippines leading operator Globe CEO declared that they continue to work with Huawei and the partnership covers both 5G equipment and mobile telephones (Waring, 2019).

of socioeconomic domain. Here, telecom operators may take different positions in the value chain.

Assuming service enablers and application developers' role opens up several new business alternatives to counter decreasing revenues from voice and standard data services.

These companies can deliver services to other firms (B2B) or directly to individual consumers (B2C).

Vertical industry firms in turn use these services either in their internal processes, e.g., use of sensors in maintenance and repair services and/or in final product, service provision, e.g., communication services in automated cars (Ericsson, 2017).

Starting from 4G, mobile operators are giving more importance to connectivity applications. This precedence will undoubtedly increase with the introduction of 5G technology in a more widespread scale.

Connectivity applications include IoT and cloud networking, M2M communications, easy payment and telematics systems.

Usage and demand for these services and applications are continuously expanding from businesses in every industry ranging from public utilities (energy, water management etc.) in smart cities to other digital service providers such as cybersecurity and cloud management.

Telecom operators have introduced business models imposing charges on both providers and end users for managing such services.

Apart from this, it is clear that another business strategy is pursuing opportunities in other sectors that adopted mobile communication technologies in their operations.

Deloitte (2017) give prominence to the main status of these firms in the value chain and advantage of having straight connection (i.e., very near) to individual end users.

As an example from a sector that does not need 5G technology as much other sectors (e.g., manufacture) in a relative sense, Orange (mobile telecom operator) purchased majority share of a bank to enter digital banking services in Europe (starting from France) in 2017 (Orange, 2021)[50].

To summarize, market actors have continuously developed new services, applications and there are many opportunities for mobile telecom operators in the near future. One can say that digital ecosystem has a mechanism in which every development in a single part affects other parts in different ways, leading to changes in business practices, new opportunities and at the same time bringing risks and challenges to market actors. Technological advances in mobile communication contribute to advancement of AI, IoT and cloud capabilities; these in turn push infrastructure innovations.

3.6 Digital Transformation and Mobile Telecom Operators

As technological innovations bring new business opportunities, telecom operators have also tried to adapt and transformed their organizations to cope with ecosystem dynamics. In this regard, a look into the business structure of a telecom operator may prove useful to understand recent dynamics. In general, the first thing to note that there are scarcely any operators left with fixed and mobile telecommunication separations. Almost all telecom operators have both fixed (fiber, copper and xDSL technology) and mobile (3G, 4G and starting 5G) network investments. Few of them have cable networks (especially in USA) to give TV, data and voice services. In today's market, a typical operator gives communications, information and entertainment products and services to end users, businesses and public agencies. Connectedly, business organizations of these operators have been changing as well.

For instance, Verizon implemented a strategic restructuring of its businesses as of April 2019[51]. At the top, the company parted into two, Consumer and Business Groups[52]. Apart from these groups, Verizon has also a media section called 'Verizon

[50] The company has planned to expand (this service) to other countries, starting from Spain then to Poland, Belgium and Slovakia between 2019- 2023, with projected 4 million clients in these countries, (Rosemain, 2018).

[51] The resulting organizational structure is evaluated from Securities of Exchange Commission of USA data archives section of its web site.

[52] Whereas consumer segment gives wireless and wireline communications services/products to end users, in addition to these services business group delivers multimedia (video & data), security and managed network services, corporate networking solutions and network access to supply several Internet of Things (IoT) services and products to firms, government entities and other telecom

Media Group' that provides display & search advertising[53], e-commerce services and subscription memberships (SEC, n.d.). This group puts itself at the center of media, advertising and digital technology, which enable users to obtain entertainment media, gaming, news and commerce, among other services. The company's CEO (Mr. Kyle Malady) announced that the new structure manifests a definite strategy beginning with the company's customers.

Additionally, he has added that they are working on network transformation, intelligent edge architecture to give consumers new services and maximize growth options by leading 5G transformation (Kinney, 2018).

Likewise (among others), Vodafone Türkiye has carried out an organizational restructuring recently[54]. The company's CEO (Mr. Engin Aksoy) has announced new strategy that covers both economic and social aspects with the main objective of becoming a new generation telecom operator in 2021. Social dimension part includes polices for disadvantaged people in the form of digital literacy and other supports. This program also include supports for SMEs in their digitalization efforts. On the other hand, the firm plans to upgrade its network on the eve of 5G transition. Along with these investments, they are diversifying in vertical usage sectors in addition to conventional telecom services. Accordingly, it has four major verticals and ten firms in these groupings[55]. Apart from these undertakings, the company has been working with solution partners in various projects like digital agriculture station and energy consumption management named Red Control. Although it is not directly related to the study topic, it is interesting to observe that this transformation has also influenced inner structure of the company. As an example, they are extending scope of home-

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companies (wireless and wireline carriers). Business group covers three subsets; global enterprise that is dealing with large businesses, small and medium companies, public sector and wholesale data and voice services to local carriers.

[53] Display advertising also called banner ads means monitoring user's conduct (while using internet) in order to put proper ads in front of the right consumers. On the other hand, search-advertising ads appear directly on search engine websites after a user has searched a keyword or phrase in the internet (DiSilvestro, 2018).

[54] Please note that a more detailed analysis of mobile operators' business operations is given in Table-28, (pp. 194-195).

[55] Telecom group (as the core) has mobile (Vodafone Telekom) and fixed internet (Vodafone Net) service providers and Vodafone Tower. Services group includes Vodafone Provision, Information and Technology firms (three separate ones). Later additions are Vodafone E-Para (E-Money) and Insurance firms (two separate ones) in the finance group. Lastly, Vodafone TV and Content Services firms lie in media and TV category.

office workings and passing to, what the CEO calls, hybrid-working model. According to his statements related to objectives (of this transition), more flexible working will enable 3.500 (three thousand and five hundred) additional employment, many of them from students, disabled people and homemakers, in three years' time, (Ünal N. , 2021). From this, without going into much detail, one can assert the fact that advanced mobile telecom technologies will further increase home office like applications and contribute solution of some problems like city traffic, pollution etc. in the near future.

3.7 Risks and Problems related to 5G Technology Deployment[56]

As already discussed, numerous usage cases of 5G (i.e., advanced mobile telecommunications) will bring breakthrough changes in virtually every aspect of peoples' lives. In essence, this technology forms the infrastructure of digital transformation on which new applications, business models, production processes run with gigabit speeds, minimum latency and reliability. However, there also exist some risks and problems related to deployment of this technology on a wider scale.

High Investment and Deployment Costs: Apart from technology development and testing costs, deployment of 5G networks will entail high investment (capital expenditures) depending on intended coverage requirements. Some industry experts and telecom operators express their concerns and warn about 5G expectations, in this regard.

Telecom operators especially, emphasize high investment costs and the need for (more) reasonable license fees to undertake widespread network deployment. Managing director (Mr. Beng Nordström) of the Northstream consulting group indicated the fact that revenues had been declining since 2008 in spite of investments in high-speed technologies during this period. He further argued introduction of 5G to the consumers would not automatically increase revenues based on this trend.

Vodafone's chief technology officer (Mr. J. Wibergh) also said that the main benefit of next generation mobile technology is in the cost effectiveness rather than immediate

[56] This part evaluates problems that are related to 5G technology deployment, adoption and does not cover problems such as internet addiction etc., which are considered as negative consequences of internet usage.

growth in revenues or new business cases[57]. However, operators' main concern remains in the spectrum issue and they argue that if spectrum fees are excessive, these cost efficiencies will not be decisive factors in the investment decisions. Secondly, taking into consideration the fact that mobile network technologies have nearly ten-year life cycle, full potentials and benefits of 5G will not be immediately available to both industrial users and individual consumers in the short term, (Morris I. , 2017).

This may cause user dissatisfaction leading to decreasing demand and slowing the adoption rates overall. Any case, as it is discussed in later parts of the study, 5G deployment costs have both initial (and substantial) spectrum fee payments (to public organizations) and subsequent infrastructure related expenditures like installation of base stations.

Spectrum Licensing: Licensing is one of the most fundamental regulatory tools in the network economies. Depending on the licensing policy, first comer advantages and network effects may determine the market (i.e., competitive or oligopolistic markets) structure and this is particularly relevant for network economies including telecommunications sector, (Tozer, 2010). In this context, ITU (2018, p. 25) highlights the fact that the choice of selection procedures and obligations included in 5G licenses can tremendously affect market ranging from competition to service availability and coverage.

Above all other issues, spectrum fees form the primary cost item of telecom operators. Governments aim to maximize these fees obtained from spectrum auctions as a means of generating significant budget incomes, in most cases. This leads to conflict of interest between stakeholders in related ecosystems. In this respect, some experts argue spectrum auctions may reduce the funds available for infrastructure investments.

This consideration can be more important as 5G rollout and widespread availability is a prerequisite for the digital transformation of any country in both economic and social perspectives. GSMA (2018b, p. 6) assert that supporting digital transformation by encouraging network rollout and high-quality service availability should be main

[57] According to his speech, 5G is approximately ten times cost efficient than the previous 4G technology thanks to massive MIMO and radio that can handle up to 100-megahertz (MHz) transmission speeds.

priorities of governments instead of trying to maximize fees for short term benefits. Regardless of these issues, it is evident that if 5G and new generation mobile technologies are in the center of digital transformation, spectrum licensing is the starting step and in the core of this technology deployment process. Nearly all actors (in these ecosystems) including industry associations and operators prepared policy papers to emphasize this subject.

For instance, according to GSMA (2018b), 5G spectrum supply should not be limited to avoid excessive auction prices and price setting should include obligations of license holders such as quality of service and coverage levels.

In this regard, regulators should prepare 5G spectrum roadmap and plan activities and timeframes by taking into account the views of interested parties.

Relatedly, it is better to make detailed consultations with the stakeholders before finalizing the license conditions, obligations and auction details.

Spectrum management: Since spectrum is a scarce resource, public authorities normally grant exclusive usage rights to auction winners. With this method, both state revenues are maximized and spectrum owners (operators) can make long term operational (usually 15-20 years) plans and will be able to make investments in the network with a profit margin.

Huawei in a 5G spectrum public policy statement stress that similar to the 3G and 4G licenses, new spectrum assignments should be exclusive and nationwide to guarantee faster roll out and adoption rates.

Besides this, the company thinks reasonable spectrum fee and investment incentives are also necessary for the development of mobile telecom industry that forms backbone of digital transformation, (Huawei, 2017b).

As indicated in Table-11, licensed usage of related spectrum nationwide is the most common methods applied in many countries. Few of them give geographically limited spectrum to operators but this practice is not common in general terms. On the other hand, policy makers consider unlicensed spectrum only for some usages due to lack of investment payback assurances, interference and low quality of service issues.

ITU (2018) endorse unlicensed spectrum use in high-frequency bands such as 60 Ghz and mmWave band with poorer propagation characteristics and high atmospheric attenuation[58].

Table 11- Spectrum Types (with respect to usage rights)

Types	Licensed	Unlicensed	Shared-access
Authorization-spectrum need	Yes (generally via auction)	No (free use)	Yes (cost sharing)
Accessibility	Licensee	Anyone (free to use)	Depending on the share agreement
Advantages	Investment-operational certainty, quality of service, widespread availability	Low cost of use, easier market entry	More efficient use of spectrum, more flexible capacity adjustment
Problems	High cost, underutilization and low scalability	Interference problems, low quality of service,	Control, coordination and standardization problems
Frequency bands (sample)	700, 800 MHz, 2.6, 3.5 GHz	5.8 Ghz, 60 Ghz	-----
Interference Management	Planning and central management	Distributed management, good neighbor behavior	Dynamic frequency selection
Typical Systems	GSM, UMTS, LTE TV broadcasting	Wi- Fi, U-LTE	Spectrum utilization in rural areas

Source: ITU (2018), GSMA (2018).

This type of use can enhance spectrum utilization in sparsely populated areas. Secondary users can utilize these spectrums in rural areas without interfering with the primary license holder’s network operation. Although, shared licensing may result in more efficiency and flexibility, it is difficult to operate in practice. As different class of users coexist, some kind of coordination and enforcement mechanisms are necessary to minimize interference problems.

Here, regulators (policy makers) should draw a framework that is comprehensible, convenient and accommodate the requirement of sharers. Furthermore, selected bands must be accessible and in sufficient quantity to satisfy demand when needed (i.e., time and place requirements). Network operators should not be prohibited from voluntary sharing and regulators may even use some incentive mechanisms in the first place. In

[58] Millimeter wave (also millimeter band) refers to spectrum range between 30 gigahertz GHz and 300 GHz. ITU also used extremely high frequency band (EHF) for this spectrum range (Slattery, n.d.).

any case, the regulatory (institutional) framework should take into account current and future demands of every user in an ecosystem.

There are three main variables in a sharing framework: access terms (including fees and technical conditions), guarantees and number of tiers. In most cases, national regulatory authorities are responsible for defining the framework and its details including coordination mechanisms, time and location limitations etc. The success of this method lies in efficient cooperation between incumbent operators and new users.

Besides this, each country can decide on the arrangement depending on the availability of spectrum and national frequency plan requirements.

As an example, for spectrum sharing framework, UK's regulatory authority Ofcom has prepared policy papers and made regulations. The authority considers enabling different and new users to utilize existing spectrum (in provision of more mobile applications and services) will promote innovation and increase consumer choices. In spite of these potential benefits, there are some substantial barriers against the efficient implementation. Ofcom summarizes these as lack of available information, transparency problem and high transaction costs, uncertainty related to long term, authorization constraints and technological challenges.

Provision of adequate information about spectrum use and characteristics are fundamental factors for this market formation.

Among others, information on public sector spectrum use, real time usage, interference and spectrum demand from current and potential users help interested parties in their decisions and increase sharing. In addition to this, spectrum trading and leasing may lead to more efficient spectrum usages. The essential factor here is that policy makers should use auctions in such a way to incentivize spectrum sharing and allow secondary market activities (Ofcom, 2016).

To reiterate, spectrum licensing and usage forms one of the most important subjects in 5G technology rollout and adoption. Policy makers should use all three types of licenses and their sub variants properly by taking into account other stakeholders' opinions to support any ecosystem. Above all other issues, this ecosystem should encourage investment and innovation, secure efficient spectrum usage and stimulate competition (ITU, 2018, p.26).

Role of government policy: Market formation in mobile telecom sector is heavily dependent on governments' decisions and regulations in this field. Above all other considerations, if there is no spectrum availability then there will be no 5G service at all. This basic proposition has several components to consider in a more detailed manner.

To start with, (amount of) spectrum fees may have a critical influence on spectrum demand and in later stages on the network investment processes of operators. Here, (pre)consultations with market actors may increase the efficiency of auction process in terms of license condition and fees, (Figure-3).

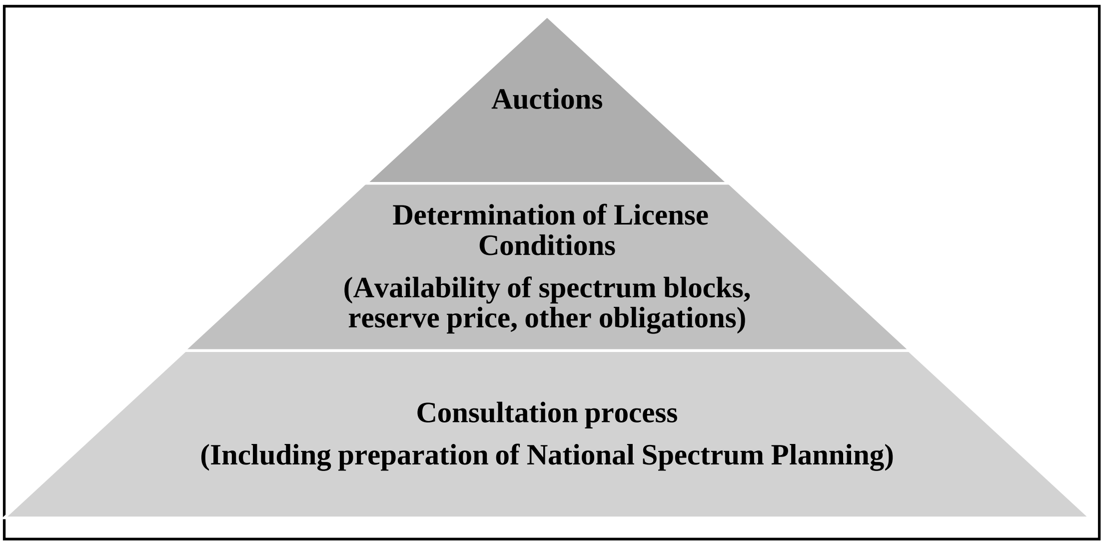

Figure 3-Steps in Market Formation

Source: GSMA (2019a), ITU (2018) and the author's contributions.

Sector experts recommend preparation of national spectrum planning beforehand to enable long term planning for operators. In determination of license conditions, they advocate setting of reserve prices and other administrative fees, leaving auction results to market mechanism, i.e., bidding process of participants (GSMA, 2019a, p.71). Many of the license conditions are actually similar to previous licenses (e.g., 3G and 4G) and this experience should help both sides in this one as well.

These terms contain length of licenses, coverage and quality of service obligations. After completion of spectrum allocation process, there comes a second stage (in a sense) in which network investments are made by related operators within a regulatory framework. Similar to the first stage, a balanced approach is necessary for a sustainable market development.

That is to say, regulatory framework should provide suitable (encouraging) environment for operators to undertake network investments in a cost-effective manner. In turn, this framework should also ensure completion of operators' obligations like coverage of certain areas on time, (Table-12).

Table 12-Main Issues in Market Formation and Workings

Main Topics	Summary notes
Preparation for auctions	Consultations with market actors Preparation of spectrum roadmap Availability of spectrum
Auction- License conditions and fees	Maximization of revenues compared to other network investment considerations (e.g., coverage, quality of service)
Deployment Process	Financial and institutional bottlenecks Higher number of base station installations Fiber infrastructure requirements Access and/or sharing of passive infrastructure, rights of way regulations Infrastructure asset database Health concerns of people
Provision of service	Monitoring compliance to license conditions (e.g., coverage of certain areas in a specified time period)

Source: GSMA (2019a), ITU (2018) and the author's additions.

Main topics in network investment process: 5G network deployment may cost four to six times higher than 4G network investments in a same area, depending on location features. In basic terms (Figure-4), network architecture of mobile telecom systems is similar and consist of radio access networks, core networks, backhaul and fronthaul components. Radio access networks (RAN) integrate user devices like mobile phones to other parts of the system by means of radio connections (Vodafone, n.d.).

It includes base stations (BBU), antennas and software-based interfaces (Sdx central, 2018a). In this context, one of the main differences between 5G and 4G is the widespread usage of miniature base stations called cells.

The number of required small cells are particularly high as compared to normal base stations to increase capacity and to meet low latency demands of usage applications in urban areas, (ACMA, 2019). Due to this need for dense adoption requirements, operators are sometimes facing with several problems in network deployment phase.

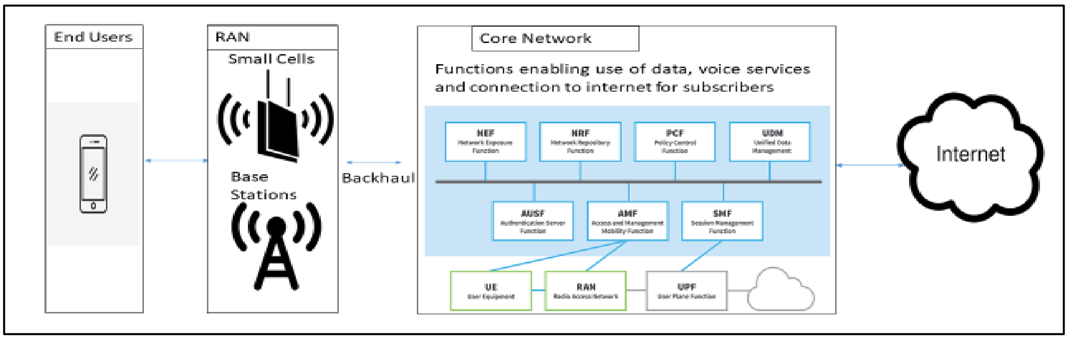

Figure 4-Basic Architecture Diagram of Mobile Telecom Network

Source: Peterson et al. (n.d.), (Ghayas, 2021)

Specific problems in small cell installations: Sector experts categorize investment process in several steps. The sequence starts with determination of investment plan and budget, which are internal procedures of operators. Second step is related to identification of suitable locations for this hardware (i.e., site survey). Then comes leasing & renting of selected locations for installation.

After this, operators need to get approvals from both regulatory and local (e.g., municipalities) authorities. Design and installation of these equipment form last step, along with recurring maintenance operations, (PwC, 2018).

In this regard, ITU (2018) points out lengthy periods of approval procedures and excessive fees required by public authorities, difficulties in using street furniture such as traffic lights in terms of procedural uncertainties and negative attitudes of people in terms of health concerns as (possible) specific obstacles, inhibiting pace of infrastructure roll out. Sector actors, in turn, urge simplification and acceleration of approval procedures, using of reasonable fees and clarification of procedures for the use of public places/facilities to reduce their investment costs and time delays. Apart from these, public authorities should incentivize voluntary network sharing agreements between operators.

While it is undoubtedly important, overcoming health concerns may be the least difficult obstacle among these problems.

That is to say, related organizations must provide easily accessible information to people about the safety rules in adoption of these network components. For instance, technical requirements (e.g., electromagnetic field limits) are determined by international organizations such as World Health Organization (WHO) and the use of these organizations’ statements in public documents may alleviate some of these concerns, (Public Health England, 2021). Notwithstanding to this, one can safely mention the fact that mobile devices become an inseparable part of peoples’ lives that widespread adoption of these technologies will be almost certain in all parts of the world in the near future and surpassing negative concerns to this technology.

Specific problems in backhaul/fronthaul connections: These two elements of 5G architecture connect end user or node to a major network but they are located in different parts of a total network. The former connects RAN to core network and the latter refers to a connection between baseband units and remote cell sites, (Zola & Bernstein, n.d.). As the transmission needs of networks are increasing tremendously in mobile telecommunications, fiber stands out as one of the most reliable technology that are used in these connections. Due to its capabilities for low latency and high transmission rates, experts recommend use of fiber connections in these parts, (ITU, 2018). Indeed, one can use ‘a chain is only as strong as its weakest link’ analogy to point out the importance of these backhaul transmission tools.

For this reason, governments have supported fiber investments and offered incentives to operators and infrastructure providers.

However, it may not be possible to deploy fiber in every part of a country and some other connections such as satellite, microwave and wireless technologies can be used in a complementary manner, (GSMA, 2019c).

Indeed, experts see insufficient fiber coverage as one of the crucial obstacles against rapid 5G deployment throughout any country.

For instance, Kaur (2021) points out a parliamentary report blaming Department of Telecommunications for delaying launch of 5G services until –planned date of- 2022 in India. Lack of widespread fiber coverage and higher costs of new investments[59] have been considered main reasons for this negative outcome (Kaur, 2021). As an example, (from a European country) UK has faced with difficulties in reaching

[59] It is stated that fiber coverage should be around 70% (instead of actual 30%) level and Indian operators need around 15.5 billion USD for these investments in the medium term (Kaur, 2021).

broadband targets[60] according to member of parliaments due to lack of funding and slow pace of fiber rollout in the country (BBC, 2020).

3.8 Evolutionary Nature of the Technology: 6G

As in most other technologies, mobile telecommunications are continuously subject to change that is summarized in ‘generation’ wording. Although 4G and especially 5G brings about previously unknown capabilities and use cases in different sectors, the technology will continue its evolution to enable even more advanced capabilities in the near future. Indeed, development works for the next step called 6G has already commenced by leading countries in this regard.

As one of these countries in the world (if not the leader) in this area, China has focused on 6G technology development along with the establishment of large scale 5G networks, (Yu & Yıran, 2021). Chinese public officials aim to commercialize 6G by 2030 and make action plans along with sector actors accordingly. To this end, they have prepared a White Paper called ‘6G Vision and Candidate Technologies’ to outline 6G vision, candidate technologies and usage applications among other related technical considerations, (IMT-2030-6G promotion group, 2021)[61].

Xuanmin and Xinyi (2021) give main application areas as *immersive cloud XR, holographic communication, sensory interconnection, intelligent interactive communication, digital twins, and global coverage.* For instance, holographic communication will bring tremendous changes in communications by also enabling haptic connections (e.g., by touch) as well as 3D dynamic integration. On the other hand, networks should provide above 100 Gbps transmission speeds along with ever increasing lower latency capabilities, (Dhar, 2021). As the other dominant country in the digital technology development race, stakeholders in USA ecosystem have also stepped up their efforts in this subject. In this regard, US House of Representatives has

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[60] UK government has planned to achieve 85% gigabit-capable broadband coverage (in terms of provision) by 2025. In that period, 18% of the country had access to full- fiber access services (BBC, 2020).

[61] The Ministry of Industry and Information Technology (MIIT) of China established IMT-2030 (6G) Promotion Group in June 2019. The organizational structure is based on the original IMT-2020 (5G) Promotion Group. The members include major Chinese operators, vendors, universities and research institutions. The promotion group is the main platform for gathering China's industry-university-research forces, promoting China's sixth generation mobile communication technology research and developing international views exchanges and cooperation.

passed a bill related to establishment of 6G Task Force by FCC (Federal Communications Commission) to lay out advancement and deployment of 6G technology in the country.

After the enactment of this legislation by the Senate, FCC has to prepare a report in one year's time. It is stated that task force will include members of all stakeholders from private sector (e.g., firms), public organizations (e.g., federal and local governments, related organizations), academic entities and non-governmental public organizations, (Castro, 2021a).

Apart from this initiative, private sector actors[62] have launched cooperative projects to work on network developments and sensing methods along with wireless machine learning technologies, (Donkin, 2021). Similarly, European Commission (EC)[63] has prepared a White Paper called "European Vision for the 6G Network Ecosystem".

EU policy makers think 6G will play an enabling role in the opening era of personal mobile robotics in 2030s. The paper envisages a world in which convergence will reach another level bringing digital, physical and personal dimensions together. It sets a timeline giving general dates for each development phase; 6G vision works until 2023, 6G requirements (determination, planning etc.) until 2027 and finally 6G evaluation (including testbeds & trials and products) until the end of 2030 leading to IMT-2030 standards. Accordingly, EU has allocated 95.1 million Euro for 6G related projects under Horizon 2020 program, (Castro, 2021b).

More recently, EC commenced first large-scale R&D program related to 6G amounting 240 million Euro initially. The name (of the program) is "Smart Networks and Services" and includes four different streams focusing on experimental networks, radical innovations, smart components and usage case trials, (EC, 2021a). By referring to this white paper, 5G IA Chairman of the Board (Mr. Colin Willcock) has emphasized the importance of establishing global standards and assert that industry will benefit from this in the end. Besides, he has pointed out two crucial objectives of 6G that should be achieved above other considerations. One is network resilience and

[62] Project partners include AT&T, Nvidia, Samsung America, Qualcomm, InterDigital and University of Texas as a research organization.
[63] Please note that EC can be seen as an executive branch of EU and for our purposes, these abbreviations are used in the same meaning, in general terms.

the other one is energy efficiency. Considering that everything will be dependent on the working of telecom networks, e.g., driverless cars, smart cities and unmanned (humanless) factories, any failure in future networks surely cause insurmountable problems for people in many aspects. On the other hand, it is evident that such a digitalized world will require enormous amount of energy and 6G technology has to solve this problem to a considerable extent, (Szporer, 2021). One can add a few countries like Japan and South Korea that are working on 6G but without going into more details, main point of the argument is that leading countries are all aiming to be at the forefront of this technology that will be ready (i.e., commercialization stage) by 2030s. At this point, patent (application) numbers of these countries can be useful for illuminating the current stage of this race.

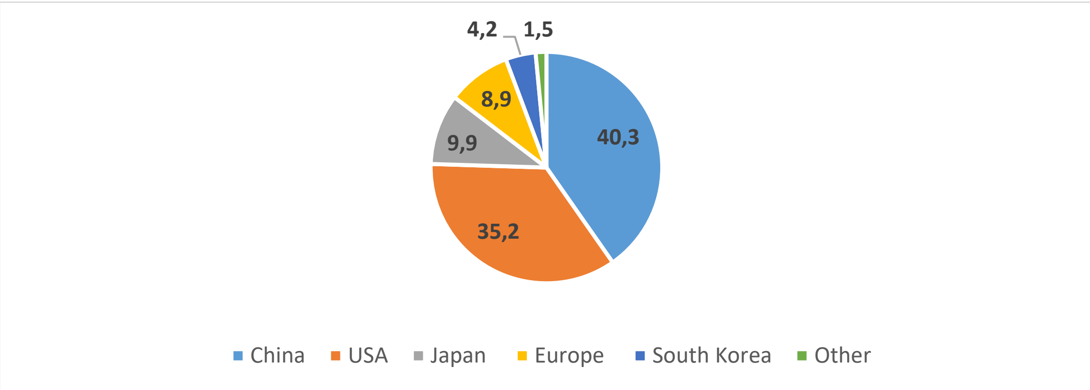

Figure 5- 6G Patent Applications (2021)

Source: (Chinadaily, 2021), via Nikkei Asia.

As Figure-5 shows, China occupies the first place with above 40% share, followed by USA owning nearly 35% of the total amount. Being much further behind, Japan and Europe have each nearly 10% shares, while South Korea has a 4,4% market share. Remaining 1,5%, which has been shared by others, clearly display the extent of other countries' backward positions in this competition[64].

Taking into account this fact, other countries, which plan to catch up with these leaders, should clearly accelerate their efforts in this technology race. Above all other issues, these policies are designed to ensure involvement and cooperation of stakeholders including firms, public organizations and research agencies, to name

[64] It is worth noting that Nikkei and Cyber Creative Institute examined nearly 20,000 patent applications in nine main 6G technologies such as communications, artificial intelligence quantum technology, and base stations to find out current picture, (Chinadaily, 2021).

some of them. At this point, systemic approaches to development programs should come to the fore because of their assumptions that variety of factors and elements influence working of whole structure (e.g., from single organizations to sectors) in question.

For this reason, the research will adopt innovation system understanding to analyze the study case at hand.

Before doing this, the study proceeds with general evaluation of these approaches followed by examination of studies and projects that have been made in different settings.

CHAPTER 4

4. INNOVATION SYSTEMS & TELECOM SECTOR ANALYSIS

4.1 Systems of Innovation Framework[65] in a Historical Context

This part starts with the brief discussion related to the emergence of this concept in a historical perspective. In line with evolutionary economic theory, historical development or simply history is an inseparable part of systemic analysis. That is to say, socioeconomic factors (changes) have contributed to the emergence and development of this new approach in the first place.

Lidén (2016, pp. 42-44) argues that the oil crises and following world economic problems contributed to emergence of system of innovation approaches beginning from early 1970s[66]. Linked to these factors, several countries faced with high inflation and unemployment (i.e., stagflation) during this and next decade, in general terms. In this period, several developing countries adopted different economic policies and growth strategies to address these global problems and to increase their economic growth rates. On the one side, there were economies including countries in South America, Africa that followed so called Washington Consensus[67] policies based on liberal-neoclassical reforms and on the other hand, countries mostly in South and East Asia devised and implemented country specific development policies with the exception that state intervention was one important similarity between them[68]. Another

[65] Please note that, concept, framework, approach is used in the same meaning and interchangeably in the text, e.g., IS framework or IS concept.
[66] In fact, the annual growth of world gross product had been at 5,3% before the oil crises of 1973, albeit after this event annual world growth reached only 2,8% for the rest of 1970s.
[67] This so called consensus includes ten reforms (advocated to every country); fiscal discipline, tax reform, privatization, liberalisation of FDI, property rights, competitive exchange rate, reordering public expenditure priorities, trade liberalization, liberalization of interest rates and deregulation, (Williamson, 2004).
[68] In numerical terms, the former country group averaged nearly between 1 to 2% growth rates as opposed to the latter group's average of approximately 7% growth rates between 1981 and 1990 (Iversen, 2017). According to Iversen, these successful growth rates of East Asian countries were largely due to state's role in leveraging markets to support development and implementation of national economic policies instead of -one size fits all- policy recommendations of the Washington Consensus.

important development starting from this era has been increasing role of knowledge and ICTs in economics, especially in developed countries and later in most of the developing countries. Indeed, leading academicians and scholars have started using the title ‘knowledge economy’ and later ‘digital economy’ to summarize the most distinct feature of the current economic structures. Although there is no single definition of these terms, what is common between them is the acknowledgement of the central role of knowledge and technology in economic growth (OECD, 1996, p. 3). For instance, Powell and Snellman (2004, p. 201) identify knowledge intensive processes as the dominant part of this economy in which these activities further lead to rapid scientific and technological progress while making prior practices and applications obsolete at the same time. Accordingly, intellectual capabilities rather than conventional inputs or raw materials form the most fundamental part of a knowledge economy definition.

Advancement in these capabilities effect every step of production process starting from research and development to customer relations and even after sale relationships in an integrated way. In addition to this, the weight of services in an economy (especially in developed country economies) have been continuously increasing at the expense of manufacturing activities since then.

However, even this distinction is starting to blur because of the widespread influence of digital transformation in today’s world. As pointed out in the 5G applications part, with the progress in ICT (especially with internet and mobile data communications), an automobile is no longer a factory assembly line product only and essential part of the value are starting to come from digital-automation services.

Within this context, it had become evident for academicians and policy makers that mainstream economic theories and frameworks (e.g., neoclassical economics) were not adequate to analyze new economic developments.

The importance and central role of technology and innovation policy in the knowledge economy necessitated a systemic analysis of this concept including the role of different actors, their interactions with each other and with external organizations. In fact, as a natural extension of evolutionary thinking (in particular Schumpeterian) academicians and policy makers have started to use the concept of innovation systems, since then.

Furthermore, in line with evolutionary thinking, one can say that innovation system (IS) approaches themselves have continued to evolve in both scope and scale to account for changing environment (e.g., technology, regional and cultural, organizational differences). It is sufficient to observe that different researchers have started to develop national, regional, sectoral and technological IS models. Lundvall (2015a, pp. 3-4), as one of the pioneers along with Freeman in this strand, considers IS research as a dynamic and evolving field adding new theoretical and empirical studies coming from different academic and policy-oriented areas.

Freeman (1982) started to analyze the role of innovations in economic development and international trade as electronics and ICT became main impetus of new economic cycle. In this regard, he went to Japan to observe the reasons for this country's economic success at the same period in which other developed countries experienced with stagnation in their economies[69]. Continuing his analysis, Freeman further

[69] Here, he observed the role of organizations, institutions and especially highlighted the Ministry of International Trade and Industry's (MITI) central position within an interconnected national innovation system. In his book related to these observations (Freeman, 1987), he used 'national innovation system' concept specifically for the first time in the literature (Edquist, 1997, p. 3). Freeman himself addressed Lundvall as the first person using this term although not in a formal (published) context and further pointed out List (Friedrich) as the originator of the idea by referencing his conception of 'The National System of Political Economy (1841)'. Written in the background of Germany's late-industrialization and catch-up efforts to England, List mainly highlighted the importance of learning and utilization of new technology in this (catch up) attempt. He foresaw the role of intangible capital and knowledge accumulation as well as other physical capital endowments in other early-industrialized countries, mainly Britain. According to him, importation of foreign technology only formed one of the initial steps in this process. Most important step was the national (in-house) adaptation and development of this technology under the coordination of state. Relevant and supporting educational infrastructure was also an essential part of this ecosystem (Freeman, 1995). In other words, one can say that what List advocated covers many aspects of future and more refined systems of innovation concept. Notwithstanding, it is natural that List's arguments would not cover all (later) changes in the world economy. Without going into a detailed historical analysis, Freeman has pointed out among the most important changes of the current era are increasing role of multinational companies and location of their R&D activities in different countries (other than home country) as well as rapidly expanding share of in-firm R&D activities in almost every industry. Upon analyzing different national system of innovations, he emphasized that success of any technology policy depends on systemic aspects of both firms' internal adoption (i.e., restructuring work organization etc.) as well as relations between other firms and related actors like suppliers, sub-contractors, in addition to formal R&D activities (Freeman, 1995). As a starting point, his analysis on Japanese case revealed the different phases of this country's technology development policy. In the first place, importation and imitation of foreign technology formed the necessary infrastructure upon which further national (indigenous) capability building became possible. Afterwards, the country gradually increased her spending in R&D, reaching high GERD/ GNP ratios of 2.5 % in 1970s. Although some other countries like former Soviet Union made similar or higher R&D expenditures, they could not compete with Japan in terms of productivity gains and diffusion of new technologies in commercial sectors. Even this observation showed that not only R&D commitment is sufficient to generate economic development and social welfare improvements of any country but also there exists many other qualitative factors determining the efficient functioning of national innovation systems.

compared East Asian countries (namely four dragons) with that of Latin American countries such as Brazil. In brief terms; establishment of widespread telecom infrastructure, emphasis on high quality education system, development of science-technology infrastructure and links with industry, continuous improvement of user-producer and subcontractor linkages and value-chain relations, diffusion of new technologies and focus on foreign markets (facing competition internationally) were among the distinct features of these four dragons (former group). It is important to note that these features are still valid for any country to establish a foothold in digitalization and aim to develop domestic (national) capability in ICT related industries.

Being a more recent phenomenon, accelerating pace of globalization and increasing role of multinational companies in the world economy starting from 1980s has continuing to affect almost every country and their industries. These developments have also led to different arguments on the (validity of) national innovation systems by academicians and policy makers. Shangquan (2000) defines economic globalization as an irreversible trend of widening interdependencies between countries due to rapidly increasing trade volume, flow of capital and diffusion of technologies, especially ICTs throughout the world. Furthermore, multinational corporations (MNC) by making foreign direct investment (FDI) and knowledge (technology) transfer are at the center of these processes, (Kleinert, 2001).

Having observed these trends, some authors claim that role of national states have becoming less and less important as opposed to increasing dominance of MNCs in the world economy. Among the most prominent of these thinkers, Ohmae (1995) uses the term ‘borderless world economy’ to emphasize the growing role of MNCs in this ecosystem. According to him, governments roles are reducing, leaving education of labor, protection of environment and provision of adequate social infrastructure as the main responsibilities for the national states in this interlinked global environment, (Kernan, 2013, p. 4).

In spite of these roles played by MNCs, it is evident that national states and their innovation systems are still crucial in the international arena for economic and social competitive advantage [70]. Before other considerations, data and communications

[70] Detailed analysis of the role and importance of MNCs in the world economy is beyond the scope of

infrastructure form the fundamental building blocks of a knowledge economy.

Accordingly, almost every state intends to control this (i.e., data transmission, analysis, security etc.) infrastructure by developing her own capability and/or by using technology from trusted partner countries' firms. Especially, technologically leading countries aim to maintain their central roles in the future mobile telecommunications, i.e., 5G and beyond. For instance, USA (government) are actively supporting her ICT companies at the expense of Chinese ones like Huawei.

This strategy stems from both economic and other security issues. Similarly, and even one-step further, Chinese government has recently declared a plan to prohibit the use of foreign ICT related hardware and software within three years' time, i.e., in 2022 (Lyons, 2019). Experts consider these actions as a struggle between these two countries over control of future technologies (Pham, 2019).

In addition to these factors, academicians still consider national and/or domestic peculiarities as crucial factors for different economic performances between countries. In this context, Porter (1990) gives priority to the quality of business environment as a whole for the successful economic development and competitiveness. According to his diamond model *factor conditions, demand conditions, related and supporting industries and firm strategy, structure- rivalry and their interactions* largely determine competitive advantage of a country's specific industry. Moreover, Lundvall (2015b) points out several factors such as bounded rationality, localized learning, path dependency, user-producer relations and untraded interdependencies, which are bringing differences in terms of economic growth, technological development and increase diversity in markets.

In short, it is clear that in an increasingly global world (economy), national (domestic) factors are still very important for the competitiveness of countries.

What is more crucial is that knowledge and data related capabilities (communication, storage, surveillance, analysis etc.) are determining the extent and success of digital

this work. What is important for the study purposes is the evaluation of these companies in the telecommunications ecosystem. One MNC's marketing strategies are examined in chapter 4.5.2.2. and some observations related to working of these companies are made in the case study part.

transformation of any country in current environment.

On top of it, digital security concerns are forcing each state to protect their telecom networks against intrusions by devising measures including efforts in using national and domestic hardware. In the light of these arguments, the study continues with analysis of IS (framework) in a more detailed manner.

4.2 Main Classifications of IS Framework

Referring to the previous discussion, theoretical basis for innovation system studies depends on different traditions and approaches. Malerba (2006) has indicated that after the early works (of Freeman, Lundvall and Nelson), industrial dynamics (i.e., market entry, survival and growth of companies) and sectoral system evolution studies have getting increasing attention since the early 1980s. The latter tradition has continued especially with the works of academicians like Edquist and Carlsson. These researchers have highlighted central role of knowledge, learning in the economy and the necessity of taking into account complex (interdependent) nature of innovation, historical perspective and interdisciplinary approach when analyzing economic systems. Encompassing a broader perspective, evolutionary theory provides the basic building blocks of different system of innovation approaches. In this framework, there is a special emphasis on process of transformation in a generalization (e.g., regional, sectoral etc.) under analysis. In other words, historical perspective or path dependence is important to understand an innovation system. Agents have bounded rationality; thus, they are incapable of making optimal decisions. Economic change can be explained by the concepts such as variety formation in technology, products, firms and organizations, replication which generates continuity in a system and selection which reduces variety and discourages the inefficient uses of resources. Furthermore, evolutionary perspective implies that there is no equilibrium (stability) due to dynamic nature of conditions and environment itself (Malerba, 2002).

Afterwards, academicians have developed different types of innovation system frameworks that are depending on the scope specifications and priorities. Coenen and Díaz López (2009, p. 10) classify these by indicating their handling of system boundaries, actors and networks, knowledge, dynamics, institutions and policy implications. The most common and popular ones are national, regional innovation systems based on geographical boundaries (limits) and sectoral, technological innovation systems based on used/ adopted technology (either single or multiple sectors) specifications [71]. Edquist (2001, p. 13) points out to the fact that these classifications do not contradict, rather complement with each other, making up the whole picture in different dimensions. In fact, they all emphasize the role of organizations, institutions and their interactions (in a historical perspective) in the relative performance levels of any IS under study.

In what follows, most commonly used IS types are discussed to shed more light in this topic.

The discussion covers national, regional levels in terms of geographical specification and sectoral, technological levels in terms of product/service specifications.

4.2.1 National Innovation Systems

Early IS studies focused more on broad generalizations whose scope covering national state boundaries. According to Edquist (1997, p.12), nation specific factors such as culture, language and institutional set-up lead to distinct IS and national innovation system approach (NIS) takes all these issues into account when studying and comparing country differences[72].

Lundvall (1992, p.2-15), on the other hand, specifically used "nation state" term in his definition of NIS. According to his definition, production and dissemination of

[71] There exists various other IS approaches in the literature, but for the research purposes, four variants are elaborated to set up the theoretical framework of the study. Among them, socio-technical system of innovation (STS) approach takes into account both technical (production, distribution, consumption) and social (relationships, conduct, and culture) aspects of innovation process. Geels (2004) maintain that including users in the analysis expands the boundary from sectoral systems to socio-technical ones. He further argues that this approach is more suitable for analysing long term dynamics, i.e., *transition from one socio-technical system to another and the co-evolution of technology and society.* (Geels, 2004)

[72] Indeed, in his first study, Freeman (1987) scrutinized the whole country setup (i.e., Japan) without making any regional and/or sectoral delimitation. Soete et.al. (2010, pp. 14-15) summarized main points of Freeman's analysis in four topics. In brief terms firstly, state organizations (government agencies) especially the Ministry of International Trade and Industry (MITI) were in the center of the innovation system (of the country) by prioritizing certain sectors and supporting their development to become competitive globally. Secondly, R&D activities of firms were important in assimilation of knowledge (initially outside, imported) and increasing their absorptive capacity. Thirdly, human capital and management practices of companies (e.g., just in time production) increased the innovative performance of the critical sectors. Lastly, conglomerate structure of domestic industries helped these companies to implement innovative supply chain solutions, bringing more efficiency and productivity improvements.

knowledge rooted within the geographical boundaries of any state plays a central role in functioning of the whole system.

Relatedly, three main blocks under the umbrella of a nation state form NIS. These are sources of innovation (e.g., learning, exploration), types of innovation (e.g., radical, incremental) and non-market institutions (e.g., user-producer interactions). Nelson (1993) used a national framework to make comparative analysis between countries (national states) and found important differences in various aspects ranging from institutional set-up, work organization and role of public sector to name a few[73].

In a similar manner, stressing the importance of this type of IS analysis, Edquist (1997) recalled the fact that even similar countries (in terms of culture, lifestyle etc.) like Denmark and Sweden has different systemic characteristics and innovation performance in different sectors.

Moreover, public policies affecting the performance of industries mostly devised and put into force at the macro level and a central government organization (e.g., Ministries, State Planning Organizations) has been responsible for policy coordination between related actors. Based on these initial contributions, NIS further developed by other researchers in various dimensions[74]. Teixeira (2014) also points out widespread usage of this approach in both academic and public policy fields in recent decades. Indeed, policy makers and public agencies have adopted this framework to analyze and identify weaknesses in their innovation systems. For instance, OECD uses this approach in several policy papers, indicating the importance of knowledge flows and interaction between relevant actors in the innovative performance of countries, in addition to more classical (conventional) indicators like R&D expenditures[75].

In a similar manner, EC has supported projects on national innovation systems and European integration related to economic development. One of the main conclusions

[73] According to Schrempf et.al. (2013, p. 6), Nelson especially emphasized the role of national organizations-institutions operating in the science and technology related areas like universities and R&D centers.
[74] Starting from initial case studies, sources of innovation, institutions, interactive learning, networks and social capital has become main elements of analysis in later researches, (Schrempf, 2013, p.7-8). Martin and Bell (2011) underline the fact that this strand of research has come into being as one of the most influential concepts in the subject of innovation studies since nearly past three decades.
[75] E.g., OECD (1997), *"National Innovation Systems"*, OECD (1999), *"Managing National Innovation Systems"* and OECD (2002), *"Dynamizing National Innovation Systems"*.

of these studies is that innovation policies like developing knowledge infrastructure and public technology procurement activities have different effects on each member country owing to several (country specific) factors such as varied institutional set-up and specialization patterns, (EC Project Information , 1996)[76].

In spite of its usefulness in comparing national differences, some experts argue against adopting NIS framework due to generalization of different sectoral characteristics and global changes throughout the world. In this context, Nelson and Rosenberg (1993, p. 5) explain that every industry has different structure (e.g., requirements and weaknesses) and needs specific institutional set ups for increasing innovative performance of sectoral systems. Besides, there are multinational corporations (MNCs) in some sectors like ICT and aircraft, limiting the effectiveness of country (national) level policies. Accordingly, governments may not have total control in the national boundaries, even though they think otherwise. Here, Lundvall (2007) points to the fact that a NIS or regional approach should take into account the effect and role of globalization in the working of any innovation system.

This is especially relevant for this thesis case study (i.e., telecommunications sector in a developing country) where factors such as technology adoption including licensing, outsourcing, reverse engineering and international collaborations all needs to be considered in implementing innovation policies[77].

At this point, Cowan and Van de Paal (2000a) assert that firms are becoming more global in terms of knowledge diffusion because of new ICT technologies. As the

[76] Likewise, Verspagen et al. (2018, p. 26) have found that innovation system characteristics in EU vary between member countries. According to their research, some countries have innovation systems that are developing relative to few states that have more advanced systems. Countries such as Germany, UK and Finland are in the ‘strongly geared towards science- based innovation category’ whereas Poland, Hungary and Bulgaria lie in the ‘weak category’. These findings demonstrate the need for case-by-case approach (even in EU where there is relatively some degree of integration between countries compared to other parts of the world) in devising innovation policy frameworks, since there is no ‘optimal innovation system’ and no ‘one fits all solution’ to each country.

[77] In a similar manner, Soete et al. (2010, p.27-28) see globalization as a factor that are restricting the effectiveness of boundary limited (i.e., national) policymaking capability of governments. According to their arguments, increasing mobility of knowledge flows especially represent crucial problems for domestic innovation policies devised without taking into consideration changes in the global environment. It should be emphasized that this perspective is a prerequisite in today’s world economy whether the scope (or boundary selection) based on national, regional or sectoral basis. More interestingly, widespread adoption of internet and advanced mobile communications (both networks and supporting devices) have further accelerated these interactions and the diffusion of knowledge throughout the world.

service economy gains more share as opposed to classic manufacturing industries in the world economy, firms are also giving more priority to exploiting existing knowledge stock. In this diffusion process, they also underline the key role of ICT infrastructure, especially widespread and high-speed capacity internet infrastructure. What is more crucial is that growing demand and increasing requirements of new applications (e.g., high speed and low latency) necessitate further investments and upgrade of this infrastructure. That is to say, globalization and advancements in ICT may limit the effectiveness of national policies but at the same time provide opportunities for countries (governments, firms etc. all over the world). In sum, it is certain that ICT adoption, usage and availability of telecommunications networks are among the prerequisites of any economic development irrespective of national, regional or sectoral basis in today's knowledge economy.

These developments have in turn affected innovation system concepts and lead to both proliferation and modifications of these approaches. In any case, while these all stem from NIS and share similar structures (e.g., institutions, activities, relevant actors etc.), they mainly differ in terms of boundary or scope (i.e., regional or sectoral, technological) selection.

4.2.2 Regional Innovation Systems

Although some policies devised and/or implemented in the whole country (national level), it is no doubt that there exist many differences between specific regions of even developed countries. These regions in a country may have distinct economic, social and cultural endowments and/or characteristics. In other words, some regions show more homogeneous characteristics and territorial agglomeration may occur because of local advantages such as availability of qualified human capital, related technology, infrastructure and interactions between these production factors.

As innovation forms fundamental part of economic development, because of localized advantages some of these regions display more innovative capability even in todays' globalized environment. Connected to this, region specific analysis focuses on the interaction between innovation, economic performance and locational factors.

Here, D'Allura, et al. (2012, pp. 139-140) observed that both academicians and policy makers have increasingly adopted this framework to address (some of the) weaknesses of NSI. According to them, researchers in this field think that territorial agglomerations ensure optimal settings for global economy where innovation is at the center due to geographically based knowledge flows and interactive learning processes.

In a similar manner, Doloreux and Parto (2004, p.2) link the increasing popularity of regional innovation systems (RIS) to the distinct innovative (and of course economic) performance of certain regions across the world. For instance, among others, Silicon Valley is the most widely known region for innovative potential and more critically, what the related studies indicate is one of the most difficult to replicate in other parts of the world. One can claim that even this observation is helpful to policy makers apart from other benefits of RIS analysis. In other words, simply copying visible or easily observable parts of any RIS and neglecting others such as institutional, social and cultural background may not lead to comparable performances in another part of even the same country. In the light of these observations, Saxenian (1994) compared two different regions of same country, Silicon Valley (California) and Route 128 (Boston) in USA. Without going into detail, it is illustrative to observe different development paths and innovative performance of these regions, starting from similar resource endowments and infrastructures in the same country. Of course, there are several reasons for this outcome. Apart from more easily observable (or quantifiable) factors, the writer considers business culture of Silicon Valley, which is open to quick adoption of innovation and collaborations between entrepreneurs to exploit new business opportunities, has further strengthened advantages of the region.

Although RIS has a more specific regional scope, this delimitation usually corresponds to sectoral specifications (e.g., ICT in Silicon Valley) in actual terms. Gertler (2003) underscores the importance of interactions between relevant actors to support innovative performance of any region.

Relatedly, Doloreux and Parto (2004, pp. 3-4) characterize RIS as a collaboration in innovation efforts between firms and other organizations such as universities, technology offices that have knowledge production, diffusion roles in a specific region. Like Saxenian and Gertler, they also consider innovation-supportive culture in a region as a prerequisite for the evolution of firms and ecosystem in a sustainable development context.

One advantage of this regional delimitation and focus lies in the easier identification of critical relations in this more closed system as opposed to NIS approach that encompass whole country, (Cooke, 1998, p. 3). Hence, both increasing importance of regions in the world economy and more manageable systemic analysis opportunity has brought increasing number of studies in this field[78].

In sum, NIS and RIS approaches have several common characteristics and precise distinction between these two systems is very difficult- if not impossible in some cases and in actual terms, NIS may comprise RIS as a subset[79] (Doloreux, 2002).

Accordingly, it is evident that most of the problematic (i.e., weak) areas of the former one is common to RIS[80].

4.2.3 Sectoral Innovation Systems

Apart from the above-mentioned spatial approaches, academicians (researchers) employ two other main concepts, namely sectoral and technological systems of innovation.

As indicated previously, although all these approaches have some differences in terms of methodology and objectives, they also have interdependencies and share common terminology to a considerable extent.

Indeed, Edquist (1997, p.12) maintain that these approaches do not exclude but complement each other and selection of one may be appropriate for the object of

[78] Although differing from each other in several ways such as methodology and emphasis, they all focus on systemic aspects (key actors, their interactions, business culture etc.) of innovative performance in a territorial setting. Among them, one can indicate regional innovation systems (e.g., Cooke 2004, Doloreux 2003), learning region (e.g., Florida 1995), regional clustering (e.g., Porter 1990), innovative milieu (e.g., Gremi group 1980s), industrial district (e.g., Marshall 1920s, Becattini 1970s) technopole analysis (e.g., Scott 1988) as closely related studies. Within RSI, there are also different typologies developed by several researchers.

[79] As indicated previously, although all IS frameworks have common characteristics, they differ in several aspects. Furthermore, in many cases, RIS has a dominant technology and/or sector and in this respect some of comments made in this part are also applicable to SIS/TIS approaches.

[80] Most importantly, as Edquist (2005) asserts IS approaches (irrespective of different frameworks) are subject to *conceptual diffuseness*. To start with, one can find several definitions (sometimes conflicting) of main terms used such as institutions, innovation and region. For instance, some scholars define institutions as rules of game, whereas others see them as different kinds of organizations. In addition to this, some researchers prioritize the view that innovation is either incremental or radical, on the other hand there exists other approaches that emphasize innovation is the outcome of learning by the firms that change their production processes, scales etc. to stay competitive in today's globalized world economy. Furthermore, boundaries are not specified in advance (a priori) in both approaches. That is to say, the problem is how to identify an RIS in practice. More specifically, Doloreux and Parto (2005) assert that the most crucial problem in this area is the lack of clear guides to determine the existence of a RIS in a specified place. Similarly, Edquist (2005) indicate that the distinction between what is inside and outside of a system is crucial and it is necessary to specify the boundaries if one wants to conduct empirical studies in this field.

particular analysis in the hand.

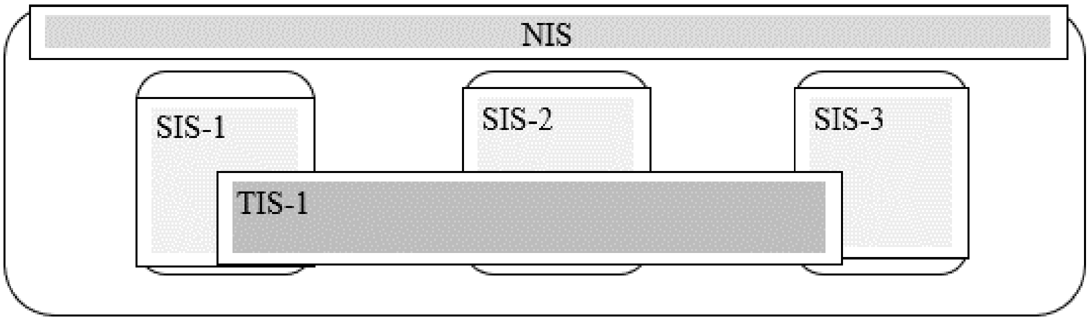

Figure 6- Domain of Innovation Systems

To begin with, as the above Figure- 6 implies, Schrempf et al. (2013, p. 16-17) present sectoral innovation (SIS) and technological innovation systems (TIS) as either adopting a particular technology covering several sectors or a sector adopting various technologies[81]. Bresci and Malerba (1997) have emphasized “sectoral boundary” to specify a system in which a group of firms making a sector’s products by also adopting and developing related technologies. In a more detailed way,

Malerba (2004) defines SIS as *a “set of new and established products for specific uses, and a set of agents carrying out activities and market & non-market interactions for the design, production and sale of those products”.*

From this definition, it is apparent that a geographical and/or technology delimitation is not necessary for SIS scope setting. In other words, a product or product group such as automotive may define the boundary, (Malerba, 2004, p.10)[82]. Besides this, Malerba (2004) puts SIS framework on three principal dimensions: ‘actors and networks’, ‘institutions’, ‘knowledge and technological domain’. As in other IS approaches, there

[81] According to the authors, Pavitt (1984) put forward the idea that each sector has its own technological development path (i.e., trajectory). Pavitt’s classification consists of four main categories. In the *supplier-dominated sectors* like clothing and agriculture, firms depend on outside sectors to introduce novelty in their processes. *Specialized suppliers* such as producers of special machinery form the second category. Third category belongs to *scale intensive sectors* like automotive where innovation comes from both in-house and outside sources. Last category comprises of science- based high technology like electronics and pharmaceuticals where companies have competitive advantages in the form of tacit knowledge and patent protection etc.

[82] A SIS analysis can be made in different product aggregations like putting computer hardware/software together or narrowing the scope to only software part. In line with this this logic, for instance it may even be appropriate to restrict this scope further to ‘gaming software’ depending on the object of the study. This is also valid for the (our) case study in that telecommunications sector comprises various sub sectors ranging from telecom services to telecom hardware equipment and with increasing digitalization, several new areas such as media-entertainment services.

are numerous actors beginning with firms, non-firm entities (e.g., financial organizations), public organizations, industry or sector associations, voluntary groups and individual customers, users. In this category, individuals like scientists, entrepreneurs play roles to perform various functions. Furthermore, these agents have all their histories (i.e., path dependency) and their actions both depend (constrained) on these experiences and institutions such as rules and regulations. SIS takes into account non- firm organizations and all the interactions of related actors as opposed to other traditional approaches (in the industrial economics literature) in which only one actor (business firm) exists, and even interactions within this entity are ignored to treat it like a black box. Notwithstanding to this, Malerba (2004, p.24) puts firms as main actors in SIS framework. Surrounded by other actors, their importance stem from generation, adoption and use of new technologies. Moreover, they continuously participate in learning and knowledge gathering processes. The assumption that other actors in supporting or secondary roles does not mean that they are unimportant; it is only due to their indirect involvement in the production process. However, these actors may assume key roles depending on the context. For example, universities and other science related organizations' roles are fundamental in emerging technologies according to Coenen and Lopez (2008, p. 10). Even in such cases, firms' part is undeniable, taking into account the fact that innovation is not considered successful unless accompanied by marketing value, especially in the later stages of product/service development cycle. In any case, interactions between all actors (i.e., networking) are essential for learning processes that lead to various gains for the sector as a whole. Pittaway et al. (2004) find some of the benefits as risk sharing, reaching new markets and external knowledge, accelerating marketing of new products, pooling competencies and giving more protection to property rights.

Networks refer to the market and non-market relationships between firms (other actors as well) within any sectoral system. In uncertain and changing environment, formal as well as informal networks emerge because agents are different and so networks integrate complementarities in knowledge, capabilities and specialization. These relationships are a source of innovation.

Instead of an aggregate set of similar buyers, demand seen as composed of heterogeneous agents that interact in various ways with producers. SIS approach emphasizes both formal and informal networks facilitating transfer of tacit knowledge, leading to more innovative performance of a system's actors. In telecommunications sector, user-producer relations and linkages are also essential for the functioning of an ecosystem. Especially in the hardware part, telecom operators are customers of global equipment providers and any innovation system analysis should take into consideration user-producer relations.

As another cornerstone of SIS framework, institutions include norms, routines, common habits, established practices, rules, laws, standards and contracts, to name some of them. Ranging from formal and binding (e.g., laws) to informal ones (e.g., traditions), they shape each actor's actions and interactions between themselves. Institutions can be general (i.e., applicable to all sectors in a country level) and/or specific such as sectoral regulations like licensing and tariff controls (Malerba, 2006b, p. 385). National and/or international institutions (e.g., WTO agreements) may have different effects on each sector. It is even possible that some sector actors can shape these institutions to their favor (e.g., lobbying), indicating two-way interactions.

Knowledge and technological domain as a last building block, defines boundaries of the system (which is the sector under study) and at the same time, are in the study list of any IS analysis, Schrempf et.al (2013, p.17). SIS approach sees knowledge integrated within technologies as a major source of innovation and learning as a prerequisite for this activity, (Coenen and Lopez, 2008, p.15). Knowledge does not diffuse automatically among firms. Firms have to absorb knowledge through differential abilities accumulated over time. Knowledge and learning come from both firm's own capability (internal) and from external partners. In today's competitive business environment, although the importance of transferring external knowledge is increasing due to higher cost and complexity (as well as requiring interdisciplinary approach) of developing new technologies, both internal and external sources are complementary and firms should develop each one without neglecting another. These sources and learning may lead to changes in knowledge base of any sector. In some cases, different technologies compete and a dominant design may prevail in any sector until another innovation comes into stage, disrupting the status quo, (Abernathy & Utterback, 1978). Dominant design provides competitive advantages for the developer firms and may even lead to (in both domestic and international) market dominance.

There are various factors for the emergence of this phenomenon. For example, technology competition, marketing strategies, vendor and standard setting activities may all result in this outcome (Pelkey, 1988). This is especially relevant for telecommunications sector where global equipment vendor firms compete with each other to capture international markets.

Closely related to market formation and learning capabilities of firms in a sector, SIS proposes key roles to public policy. Schrempf et.al (2013, p.19) advocates a mission for government organizations to promote transformation in related sectors by being a lead user for new technologies. This entails, other than tax and financial incentives, mainly public procurement policies and usage of sectors' products in public organizations. Public actors as users of technology can induce innovations either by building more stable incentives for firms or by forcing them to be more innovative in unstable circumstances. In some countries like Finland and Sweden, public telecom operators supported innovative activities in their sectors by taking risks of developing new telecom technologies in their sectors, where private firms could not undertake these research and development costs, e.g., Palmberg (2002).

4.2.4 Technological Innovation Systems

Technological Innovation System (TIS) approach came into stage as a result of a research related to Sweden's technological system undertaken by B. Carlsson in 1987[83]. Afterwards, related to this project's outcome, Carlsson and Stankiewicz (1991) constructed the basic framework of TIS. In their views, technological systems determine the extent of a country's economic development and TIS can be used to evaluate main functions of a system with the objective of eliminating barriers (to innovation) by devising specific innovation policies. They consider TIS as a network of actors engaged in development, adoption and dissemination of technology within a specific industrial domain surrounded by specific institutional infrastructure. Instead of conventional analysis in terms of physical goods and services, TIS deals with

[83] As the full name of the project *"Sweden's Technological System and Future Development Potential"* implies, this study initially intended to cover national system as a whole. However, after the observation that there were several different technologies in each sector, the 'System' word changed to 'Systems' in the project title (Carlsson B. , 1995). In fact, Hekkert et al. (2007, pp. 416-417) consider SIS as a cluster of different but interconnected technologies, in a sense covering various TIS, each focusing on specific set of technology.

knowledge or competence flows, in turn forming dynamic networks. An entrepreneurial action and/or establishment of critical mass may further lead to clusters of firms and technologies. In a more recent definition, Markard and Truffer (2008) present TIS comprising a group of networks that cooperate in a particular technology domain and by doing so, taking part in the production, adoption, dissemination and commercialization of related technology, including its different variants and connected products.

From these definitions, it is apparent that actors, networks and institutions are the principal components of TIS, very much like other innovation system approaches. Although territorial focus is not the main aim of TIS, this kind of system may have regional, national and/or international coverage and may include several sectors that adopt similar technology base. Indeed, the number of technologies that have several uses in different sectors are proliferating in todays' increasingly digitalized ICT environment. Among others, Artificial Intelligence (AI) has several uses ranging from less technology intensive sectors like agriculture to high technology areas like medical diagnosis. In a similar way to SIS, TIS sees formal and informal networks, by which cooperation and interaction between actors take place, essential for the efficient functioning of innovation system. In particular, user-producer linkages and value chain relations regarded as major sources of novelty by Coenen and Lopez (2008, pp.11-12).

Although these two approaches are similar in terms of these basic components, there exists various different points and focus areas between them. To start with, Suurs (2009, pp. 38-42) asserts that TIS prioritizes commercialization of technological innovations as new business opportunities and sees knowledge production and exchange as a supporting function of the main objective.

This emphasis on exploitation of innovations and entrepreneurship inevitably necessitates a detailed examination of system dynamics. With this focus on system dynamics, TIS can provide more suitable framework for studying emerging technologies and related market development stages, i.e., introduction, growth, maturity and decline.

As a matter of fact, various researchers question the static perspective of SIS and instead adopt TIS to analyse development of specific technology related sectors due to its focus on system dynamics. For instance, Hekkert et al. (2007) advocate a dynamic IS approach to figure out technological (and related market) change which is also a continuous process.

In doing so, they have developed a set of functions to capture changes in a specific TIS. '*Entrepreneurial experimentations', 'knowledge production', 'knowledge exchange and dissemination', 'influence on the direction of search', 'market formation', 'resource mobilization' and 'establishment of legitimacy, prevention of resistance to change'* form these seven main functions of their analysis[84].

4.2.5 Commonalities, Strengths and Weaknesses

Before concluding this general discussion on types of innovation system approaches, it may be suitable to summarize (i.e., restate) some of the commonalities, strengths and weaknesses of these models. To start with, even this brief analysis shows an ongoing evolution of IS research approximately since its inception and one can assume this process will continue to provide new insights for current and future developments, problems and challenges[85]. Academicians and policy makers both have extensively adopted IS framework, making it not only a subject of academic study but also a (sectoral, technological) public policy development plan for practical implementation (Lindner, et al., 2016). There are several reasons for this increasing and widespread usage (as opposed to neo-classical policy frameworks discussed earlier) throughout the world and Edquist (2005) classifies these as strengths of IS approach in six topics. Most importantly, IS approach considers learning and knowledge (i.e., production, dissemination, exchange and new combinations) as decisive factors increasing innovative performance, which is also exogenous, of any system (whether regional, sectoral or technological) under analysis. Although no one can deny the role of knowledge in any era, today this importance has reached to a new status and experts define new system as knowledge- driven economy. A report on innovation policy by EU Commission emphasized this by recommending a *change in terminology from "knowledge-based economy" to "knowledge-driven economy",* (Cowan & Paal,

[84] These functions will be evaluated separately in the following part.
[85] Here, one can immediately think about the latest Covid-19 pandemic throughout the world. This pandemic disease will not only effect human health but also may lead to changes in the world economic order and value chain relations in the near future.

2000b, p. 2). That is to say, knowledge has become a driver in today's economy due to developments mainly in ICT. These technologies not only increase the amount of knowledge gathering and diffusion but also raise the connectivity between everyone, including machines to machines, drastically. Moreover, this process turns knowledge in to commodity, further increasing its value. Connectedly, knowledge permeates virtually all sectors whether it is low or high tech and is changing the fundamental production processes. Considering these facts, it is no doubt that IS approaches- due to their ecosystem considerations- will continue to attract (more) attention and (more) widely used by researchers in different sectors. In turn, IS framework requires an interdisciplinary perspective ranging from economics to sociology and technical subjects. Besides, as a holistic approach, it encompasses broad variety of variables driving innovation and enables the incorporation of different political, cultural and organizational factors.

Adoption of historical and evolutionary thinking inherent in IS presents another advantage of this model to understand the role of institutions and politics in this context, according to Fabergerg et al. (2009, p. 24). This combination strengthens IS framework suitability to analyse complex nature of innovation processes.

In addition to these specialities, IS approach covers not only technological type of innovation but also other types such as service, organizational and inclusive ones. As mentioned before, this is especially relevant in today's economic sectors where service economy's role has expanded considerably and innovations consist of more than one type (i.e., novelties in a combination of product/process and service innovations) in many cases.

Equally important, innovation is mostly not a linear process and many actors interact until the outcome (i.e., product, service, process or organizational) has an economical value (addition). Indeed, as Kline and Rosenberg (2009) emphasize, *innovation is complex, uncertain, somewhat disorderly, and subject to changes of many sorts.*

Exploration of this non-linearity and interdependence between actors are one of the main objectives of IS approaches, i.e., networks and functions. Lastly, this type of analyses considers institutions as rules of a game, which determines incentives and obligations of related sector actors. Institutions influence industries' development and telecommunications is one of them. In fact, both service and equipment production sub-sectors face with numerous regulations (i.e., institutions) from network installation to quality of standard requirements. These institutions have substantial effects on all sector players from producers, service providers to consumers, as well.

On the other hand, as Edquist (2001) indicates, there also exists some weak spots of IS approaches.[86] As argued, each IS approach consist of organizations, institutions and networks in general terms. Nevertheless, ex-ante decisions by researchers (i.e., judgements) form the boundaries and core components of all IS models. Edquist (2005) sees this as a conceptual diffuseness and a weakness of IS approach. On the contrary, Lundvall (1992) prefers a flexible approach in the system definition. Here, one can argue that flexibility is a necessity of dynamic analysis in line with evolutionary theory. At the same time, however, this lack of uniformity in several areas makes comparative studies difficult in practice. Apart from system boundaries, organizations and institutions may indicate different concepts in various articles and research projects. In this subject, Edquist (2001, p.5) gives examples from Nelson and Rosenberg's (1993) usage of institutions meaning organizations, whereas in Lundvall's (1992) terminology, they mean rules of the game.

Edquist (2005) continues to indicate innovation systems (or system of innovations) as an approach or conceptual framework rather than a formal theory, owing to this conceptual diffuseness and lack of general empirical regularities. In spite of this argument, he further adds that there is also no consensus among academicians on whether this concept should be over-theorized or under-theorized.

4.3 System Understanding and Framework of IS Research

As a starting point, it can be said that one use 'system' word to emphasize efficient way of achieving something. Accordingly, system is normally used with other words such as business systems, IT systems or decision- making systems to specify the context.

In fact, there are many definitions of this word, because of the wide range of uses in

[86] Edquist uses the term 'weaknesses' to indicate topics which requires further research.

different fields from biology, technology to business and economics. For instance, one definition identifies system as '*a group of devices or artificial objects or an organization forming a network especially for distributing something or serving a common purpose'*. In another, '*a regularly interacting or interdependent group of items forming a unified whole'* is given for definition of this subject (Merriam-Webster dictionary, n.d.).

Amongst them, it may be sufficient to refer Boulding's (2009, p. 9) resemblance of system as anything that is not chaos, to highlight the widespread usage of this term. In line with these delineations, Lundvall (2010, p. 2) identifies IS as a social system that is composed of elements and relationships.

These elements cooperate in the generation, dissemination and utilization of economically useful new knowledge. Constituents of IS interact with each other, generating either positive or negative effects for development or decline of a system.

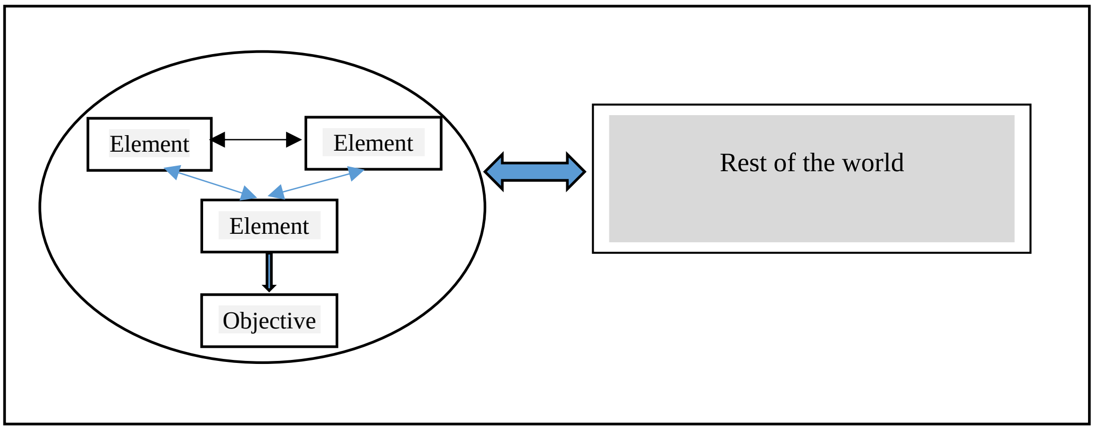

Figure 7- System Description

In a similar manner, Edquist (2005) resembles IS to general system in which there exists components and their relations, (Figure-7).

Moreover, a system has an overall function and own boundaries apart from the outer world.

This does not mean that, a relationship and/or interaction does not exist with outside of a system. Liden (2016, p.80) mentions two main traditions of system theory; one is focusing on the relation between whole and its parts and the other one is concentrating on the relation between system and environment. In the system definition, main problems occur in the specification of all these components and their relations between each other, together with boundary delimitation.

According to Luhmann (1995, p. 2), ‘system’ is used as an umbrella term in socio-economic studies and may refer to different level of analysis, generating ambiguity and confusion.

However, Edquist (2005) insist on the fact that it is both unrealistic and unnecessary to attempt such an undertaking in an innovation policy framework.

Instead, he proposes identification and analysis of main components, their interactions and functions for making observations and inferences about relations between specific variables in IS to enrich the subject of innovation studies.

In sum, a systematic framework is an appropriate method to research innovation in terms of economic effects, especially taking into account essential role of market and non-market interactions (e.g., role of culture) in this process.

Thus, an IS framework should specify system components (including boundary), analyse relationships between these components and identify competencies and functions of these components (Carlsson B. , 2007, pp. 4-5).

4.3.1 Elements of Innovation Systems Framework

This part deals with main components of a system, namely organizations, institutions and interactions between these system elements in a more detailed manner.

4.3.1.1 Organizations and Institutions

To begin with, organizations and institutions are the fundamental building blocks of IS. In all different types of IS models, it is not wrong to say that identification of these two form essential steps of analysis (after boundary selection, of course).

On the contrary, what is problematic is their definition and ambiguous use in practice.

This ambiguity and definitional problems are not confined to IS literature and there exists debates in different disciplines including sociology and organizational studies.

For instance, Parto (2005, p. 7) gives fourteen different definitions of 'institution' concept in different contexts.

Some academicians prefer to make broad definitions of these terms by putting them together in one basket.

Patel and Pavitt (1994) describe institutional structure of a specific set (i.e., national, regional or sectoral) consisting of *companies, universities, research and training organizations, norms, routines, networks, financial organizations, and the policy of promoting and regulating technical change.* While, Carlsson and Stankiewitcz (1991) use institutional infrastructure to refer a group of regimes and organizations at the same time. This broad group includes such concepts as political and educational system, patent legislation, and institutions that can shape innovation, development, transfer and application of technologies.

On the other hand, several other scholars point out the necessity for clarification and prefer separate definitions (categorizations). Most prominently, Edquist (2001, 2005), Edquist and Johnson (1997, pp. 46-50) make distinct classifications to bring more clarification to the terms used in IS framework. Accordingly, they define institutions as *sets of common habits, routines, established practices, rules or laws that regulate the relations and interactions between individuals and groups* while organizations mean *formal structures with an explicit purpose.* In other words, players or actors[87] that are intentionally set up with an explicit objective constitute organizations in this model. It is evident that there can be numerous players in any system including firms, universities, vocational schools, regulatory agencies, ministries, local governments, to name only a few of them. Moreover, the importance and effectiveness of these organizations differ in each IS, which is under study. Galli and Teubal (1997, p. 346) indicate the effect of technological revolution since 1970s for the changing characteristics (and number) of organizations and the influence of specific factors like cultural-sociological background, traditions and resource endowments on the organizational structure of each system.

Following this argument, they categorize organizations in a more detailed manner. Political bodies include national councils for science and technology policies,

[87] There are some other words used for organizations such as shareholders, agents, agencies and bodies.

bureaucratic bodies such as public offices for R&D, social bodies like industry associations, educational bodies containing universities, regulatory bodies for different sectors like telecommunications and general ones like competition authorities.

Continuing this, knowledge- oriented bodies without economic objectives such as public health laboratories, non-profit entities with economic aims like technical centres of sectoral associations, bridging bodies like innovation centres and most importantly commercial enterprises ranging from start-ups to joint ventures and R&D companies make up their long list of organization categories. They consider institutions as formal constraints like patent regulation, safety standards and informal ones including conventions and traditions, among others. North (1990) also see institutions as limitations that people impose on themselves, formal ones including contracts, constitutions and informal ones like moral values, beliefs. Similar to formal-informal classification, Woolthuis et al. (2005, pp. 613-614) make hard-soft institutional separations in their categorizations. Hard institutions like laws are compulsory in the sense that there is a penalty for violation of their terms and conditions. Conversely, soft institutions such as traditions and code of conduct are not legally binding in most cases. This does not mean that they are unimportant and indeed, they play key roles in various stages of innovation process.

For instance, level of entrepreneurial culture and risk-taking attitude of a society has an influence on the innovativeness of specific sector, region or country.

In short, Edquist (2006) by referring to North (1990) summarize this topic by stating *rules of the game* as institutions and *players in the game* as organizations. In this context, one can point out to the fact that in some cases there exists one to one correspondence between institutions and organizations in any system environment. As an example, telecom sectoral regulators are responsible for this market regulation.

However, some other organizations may have partly overlapping roles and this may lead to regulatory (i.e., institutional) confusion in (sector) actors as well. Apart from this, relationships between organizations and institutions occur in several different ways.

There exists complicated mutual embeddedness between these two concepts. Like a chicken-egg situation, institutions (e.g., laws) may establish organizations (e.g., techno parks) and organizations –in turn- prepare and put into force institutions (e.g., market entry-licencing procedures by sectoral regulatory authorities) affecting other market players. What is more interesting is institutions enacted by an organization may even influence this entity in turn by leading to establishment of a new division or work relation etc. In this context, it can be said that an IS approach should analyse whether there are overlapping roles of these components and whether these are supporting or conflicting with each other to inhibit working of the whole system under study. These arguments lead to another fundamental building blocks of IS, functions (activities) and linkages between elements in the framework.

4.3.1.2 Functions and Linkages

Although some degree of confusion and conceptual diffuseness exist between organizations and institutions, several scholars point out lack of system level explanatory factors as more crucial shortcomings of IS research and attempt to rectify this weakness. These system level explanatory factors called activities or functions[88]. Edquist (2011, p. 4) prefers to use 'activities' in the meaning of key factors for development, dissemination and exploitation of innovations. The reason for this preference is to avoid from any misunderstanding since 'function' term concentrate on results, not on determinants of a phenomenon in functionalism. Although used in a similar meaning (i.e., contribution of elements to main aim of IS), some others may prefer to use 'role' (e.g., Galli and Teubal, 1997) instead of this word.

As one of the major contributors in this subject, Galli and Teubal (1997, pp.345-347) indicate it is necessary to separate organizations and functions because of the fact that organizations are expected to perform increasing number of functions simultaneously. In this respect, they firstly divide functions in hard and soft ones, like the division of institutions. Their main criteria for this are the role of R&D activities performed by organizations. Accordingly, hard functions include R&D activities and provision of S&T services to other parties and related organizations include entities that have physical R&D infrastructure with laboratories like universities and technology centres. Naturally, all other functions belong to soft category like diffusion of knowledge,

[88] Before all else, it may be useful to note that usually these two words are used interchangeably by the scholars but some of them prefer to use one of them depending on his/her theoretical preference.

policy making, regulations, coordination and mentoring done by sectoral associations, government organizations and regulators, to name a few of them.

They also identify three linkages between components of IS. These are market transactions, one-sided flows of resources and knowledge from inside and/or from outside the system boundary, lastly interactions between actors inside and/or outside of related system such as user and supplier networks. Apart from conventional market transactions, unilateral flows and interactions between system actors are particularly relevant for the early development of high-tech innovation systems.

One can see importance of these linkages from early development of GSM in Europe as public organizations actively supported development of a new technology undertaken by Europe’s major equipment producers like Ericsson.

Starting from non-market interactions and linkages, this sector eventually developed into one of the biggest industries in the world as (self- working) market mechanisms has become more dominant in later stages.

Furthermore, Liu and White (2001, p. 1092) draw attention to absence of system-level explanatory factors (i.e., activities in a system) as opposed to numerous studies focusing on basic components of IS analysis. They claim that this narrower focus may inhibit cross-country comparisons, especially if they have different type of socio-economic institutional and organizational infrastructures. Accordingly, they set up five activities that play fundamental roles in generation, dissemination and exploitation of innovation in a system setting. Not only focusing on narrow R&D system activities, these groups consist of all kinds of research, production, final usage, linkages and education to emphasise economic aspects of innovation, i.e., market outcome and commercialization.

In a similar perspective, Jacobsson et al. (2004, pp. 6-7) focus on functional patterns of components to analyse the overall picture and effectiveness of an IS. That is to say, they first determine system functions and secondly evaluate the performance levels of these functions to put forward dynamics of a technological innovation system. By identifying these, they aim to specify borders of a system and to observe which factors (including actors, institutional set up etc.) influence generation, dissemination and exploitation of new technological innovation. Against this background, there are five basic activities required for the functioning of a technological system in their framework. These are generation of novel knowledge, affecting the path of search processes, resource provision, formation of positive external economies and markets. It is also evident that these functions interlinked with each other and alteration in one of them have repercussions on the other ones. As shown in their study, public policy can be instrumental in development of new technology, facilitation of user- producer links and formation of new markets.

In addition to these contributions, Edquist (2011, p.10) has started from a basic function (of IS) consisting of development, dissemination, exploitation of innovation and continued with assessment of contributory activities to realize IS objectives. He categorizes four main groups and overall, ten important activities in an IS framework. Supply of related knowledge, demand side factors, supply of constituents and assistance services for main actors (i.e., firms) constitute these groupings. In turn, ten activities are composed of generation of novel knowledge, competence building, formation of new markets, and articulation of user needs, establishment and restructuring of institutions, networking, incubating, financing and consultancy services. Certainly, as Edquist himself underlines these lists (this and similar ones) are not complete and may change in line with the advancement of (our) knowledge related to innovation process. Moreover, parallel to the arguments related to organizations and institutions, some activities are more significant than others in different national, regional and/or sectoral, technological IS settings. For example, along with the role of public policy instruments, specification of technical standards is crucial in the early market formation of mobile telecommunications sector (e.g., GSM standards) especially for telecommunications equipment providers and vendors.

However, Lundvall (2007, pp. 13-14) criticizes these definitions and argues that such attempts may negatively affect theoretical understanding of innovation process. He indicates the fact that one can add various other factors to these lists and just telling further research will aid in finding the right ones is not a solution to this selection challenge. He also gives some examples to consider including *openness to international trade and capital flows, competition, labour market dynamics, social welfare systems and quality of social capital.* Instead, he proposes a four-step procedure in a IS framework. Analysis of firms' inner structures in terms of innovation and competence formation makes the first step. Second step involves examination of the interactions (e.g., competition, cooperation and networking) between firms. Cross country comparisons of these subjects with reference to several topics such as financial, labour markets and educational infrastructures forms third phase of the study. Last one consists of using company organization and network positioning to expound the specialisation and performance of IS under study. In sum, firms, their interactions with each other and with knowledge base establish main part of an IS setting.

As an overall review of this topic, Bergek (2011) finds that different IS studies have similar understanding of system functions and she categorizes them[89]. First step is composed of functions directly associated with the innovation process such as identification of problem, functional failures and missing complementary stages. Second step is to propose a solution to system problem including new knowledge formation by R&D, imitation and learning (by using and by doing). Moreover, she states some other functions in the supporting category like providing incentives to companies, provision of resources, guidance of search direction, market formation, reduction of social uncertainty, facilitation of knowledge exchange and helping to counter resistance to change after an innovation (e.g., new product and/or new process) introduced in a market. More importantly, these functions are interrelated with each other and they should not be seen in an isolation. On the contrary, they either reinforce or block each other by generating synergies or negative effects in working of any IS (Bergek, 2011, pp. 11-15). Having seen several views on this issue, it is convenient to conclude by looking into each basic function that is most commonly analysed in IS studies. In this regard, Hekkert et al. (2007, pp. 421-425) proposes several (significant) functions based on their literature review and on empirical studies.

4.3.1.2.1 Knowledge Development, Education and Training

While different researchers disagree on the important functions of any system, there exist a widespread recognition that ‘knowledge development and diffusion’ occupies the main place. Among others, Lundvall (2010, p.329) regards knowledge as the most

[89]Please note that at the time of this conference, the author surname was Johnson but, in the citation, it is currently written as Bergek.

important source and learning as the most significant activity in in the current economy. Likewise, Edquist (2011, p.6) starts his activities list from ‘provision of knowledge inputs’ to the innovation process. Indeed, if there is no new knowledge or recombination into a new form and learning activities (i.e., competence building) on individual, organizational, sectoral levels, there will be no innovation at all. In this subject, Bergek et al. (2005, p. 9) differentiate between types (e.g., scientific, logistics, application specific) and sources (e.g., R&D, imitation, importation, and learning by doing) of knowledge development.

As one of the most important new knowledge sources, R&D consists of basic, applied research and experimental development. Public policy has either directly influenced basic and applied research through public research organizations and universities and/or through R&D incentives such as tax exemptions and grants. In this context, one should not forget the protection of variety in such activities. Because of path dependency, supporting only one technology may lead to inferior outcomes. For this reason, public policy should stimulate experimentation and variety formation in any sector, (Edquist, 2011, p.8).

In addition to new knowledge generation, diffusion of this by learning to use forms a related but inseparable part. On a macro level and generally speaking, quality of an educational infrastructure (whether national, regional or sectoral system) determines quality of human capital and this directly effects the performance of any IS. It is obvious that, learning is not only limited to formal education and consist of informal learning or lifelong activities including learning by doing, by using and by interacting. As part of competence building, individuals may learn in their organizations and in their other networks such as industry associations and profession related clubs. Edquist (2011) indicates the necessity to analyse these activities because of the reason that human capital remains the least mobile production factor even in today’s environment and this gives a distinctive characteristics in each national setting [90]. Thirdly, knowledge exchange and interactive learning between components may determine the long-term effectiveness of any system. As technological innovation becomes more

[90] It is apparent that mobility of human capital has been increasing in each year but in general terms; it remains the least mobile one compared to financial capital, for example. This is even more so when we consider not highly qualified scientists and researchers but factory labour etc.

costly (complicated) and showing non-linearity in development phases, efficient working of system increasingly necessitates coordination of multiple organizations working in same or different institutional settings, often under the umbrella of public policy guidance.

4.3.1.2.2 Guidance of Search, Market Entry & Formation

Bergek et al. (2006, p. 9) point out to the fact that quite a lot of organizations (mainly business firms) should enter in related markets to develop any IS. Either market signals and/or public policy may guide and incentivize firm entry in the first place. These range from expectations of individuals (e.g., entrepreneurs, company managers etc.), regulations and public policy, articulation of demand from leading users to changes in input costs and crises in existing markets, among many others. These factors may lead to market entry (i.e., entrepreneurial activity) by firms in different formats. Some people establish new companies (i.e., entrepreneurship), some existing company employees act like an entrepreneur within that organization (i.e., intrapreneurship). Some firms merge with each other to enlarge their sectoral presence and public organizations may establish firms and/or other IS components such as public laboratories etc. New forms of market entry normally cause more variety that increases the chance of success in line with the evolutionary economics thoughts, (Mathews, 2003, pp. 84-86).

Indeed, establishment, destruction and change of organizations have played important roles in the development processes of successful Asian nations (Edquist, 2011, p.11). Here, public policy has two main functions, supporting variety formation (e.g., entrepreneurship and intrapreneurship activities) and regulating selection environment (e.g., standards). Policy instruments for this include venture capital support and funding, business establishment legislations. While, competition law, trade and taxation regulations are among the policy instruments for generating a selection environment. Lastly, one can add policy instruments for advancing entrepreneurial culture including entrepreneurship education and mentoring activities as long-term strategies, (Borrás, 2016, pp. 12-13).

In some cases, and especially in the early stages of formation, intra/entrepreneurship activities may not be enough for a sustainable market development and public support or direct involvement of state organizations are necessary for this process. Edquist (2011) gives development of initial mobile telecom systems by state owned enterprises of Nordic countries in 1980s, as an example. This technology then surpassed all expectations and has become one of the most important factors enabling digital transformation to the extent that never seen before. Another policy tool closely connected to this is the aforementioned public procurement practices. This tool is particularly essential for some network sectors like telecom, railways and military defence industries for security reasons as well as for the development of indigenous capability (Edquist, 2011, p.13).

4.3.1.2.3 Resource Mobilization and Support Services

Another main issue is increasing need for resource influx in a system, especially in formation stages. These resources are composed of many factors ranging from technical, financial to consultancy services. In this context, Bergek et al. (2006, p.12) emphasize need for the mobilization of three resource categories for advancement of IS and consequently recommend analysis of these points in innovation policy studies.

These three sources consist of human capital, financial capital like venture funds, subsidies and complementary assets such as incubation services and network infrastructure.

4.3.1.2.4 Legitimation and Counteract Resistance to Change

Legitimation is particularly relevant for newly developing IS. Social acceptance and compatibility with institutions determine the extent of legitimacy. That is to say, as legitimacy and political strength of an IS increases, popularity and demand for related IS outputs also grow accordingly.

System components establish and shape legitimacy of any system through their intentional and/or unintentional actions. Bergek at al. (2008, p. 20) mention conformity to existing institutions as one of the most common strategy for sectoral legitimation.

For instance, installation of base stations concern people fearing dangerous side effects of radio signals in mobile telecommunication sector. In the first place, telecom operators take into account international safety standards and public organizations inspect these installations within predefined standards[91]. It is very interesting to observe the reaction of some people to newly developed 5G technology due to Coronavirus (Covid-19) epidemic throughout the world. Especially in social media, people react to news that are making 5G responsible for transmitting this virus and/or indirectly responsible by making immune system vulnerable (Schraer & Lawrie, 2020). On the other hand, several countries have developed mobile tracking systems[92], further increasing the use of these mobile technologies but at the same time forming doubts related to data privacy issues (Kirchgaessner, 2020). Indeed, industry associations and global companies are working to alleviate these health concerns, like lobbying activities and giving information to public etc. For instance, a report prepared by GSM association (GSMA) state that although people in general acknowledge the positive impact of mobile technologies, some (of them) have concerns about the possible risks from the signals radiated from base stations and mobile devices. The document continues by mentioning that these negative impressions may bring in adverse public opinion in the form of media news or political risks. According to this report, research in various countries reveal that a considerable amount of people has not sufficient knowledge of the requirement for base stations, working of mobile phones, role of standards and public organizations in the regulation of these issues. In short, experts advocate risk communication guide for mobile telephones and base stations for the mobile industry (GSMA, 2012). The report advises telco firms to focus on some points when dealing with health concerns. Relatedly, when communicating with people through different channels, it is recommended for them to emphasise that they are complying with safety standards, to indicate scientific studies showing no negative results provided that these standards are met and to undertake (and to inform people) independent assessments for specific installation areas.

Experts think these measures may alleviate fears of people living nearby areas of base stations and other related communications devices. Indeed, this issue will be more prominent in the era of 5G (and beyond technologies) in which far greater amounts of

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[91] E.g., ITU-T Recommendations on Human Exposure to Electromagnetic Fields (https://www.itu.int/net/ITU-T/lists/standards.aspx?Group=5&Domain=40) such as guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields, 5G technology and human exposure to radiofrequency electromagnetic fields.

[92] Some people also concern with the violation of data privacy as a result of these applications, e.g., BBC News (2020), "Coronavirus privacy: Are South Korea's alerts too revealing?"

(small cell) base stations are required in densely populated urban areas. At this point, Bergek et al. (2006, pp.11-13) argue increasing legitimacy may affect *'resource mobilization, influence of the direction of search, market formation and entrepreneurial action'* in a positive way. As legitimacy of an IS increases and uncertainties decrease, market comers generate positive externalities for the whole system. These externalities may include more easy access to resource inputs such as qualified personnel, lower transaction and supply chain costs arising from availability of specialized suppliers and information spillovers due to working on related subjects, (e.g., usage of mobile technologies in different services), according to Audretsch et al. (2007, p. 4). In this regard, Porter (1990, p.78) underlines the existence of related and supporting industries among the four factors[93] that enable firms to compete in a global environment.

Accordingly, existence and/or development of one element (of an IS) may strengthen another IS components.

This is particularly relevant for ICT, which consist of many sub sectors ranging from telecommunications services to software development.

It is evident that knowledge accumulation in one of these areas will be beneficial to other actors in terms of positive externalities such as enlarging human capital and knowledge spillovers.

In sum, different researchers agree on basic functions to be served in any system and it is thought that evaluation of these provide several benefits to IS studies.

As argued, determination of functions will help in setting boundaries of IS under study and may reduce the need for a priori boundary setting (e.g., regional or technological).

Secondly, examination of functions that affect a system either way ease overall analysis of current situation in a more dynamic framework and help assessing performance of different ones in a comparative perspective.

Thirdly, identification of the mechanisms that are affecting the functions in either way

[93] These are 'factor conditions', 'demand conditions', 'related and supporting industries', 'firm strategy, structure and rivalry'.

(i.e., positively or negatively) may help public organizations to devise and implement policies (e.g., incentive packages, new regulations) and strategies more effectively, (Bergek A. , 2011, pp. 16-17).

4.3.2 Systemic Problems and Instruments

While system functions are expected to perform their duties, some mechanisms may block efficient performance of IS functions and these are called ‘systemic problems’.

Accordingly, identification of systemic problems should be seen as a prerequisite of innovation policy design. As a starting point, any analysis of IS may cover both national, sectoral and technological approaches, as Edquist (2011) calls ‘cluster of these perspectives’ depending on case-by-case situations.

Furthermore, either private or public organizations perform the functions (mentioned previously) and sometimes both of them are involved in these undertakings. Notwithstanding to this, private firms are the main players and free market dynamics are preferable to other alternatives, in a liberal economy.

At this point, it can be said that two conditions should exist for public intervention in a market; private players are not able to solve problem/s while at the same time, public organizations should have the ability to cope with these issues.

In this context, unsatisfactory performance of an IS (if this is the case) under study forms the main problem. In determining this, Edquist (2011, pp.21-22) recommends comparisons between different systems since there is no single optimal IS in theory or in practice. Besides this, he links the level of performance to the outputs of the system (e.g., R&D intensities, number of patents, product/process innovations etc.) directly but at the same time he admits the fact that innovation policy targets are more broad encompassing socio-political issues such as higher economic growth and military superiority, to name a few. Indeed, as an example, EU policy makers see innovation as a prerequisite to generating more businesses and jobs, improving life standards and increasing (the union’s) competitiveness in the world markets, (Gouardères, 2020).

As pointed out, there are different categorizations and depending on IS under study these may all or partly be included in a system. These categorizations include product and/or process innovations, high and/or low technology intensive products, radical and/or incremental innovations.

These novelties may be either new to the world or more importantly for developing countries new to an IS whether national, sectoral or technological one. For instance, mobile telecommunications came into stage as a result of radical innovation and following developments can be seen as incremental upgrades, through increasing technical performance specs in each generation (e.g., from 2G to 3G and in terms of transmission speeds and data capabilities). In addition, related actors have introduced both product, process and service innovations continuously in parallel with technological developments (e.g., Wi-Fi technology as an innovation itself both enabling further product and service innovations). Lastly, as an enabling and general-purpose technological innovation, virtually all countries in the world have been working on targets to achieve widespread availability and adoption rates within their borders (e.g., universal service policies and funding of broadband network in rural areas).

Within the umbrella of this main setting, several researchers identify various sub level problems that jointly responsible for the performance of whole IS. In particular, Chaminade et al. (2012, pp. 1477-1478) classify them in relation to *'institution, network, science and technology infrastructure and other support services.'* Jong et al. (2010, pp. 881-882) distinguish them as "capability, institutional, networks and framework failures". Similarly, Edquist and Chaminade (2010) make '*infrastructure provision and investment problems, transition problems, lock-in problems, capability and learning problems, network problems, unbalanced exploration-exploitation mechanisms and complementary problems'* differentiations. Woolthuis et al. (2005, pp.612-614) also identify infrastructural, institutional, interaction and capabilities failure categorizations.

Weber and Rohracher (2012., pp. 1041-1045) add directionality, demand articulation, policy coordination and reflexivity failures to their list to account for transformative change.

To begin with, infrastructural failures (or lack of necessary infrastructure) present in most of these studies. Woolthuis et al. (2005, pp. 612-613) emphasize the importance of knowledge infrastructure and a high-quality ICT infrastructure in this regard. Currently, high speed broadband capability provided by fibre connections form the backbone of this infrastructure. In addition to this infrastructure, they further highlight the role (availability) of other infrastructure components like techno parks and living conditions like traffic congestions, office availability etc. For the science and technology infrastructure, one can add universities, regulatory authorities, availability of knowledge transfer mechanisms and testing facilities, patent activities, among others. It is evident that, public organizations have different roles to play in providing these infrastructural necessities and in solving related problems. The problem of infrastructural investment failure is an important rationale for government intervention in all three modes possible, namely regulations and controls for private provision, subsidies and incentives to private provision or direct public supply.

Institutions also affect the working and interactions of all actors (from firms to consumers) in every IS. That is to say, institutions comprising of sectoral regulations, patent laws to socio-political culture shape the capabilities (and actions) of economic actors, determining the extent of economic performance in turn. Hence, evaluation of institutions performance and if necessary, making revisions as well necessitate public policy intervention and guidance. For instance, as a hard institutional element, policy makers may revise tax regimes for R&D or intellectual property systems to increase innovative activities and may provide business consultancy services to solve soft institutional failures.

Networks or interactions between elements of a system lie in the centre of innovation activities by facilitating knowledge flows and learning. One can see formal and informal networks as carriers of both codified and tacit knowledge, which is relatively difficult to learn and a valuable source of expertise, (Senker, 1995). According to Carlsson and Jacobsson (1997, pp. 302-304), strong and reciprocal external economies, which connect each actor (e.g., firms, competitors, suppliers and other support agencies) is a necessary precondition for a well-functioning system. If these connections are not well established, network failures occur in two dimensions. Either too weak or too strong networks may cause problems in varying degrees. In the first place, interactions and connectivity between elements of a system (or network) should be working efficiently for continuous learning and knowledge transfer process.

Although strong networks are beneficial in certain aspects such as capacity sharing, complementary know-how, there are some negative effects that may lead to systemic failures. In the meaning of *'blindness to what happens outside the network',* strong network failure occurs when members lead each other to wrong direction or could not provide necessary information to members. Woolthius et al. (2005, p.614) link this failure especially to the lack of connection with new information sources, i.e., bridging to strangers with weak ties. Connected to this argument, existence of dominant partners and myopia due to internal orientation may limit the ability and innovative performance of other sector players. According to Granovetter (1983), although strong ties occur in the centre of a network, bridging function of weak ties feeds the system with novel and more information that is heterogeneous.

The upshot of this is that external links to any system are necessary for system dynamism and avoiding from lock-ins.

Apart from interaction problems between elements of a system, elements itself (especially firms as main actors) may lack innovation capabilities due to resource inadequacy, low absorptive capacity and technological expertise, organizational and managerial deficits. Public policy has also a role here in providing educational services to SMEs to promote their human resources, organizational capabilities and technological expertise (know how).

This is especially relevant for the adoption and use of new technologies and some researchers call this problem (if it exists) a transition failure. As a case in point, Germany has prepared and implemented several programs for the firms to adopt industry 4.0 manufacturing processes, during transition periods. In general terms, these policy interventions consist of establishing framework conditions by upgrading related infrastructure and providing programs, incentives to increase adoption of necessary technologies by manufacturing firms.

As a part of this strategy, for instance, public policy aims to increase adoption of ICTs and usage of cloud computing together with the development of interoperability among SMEs. Furthermore, public organizations have been supporting SMEs to enhance their innovative capabilities by facilitating connections between them and the research sectors through public funding activities such as *Central Innovation*

Programme for SMEs, (Horst & Santiago, 2018, pp. 5-8).

In addition to these arguments, Weber and Rohracher (2012, pp.1042-1045) indicate that transformative change is helpful for public policy purposes. In accordance with this, innovation policy should entail formation of shared future visions to avoid directionality failure. In their framework, public policy should address demand articulation failures by public procurement and by incentivizing joint learning between producers and users in innovation processes. Continuous monitoring, feedback mechanisms (reflexivity failure) and coordination at policy level between different public organizations (policy coordination failure) are other critical factors for the efficient implementation of innovation policies. The importance of this policy coordination has been continuously increasing as the boundaries of national, sectoral or technological innovation systems intersect with each other and some actors and institutions are both present in each setting. In this context, they propose three kinds of coordination problems that needs to be dealt with, vertical level (e.g., interaction between sectoral level and general socio-economic policies) failures, horizontal level (e.g., interactions between ministries and other related organizations sharing similar responsibilities, functions etc.) failures and temporal mismatches in the timing of interventions by different public organizations. Accordingly (in the light of this complicated policy networks), administrative capacities of public organizations should be increased to tackle with possible policy coordination failures and implementation. As a last remark in the related category, O'Doherty and Arnold (2003) points out framework failures including sectoral regulations may have negative consequences on the efficiency of innovation policies. In fact, Cave et al. (2019, p. 60) in analysing EU regulatory framework for telecommunications within 25-year period- concluded that although considerable success has been achieved in this period, EU telecom sector is not currently a leader in technology development or technology adoption and behind some Asian countries and USA with reference to next-generation access technology. EU policy papers have also addressed these issues and pointed out the need for a change in regulatory framework to assist in solving the failures in technology development and up to date telecom network investments according to Villar Garcia et al. (2016).

In sum, as Edquist states public organizations and policy may not be able to solve all these failures. For this, in the first place these organizations should have the required capabilities to deal with these problems. Even then, governments do not have all the necessary tools for practical implementation. In any case, public policy may contribute to solutions by financing basic and strategic research, assisting SMEs (e.g., educational programs, ICT adoption help etc.), supporting system interactions between its elements and providing information, directionality etc. to inform them in their working and planning processes. Apart from these, understanding the possibility that public policies may not achieve all of their objectives or even fail, making detailed ex-ante impact (cost-benefit) analysis before implementation phase (also ex-post analysis after implementation) beneficial for reducing the failure of these government interventions (OECD, 2010, p. 193). In this context, Smits and Kuhlman (2004 , pp. 11-12) propose that policy instruments should concentrate on system level rather than dealing with single organizations. Accordingly, they put forward "*management of interfaces, building and organizing innovation systems, providing a platform for learning and experimenting, providing an infrastructure for strategic intelligence, stimulating demand articulation, strategy and vision development"* as five systemic instruments to target system level failures. Complementing this, Borrás and Edquist (2013) suggest combined use of policy instruments to benefit from their synergic and complementary effects. In essence, according to them, any policy analysis should start with the determination of failures (problems) and their causes (stemming from activities), then comes selection of suitable instruments and application of policy mixes. Besides, these policies should be continuously monitored, revised and updated as the corresponding problems are not static in a dynamic environment.

4.4 Application of the Framework

Having observed IS in various aspects like types, main components etc., it is appropriate to summarize the application of this framework to this research[94].

Structural Analysis: To lay the foundations of TIS, one needs to begin from the analysis of the elements of a system. They consist of *actors, institutions, networks and technological factors.* As it is shown, actor category includes many organizations and to name every one of them is both impossible and unnecessary for modelling

[94] Since some general issues are mentioned in chapter 2, these are not repeated here.

purposes[95]. Institutions put at the centre of system in the meaning of rules of the game. Identification of networks between different actors is also crucial for the functional analysis. For instance, it is beneficial for policy makers to know geographical focus (i.e., local or global) of the networks. Lastly, technological factors comprise of related equipment, infrastructures and artifacts like safety, reliability and environmental concerns, to name some of them.

In determining these structural elements, Hekkert et al. (2011) advocated some questions that needs to be answered in analysis process. It is evident that these questions are not complete and depending on the case study, one should add other questions as well. This category starts with the identification of technological trajectories of an innovation system. Some statistics like patent data can be used in this context. The second question is related to determination of actors. Other topic concerns the research and education part of system structure. Depending on the sectoral setting, different actors produce knowledge and new advancements may come from internal and/or external R&D, from new equipment, from suppliers and from users in some cases. Here, one can search scientific publications in several databases to find out the codified knowledge and the corresponding producers of these contributions.

Connected to this, analysing locational base of knowledge producers (sources) may help researchers to evaluate the concentration and accessibility of knowledge stock. It is certain that more accessible and transformable knowledge ease innovative entry and benefit IS in terms of diversity. In a similar fashion, growing knowledge base will increase generation of new opportunities for both market actors and new comers. As a vital source for knowledge development, analysis of educational capabilities related to sectoral requirements is also helpful for policy analysis.

Consideration of demand side forms other side of the coin in structure examination. As emphasised, early users of innovations play different roles especially in formation stage of a market. The study has mentioned the role of early public procurement and adoption of new technologies in mobile telecommunications' technology evolution history. In addition to this, public organizations' role in the preparation of policy

[95] For instance, *knowledge institutes, educational organizations, industry, market actors, government bodies and supportive agencies.*

papers, objectives and the evaluation of these documents should not be omitted in any analysis.

Here, the study searches answers related to questions such as examining these papers in terms of variability and reliability. In fact, one of the main arguments of (our) analysis concerns the reliability of these policy papers in a developing country context. Lastly, examination of intermediaries and networks should be conducted to account for the relationships between elements of an innovation system.

Analysis of Development Phase: Innovations and related market development follows certain phases in a form of S shaped curve[96]. In a similar manner, diffusion (adoption) of innovations in a market follow similar trends over time. Rogers (1962) classified adopter categories in the order of innovators, early adopters, early majority, late majority, and laggards. According to him, innovations that provide more relative *advantage, compatibility, simplicity, trialability, and observability* to users will be diffused faster than other novelties in a market.

For our purposes, Hekkert et al. (2007) categorize these periods as pre-development phase in which a prototype is designed, development phase in which commercial product is launched in a market, take-off and acceleration phase in which market growth is observed and finally stabilization phase in which market saturation is occurred.

The significance of identifying market phases stems from the fact that structure and functioning of innovation systems may differ and require distinct policy prescriptions in each stage. Accordingly, some diagnostic questions related to the availability of prototype, commercial product/service and state of market growth are put forward in manuals for policy evaluation. It is seen that in a scale intensive (conventional) telecom sector, new entry conditions are relatively easier in an emerging technology areas and opportunities may exist in early stages of market growth. Indeed, observations indicate that late comers may preferably focus on specific segments of the sector (e.g., software intensive and 5G usage applications) instead of more mature and scale intensive

[96] The S-curve exhibits the development of innovation from its slow initial phase as the technology or process is evolving, to a take-off and acceleration phase, i.e., a steeper curve, as it matures and lastly to its stabilisation over time, i.e., flattening of a curve, (Open.edu, n.d.)

established parts of the industry.

Functional Analysis: As indicated, different innovation systems (similar technological and/or sectoral ones in different countries) may have more or less same organizational structures like government bodies (ministries, regulatory bodies), firms (private companies, industry associations) and users, among many others. However, like in a Silicon Valley case, the performance of actors and the system as a whole varies extremely between similar looking innovation (technological) systems. Another point is the fact that there is no optimal setting of IS and benchmarking is not easy (if not impossible) due to varying conditions existed in different countries. For these reasons, the analysis of particular innovation system functions' can be more illuminating for identifying weaknesses of any IS.

In this undertaking, several researchers have stated main system functions for more detailed examination. Here, the study follows main system functions of *entrepreneurial experimentation, knowledge development, knowledge exchange, guidance of search, formation of markets, mobilization of resources and counteracting resistance to change* devised by Hekkert et al. (2007).

Owing to the qualitative nature of such an undertaking, the diagnostic questions stated in **Appendix- E** are used to form collective experts' opinion related to each function in IS setting.

Based on this kind of analysis, one can identify critical problems and barriers both for the current functioning and the future growth potential of the IS under study.

Accordingly, policy priorities and ranking of these can be planned by taking into account of constraints like budget and time limitations.

Analysis of Systemic Failures: After identification of system functions and obstacles due to malfunctioning of some parts, it is suitable to work on the causes for these problems.

This analysis consists of determination of problematic system functions and in turn identification of the structural element that causes this deficiency. Lastly, one should examine the relation between causes and obstacles in a system. Hekkert and Wieczorek

(2012) link systemic failures either to lack of structural elements (presence problem) or to lack of capabilities and properties of these elements[97].

Analysis of Policy Instruments: It is evident that main aim of IS analysis is to help policy makers by recommending policy instruments to increase system efficiency. All the previous steps should lead to prescription of possible remedies to solve systemic barriers identified in IS. Innovation policies have several objectives ranging from supporting firm's performance to more societal ones like employment growth and environmental protection, among others.

In some cases, these policy goals may be complementary but in others, they may contradict with each other.

Hence, one should consider these policies in total for optimal configuration and reconfigure them depending on the market development phase.

As both external and internal conditions change over time, the need for continuous revisions about the IS analysis should not be neglected in the context of a dynamic framework.

In the end, it is also imperative to take into account the fact that development of an innovation system is not a short-term business and policy makers do not have capability and resources to find solutions to every problem.

4.5 Telecommunication IS Studies & Projects

In this part, some of the sectoral classification issues related to telecommunication markets are mentioned firstly. Then, different studies and projects on telecom sector (innovation) systems have been evaluated to shed light on different topics and research methodologies together with policy recommendations.

4.5.1 Preliminary Remarks on Sectoral Classifications

As can be seen from previous analysis, it is now apparent that sectoral and/or

[97] As an example, if knowledge development is not functioning properly then the reason for this may be the inadequate level of education that universities provide to human capital.

technological boundary specification of any system under analysis is a difficult, if not an impossible undertaking in precise terms. In any case and like other social modelling studies, some assumptions and preliminary decisions should be made to ease any research undertaking. This is not only because of any bounded (delimited) socio-economic system has sub-sectors which are utilizing several technologies but also due to change and transformation of both its elements and a whole system as a result.

Indeed, ICT sector covers increasing number of different industries. The scope is continuously changing due to technological developments, and the resulting phenomenon called convergence. One can mention *publishing, motion picture, video and television program production, sound recording and music publishing, programming and broadcasting, telecommunications, computer programming, consultancy and related activities and information services* as important activities in ICT as a whole[98].

Telecommunications sector (or subsector compared to ICT) in turn mainly consists of telecom equipment production, telecom transmitting voice, data, text, sound, video and other value-added services in a more conventional sense. On the other hand, one can also classify these as *wired telecommunication activities (operations/activities), wireless telecommunication activities, satellite telecommunication activities, and other telecommunication activities such as reselling and satellite tracking* etc. based on the type of infrastructure from which these services provided to customers (OCHA, 2017, pp. 2-3).

Owing to this convergence phenomenon since 1990s, *boundaries between the computer/consumer electronics, telecom and media/publishing industry*, telecom sector has been increasingly blurring and value chain of these industries are also becoming more interrelated and complex. Indeed, convergence resulted in another fundamental shift in the sector, called ‘triple- play’. What triple play means is that, operators (now) can offer TV, telephony and internet via cable (TV) and/or fixed telecom (e.g., copper and fiber) network.

Developments in mobile (wireless) communication technologies further make it

[98] Please see **Appendix-A** for a more detailed ICT categorization.

possible for companies to offer quad-play services that includes wireless technology services, in addition to triple play.

Hence, not only new competitors have been coming to the market but also two former monopolists (i.e., cable and fixed telecom networks) have been entering into each other's domain, (Janssen & Mendys-Kamphorst, 2008). In fact, this brings new -in a sense radical- challenges to both firms and policy makers (regulators) in the sector. For instance, EU Single Market Performance Report (2019a) state that convergence has expanding its scope further and this time occurs between digital and conventional products, especially with the diffusion of 5G and internet of things (IoT), artificial intelligence (AI). As a result, the report predicts that new business opportunities will emerge and EU should revise her institutional framework, especially in the data sharing and privacy issues, as data becomes the most crucial resource in today's knowledge economy.

It is already shown in Table- 1 (page 6) that one can make three broad categorizations in the sector. To start, hardware and software products are necessary to establish telecom networks as related infrastructures. This segment is traditionally dominated by global vendors and producers. With the advent of software (products) in this segment, new market entries are becoming possible for small scale firms, which can be domestic as well. Furthermore, many countries have begun to support their own industries to develop related hardware/software in the context of economic and security concerns. Then, telecom operators run these networks to give various services. In addition to these operators, many other firms can also give various services such as mobile phone applications and internet provision by using these networks. Here, policy makers target establishment of widespread telecom networks and also competition in service provision over these scarce infrastructures and resources, i.e., spectrum.

Another way of classifying sectors is looking into R&D expenditures of these industries. Corresponding to this, sectors categorized as high, medium and low-tech ones. Fagerberg (2003, p. 20) connects this to either R&D intensities in production or to the use of equipment in which different levels of R&D expenditure required and puts telecommunications in the high-tech category. Furthermore, he criticizes the sole focus of R&D levels for sectoral classification and underlines the importance of Pavitt's (1984) taxonomy that takes into account other innovation inducing factors such as skills and learning by doing as well. Telecommunications industry with two main subgroups exhibit more than one specification. Global and/or multinational telecommunications equipment producers (vendors) such as Ericsson, Huawei and Qualcomm dominate the production side of the sector to a considerable extent throughout the world. This group can be characterised as high tech in terms of R&D spending and exhibits scale intensive, specialized and to some extent science-based characteristics. These specialized suppliers aim to maximize international market shares by using their scale economies, patents, technical expertise and marketing strategies. In doing so, they have established their own research facilities and collaborated extensively with other research organizations (in both public and private sectors). Apart from this, (global) firms in this sector have similar technological profiles and multi-technology capabilities like other large companies in ICT industry.

On the other side of the coin, telecommunication services subsector displays different specificities. As the name suggests, firms in this grouping provide telecom services to end users and other enterprises that are using these mediums (e.g., communication and data transmission etc.) in their own businesses such as call centres, cloud management and internet capacity through leased-dedicated line rentals. Pavitt (1984) put services in the supplier dominated sector type where providers regarded as passive adopters of new equipment and technologies.

However, especially in line with the developments in ICT, this may not be the case for all services in the market. At this point, Tether and Metcalfe (2004, pp. 294-295) separate some sectors like telecommunications, computer software being technological and point out the complex nature of evaluating service outputs from the background process (necessary to produce the service in a sense). Relatedly, they classify them as network services dependent on IT infrastructure by referring to Miozzo and Soete's (2001) categorization. What is more important, advancements in IT have enabled these service providers to upgrade existing services and even to devise new (innovative) ones.

In sum, Malerba (2003) sees *'convergence of different technologies and demand'*, *'knowledge integration and combination'* and '*production specialization'* as key factors for the characterization of telecom equipment and services sectors. Convergence of telecom, media, broadcasting & computer technologies have increased innovative capabilities of numerous specialized and integrated actors including vendors and service providers. Furthermore, institutional settings (regulations) have tremendous influence on the evolution of the sector, by way of privatization, liberalization[99] and other regulations such as standards, compatibility and coverage requirements.

4.5.2 Example Studies and Projects

Having mentioned general sector specifications, several studies and researches related to telecommunications sector innovation systems are analysed in various levels. Although, ICT and in particular telecommunications are at the centre of digital transformation, innovation system studies (related to these sectors) are relatively few as opposed to more common industrial economics oriented and quantitative, econometric studies to measure the impact (of these industries) on the economic development of countries.

4.5.2.1 The ESSY Project[100]

Among these studies, an EU research project called "Sectoral Systems in Europe: Innovation, Competitiveness and Growth" stands out as one most detailed and long-term research (ESSY, 2002)[101]. Each sector analysis has six main parts to evaluate the system under study. These are *knowledge base and learning processes, non-firm organizations, networks and institutions, geographical boundaries, long-term dynamics of the sector and co-evolutionary processes, public policy and international performance* (ESSY, p.14).

The analysis on telecom sector consists of five research outputs related to the fixed internet and mobile telephony, the internet services, fixed data communications, data communication, the satellite and TV subsystems, three generations of mobile

[99] Although most of the privatizations and liberalizations made during 1980-1990s, the effect of such restructurings and reforms have undoubtedly affected later formation (development) of related sectors in various aspects.
[100] This section draws heavily on the ESSY (European Sectoral Systems of Innovation) project final report, unless otherwise stated.
[101] The Project has covered telecom, pharmaceutical, chemical, software, machine tool and some service sectors. Franco Malerba coordinated this three-year duration project. There were several partners from different universities and research centres including Bocconi, Aalborg, Manchester Universities and Fraunhofer, Berlin Research Centres, to name some of them.

telecommunications systems and services. Experts have researched dynamics of the sector by focusing on functions of large (and established) companies, new market comers, the role of institutions and on the interactions between physical equipment (hardware) production and the services parts. Interviews, field studies and literature reviews (especially from OECD, EU and IDATE sources) form the methodological bases of the research.

Telecommunications equipment production (hardware) and services sector has diverse knowledge base and has been subjected to continuous (dynamic) change owing to convergence phenomenon (discussed in the previous section). Even a basic example may show the extent of convergence and digital transformation that we are experiencing nowadays which were unthinkable at the beginning of 2000s. Today, one can talk, watch any media, send messages, make online transactions and shopping from a single mobile telephone (i.e., phone, TV, media, radio, facsimile, computer, and mobile wallet in one device) connected to internet network.

In the near future, this trend expected to increase faster with the diffusion of IoT and AI applications along with the advancement of enabling technologies such as 5G (and later generations) mobile communications.

In the background of convergence, commercialization of internet represented a radical innovation leading to major changes in the whole structure of this sector. It is noted that this technology together with open network architecture, modular components and distributed intelligence transformed the knowledge base, actors and competences in a radical manner. At this point, one can argue second radical change occurred with the advent of mobile telecommunications.

This radical innovation (and later incremental innovations) has enabled these firms to provide both fixed-wireless and mobile services at the same time. In most of the countries, national incumbent fixed telephony operators use their network to provide internet services and later on, obtained mobile telecommunications authorizations to give both services (i.e., triple and quad play). Due to these changes, existing firms have diversified their offerings and new firms have entered in these sub-sectors. Incumbent telecom hardware producers and infrastructure service operators, latecomer mobile telecom operators, cable TV companies occupy equipment and services markets. As a part of telecom services, the number of different types of firms have also increased in internet services sector. They include internet service providers, internet content providers, B2B and B2C firms, internet and software related solution provider firms. These developments necessitated a more complex knowledge base for network providers in fields such as computer programming, network administration and content preparation, all of which previously were different firm's competencies. In addition to these business firms, the project underlines the major role of regulatory agencies (e.g., licensing), research bodies, networks between these players and finally users (i.e., demand factors). Actually, telecom service providers try to respond users demand and to compete with newcomer firms' innovative offerings, services and content provision by devising their own solutions. All of these firms have established a separate division to respond to other business firms' requirements of dedicated network, cloud management and cyber security solutions. Another point stressed in the research is the importance of public organizations and collaborations between sector actors in the (early and successful) development of mobile telecommunications technology (GSM). Initially, incumbent state-owned telecom operators (PTO) were involved in the advancement of first generation (NMT) mobile telecom technology and its standards within an organizational environment coordinated by European Conference of Posts and Telecommunications (CEPT). While in the advancement of GSM standards, a broader consortium was established with other organizations (additions) such as equipment producers like Ericsson and Nokia, public research agencies, universities and funding provided by EU sources[102], (Table-13).

Table 13- Phases Leading to GSM Dominance

Phase- I: NMT- First Generation Mobile Telecom	Phase- II: Development of GSM Standards	Phase-III: Diffusion of GSM
PTOs in CEPT framework (Monopolistic markets) Public Funding	PTOs, producers, universities, research agencies in ETSI framework (Monopolistic markets), Public funding	European Open standards, Liberalized markets, new market comers, new policy regime of EU

Source: ESSY (2002)

[102] COST (European Cooperation in Science and Technology), a funding establishment for research and innovation networks.

Malerba (2003, p.367) considers that institutions played a significant role in the advancement of this technology, a major success of Europe in technology innovation. One of the upshots to derive from this process is the significance of public policy intervention in the early stages of new technologies and/or systems. As a matter of fact, both Ericsson and Nokia owed their prominence mainly to public organizations' role (support, guidance etc.) in the establishment of first NMT, then GSM technical standards and development process.

In addition to this, privatization of incumbent telecom operators and liberalization of the sector along with sectoral regulation have drastic effects on subsequent evolution of the sector structure and performance. In this subject, it should be noted that the effects of such policies on each country have been dissimilar and case-by-case analysis of each country's sector is important to observe these differences[103].

Telecommunications equipment production sector include firms that manufacture hardware and devices related to telecommunications such as modems, circuit-switch systems, routers and base transceiver stations. Traditionally, scope of the industry included mainly equipment used in a telephone network.

In line with these aforementioned technological developments, this sector currently covers a much broader array of sophisticated equipment with more embedded specialities, (Zhu & Pasadilla, 2016, p.314). Fixed and wireless network equipment, base stations, routers, switches, digital subscriber line and cable modems, fiber optic cables, chipsets and cell phones are amongst the numerous hardware items demanded by governments, both global and local businesses, educational organizations and residents (end users).

It should be mentioned that, these are general product categories and each product category covers many sub components taking part in the final outputs. For instance, Cohen et al. (2014, p. 11) have found three key subsectors; optical core network, router/switch, and wireless equipment products[104] critical for USA's economic growth

[103] This issue is mentioned in the context of Washington Consensus policies where privatization and liberalization are recommended to every country regardless of country specific factors.

[104] Optical network types consist of *SONET/SDH (transmission, add/drop multiplexors, multiservice provisioning platforms), DWDM (metro transport, metro ROADM, Long- haul transport, Long haul*

and national security[105]. For telecom hardware production, the ESSY study pointed out a separate sectoral analysis. This may still be an appropriate methodological separation but convergence has also affected the previous clear-cut (independent) divisions between these two main sectors. Even in the relatively early periods of digital transformation, Malerba (2003, p.354) has indicated the significance of this technological fusion (i.e., knowledge base including telecom, computer, media, software etc.) to connect service providers and equipment manufacturers by facilitating exchange of knowledge and their competencies in a reciprocal way.

In the first place, technological developments (embodied in new forms of hardware) facilitate new services and applications. These novel offerings (e.g., multimedia, gaming) in turn are stimulating the advancement of new types of hardware and network elements.

At the beginning of 2000s, the ESSY research stated the coexistence of large multinational actors and specialized businesses, along with the global dominance of USA companies.

In retrospect, it should be stated that this picture has changed with the inclusion of China and other South Asian countries-based vendors. Most notable ones are Huawei, ZTE and Samsung, who are aggressively conducting market capture strategies in recent years throughout the world.

4.5.2.1.1 The Fixed Internet and Mobile Telecommunications IS[106]

This analysis has mainly two parts, fixed internet and mobile telecommunication sectors; in terms of equipment production, access and content provision. In line with historical evolution, it can be said that although these were distinct markets in the early

ROADM, Long-haul submarine line terminating equipment). Router/Switch types include IP Core Routers (high-capacity routers), IP Edge Routers (Medium-capacity routers), Carrier Ethernet Switches (Enhanced Ethernet equipment for long haul and metro). Finally, wireless equipment type category is composed of Long term Evolution- LTE (Evolved UMTS Terrestrial Radio Access Network, Remote Radio Head, and Evolved Packet Core), WiMAX (Home agent, ASN gateways, and base transceiver station).

[105] This research is discussed in a more detailed manner, (Chapter 4.5.2.3).

[106] This section draws heavily on Edquist (2004), “The fixed İnternet and mobile telecommunications sectoral system of innovation: equipment production, Access provision and content provision”, in Malerba F. (2004), “Sectoral Systems of Innovation, Concepts, issues and analyses of six major sectors in Europe”, Cambridge University Press, unless otherwise stated.

periods of market development, most of the telecom operators are currently giving both of these services and high-speed broadband internet provision requires combined use of wired and wireless technologies in advanced telecom networks.

4.5.2.1.2 Fixed Internet Sector

In his analysis, Edquist (2004) has evaluated relatively later stages of telecom sector starting with the commercial use of internet technology. These sectors are fixed data and mobile telecommunications together with mobile internet. As internet usage has increased in many other sectors, the boundaries between hardware production and services have been diminishing, making both subsector outputs complementary. His mobile telephone- mobile phone call and internet-content combination examples are very descriptive for these complementary relationships. These complicated interactions have also begun to occur in previously separate hardware and software (computing) sectors. Thanks to convergence, routers, base stations, mobile communication devices have now both hardware and software components in their structures.

Apart from this, internet access providers only enable access to the internet without any other value-added service. This kind of service providers either build their network or use other firms (usually incumbent operators) networks. If content is provided from this network, then these businesses are called internet content providers. Edquist uses 'internet service provider' term as a combination of both internet access and content provider.

According to Edquist, there exist essential functions in the sector to perform better. These are advancement of related hardware and software, R&D for increasing performance of the system, availability of suitable education and vocational training, implementation of appropriate regulations and standard setting (as in the GSM case), supply of adequate access, production of novel content and proper arrangement of consultancy services for each of these activities. One can add numerous other functions taking part in the advancement and diffusion of innovations. These range from financing methods, firm establishment procedures to demand stimulation and new market formation for these innovations in the form of both products and services. What is more crucial for Edquist here is determination of other functions that play roles in raising performance levels of a sector and he recommends additional research to fulfil this gap.

Organizations perform functions and there is no necessity for a one-to-one correspondence between one specific organization and one specific function. In other words, several organizations may undertake one function and/or one organization may perform different functions at the same time. Telecommunication and internet hardware producers like Ericsson, Nokia, Siemens and Huawei carry out the production and development of related products that have increasingly software inputs in the final output.

These global companies perform considerable amount of R&D. Some other research organizations like universities and public technology agencies are also carrying out some degree of R&D activities. As an important learning source, public organizations like universities and/or publicly funded agencies are responsible for educational activities. Besides this, businesses and/or sectoral associations organize and provide occupation related education programs. On the job training and learning by using-doing are other activities provided by businesses. Some other organizations are responsible for regulations and standard setting. These functions guide business actors especially in the market formation stage and may be helpful for demand articulation by informing consumers about the safety and environmental issues relate to these products/services. These regulatory and safety related bodies are mostly public organizations, in some cases there also exists semi-public or sectoral associations involved in standard setting and other kinds of regulatory activities. Fixed (and mobile) network operators, internet access providers and cable TV (CATV) operators form access provision part. With the widespread use of internet, content provision becomes equally, if not more, important than availability of access especially in developed countries of the world. In this category, there are general and specialized (e.g., financial news provision) content providers. Some contents mainly financed by advertising are free to use for consumers (end users), some others provided via subscription fees for revenue generation. Apart from this, the number of e-commerce firms have been proliferated in both B2B and B2C segments. Both domestic and global firms (e.g., amazon, e-bay) are active in these markets along with increasing number of market entries of traditional product selling companies, i.e., diversification of marketing in e-commerce[107]. Consultancy companies mainly assist all these firms ranging from network operators to e-commerce firms in various aspects such as web design, web hosting and cyber security solutions to address continuously changing requirements and needs of main actors in the sectoral system.

In the light of these changes, Edquist has indicated the growing *functional differentiation* and *organizational diversity* in the sector. In the first place, there is no public sector monopoly left in telecom sector throughout the world as opposed to previous public telecom operators that had regulatory powers as well.

These monopolies had also close connections with equipment producers (vendors) and as a public organization played roles in the innovation polices of countries (e.g., the case of GSM). However, it may not be wrong to state that in a liberalised (with privatizations) era, relations between network operators and global vendors are still strong in a framework of user-producer interactions. What Edquist emphasised is the fact that close ties between national hardware producers (of course applicable in countries that had such firms) and public telecom operators have been weakened after liberalization and privatization processes. After liberalization, sector specific regulatory agencies have been established especially in EU and after that in many other countries throughout the world. Some notable exceptions are USA (where a regulatory authority existed long before EU), Japan and China. In USA, Federal Communications Commission is a regulatory authority dated back to 1934. In Japan, regulatory affairs handled by the Ministry of Internal Affairs and Communications (MIAC), (Thomson Reuters, 2018), whereas Ministry of Industry and Information Technology (MIIT) is the responsible organization in China, (Simmons & Simmons LLP, 2021). Again, linked to market liberalization, former monopoly areas especially services sector has been opened to new market comers and several types of companies have entered into the sector. Among them, one can mention other fixed telephony service providers, internet service/access providers, new mobile telecom operators, virtual mobile network operators and cable TV (with internet and telephony service) providers. Here, mobile telecom network operators have achieved the highest growth rates in the

[107] This trend is further increased during the Covid-19 epidemic. In general, it is seen that companies that have internet marketing capabilities have performed relatively better than those that do not have such diversification.

service market, reaching virtually whole populations (i.e., above 100 % penetration rates in this segment) in any country where they are operating, indicating the growth potential of wireless communications.

Liberalization, privatization and other regulations are examples of crucial institutions in this sector. Although liberalization and privatization processes were completed in the beginning of 2000s, because of market restructuring consequences, their effects are still valid in some countries. As a result of these policies, related ministries and regulatory authorities have become main players to implement institutions in the sector. For instance, perhaps the most important institution is licensing as a market entry regulation.

Depending on each country legislation, either related ministry or regulatory authority is responsible for the implementation of this institution. In some cases, especially concerning auctions for mobile telecom licenses, related ministry decide on policy and regulatory authority oversees auction process. In the last stage, these auctions are approved by upper body to related ministry such as council of ministers or president of the state. Other institutions affect actors' actions ranging from safety, quality and coverage standards. Of course, one can add many organizations, outside the inner circle of the sector, such as finance, science and technology ministries that also influence these actors by implementing institutions like tax laws and R&D incentives.

Having discussed organizations, institutions and functions, Edquist has passed on the evaluation of the interactions between these elements of the system under study. According to him, beginning of data transmission (i.e., internet services) represented a milestone and led to formation of the fixed internet service sector. Two technological developments played essential roles in this process. These were packet switching technology and TCP/IP internet protocol[108]. Packet switching technology enabled sharing of network transmission in terms of video, voice and data. At the same time,

[108]Britannica (Gregersen, n.d.) defines TCP/IP (Transmission Control Protocol/ Internet Protocol) as standard internet communication protocols that enable digital devices (computers) to communicate with each other over long distances. In a packet-switched network, information is divided into several packets and sent separately over many different routes simultaneously, finally reassembled at the receiving point. In this context, TCP collects and reassembles the packets of data, while IP is ensuring the packets are sent to the right address. TCP/IP was advanced in the 1970s and accepted as the protocol standard for ARPANET (initial version of internet) in the early 1980s.

many people can use same channel by sharing the network simultaneously and it is much more efficient for data transmission by reducing access delay and rerouting capabilities. It is also cost effective in various areas such as increasing capacity of transmission channels and elimination of the need for secondary storage, (RF Wireless World, n.d.-a). Closely related to this, development of improved data networking communications protocol, which had open architecture specifications, eased routing and enabled connections between physically separate networks.

Apart from historical analysis of the internet, what is more relevant for the research (our) purposes is the fact that in the innovation process of initial version and in later stages (made possible with these internet protocols), public policy had an active involvement by providing funds and public technology procurement policies. In his analysis, Edquist underlined the role of government organizations especially during the diffusion phase of the internet. For instance, National Science Foundation (NSF) of USA accepted TCP/IP as the standard on its national university network, facilitating early market dominance of this technology.

As opposed to conventional telecommunications network management, internet is not formally standardized and there is no formal standardisation agency. In the history of telecommunications network standardization, a formal organization called International Telecommunications Union (ITU) composed of nearly all countries of the world has played roles related to spectrum management and standardization, among other responsibilities, (Hughes K. , n.d.). On the other hand, in the diffusion process of the internet, only a voluntary standardization body called the Internet Engineering Task Force (IETF) established to deal with issues such as standard updates and giving information about these changes. For political economy, the upshot of this long development history is the USA's related organizations (including business firms) resulting domination in the standardization of the internet technology. In addition to being a lead developer of this technology, USA government and sector actors have furthered their advantages by forming a supportive ecosystem in the worldwide adoption and commercialization of internet with the help of global companies such as Google, Facebook and Twitter. In fact, Netscape firstly commercialized this technology and, in a way, founded the path for other technology firms to follow. This firm launched first commercial internet browser program, followed by what is to become a leader in several domains of ICT sector, until the advent of other developers such as Microsoft, (Hoffmann, 2017).

In parallel to these changes, USA equipment producers gained early dominance in the equipment market for internet technology. Thanks to being in the forefront of this technology coupled with increasing demand from home market users for personal computers, many start-ups entered in the sector in addition to existing market players like IBM and Sun in telecom/computer equipment markets. Some of these late comers (in the beginning of 1980s) including Cisco and 3Com, grew from start-ups to become global players. For instance, Cisco was founded by two computer engineers who invented internet router to connect different types of computer systems, (Cisco, n.d.-a). The company reached highest market capitalization ranking once with a value of 569 billion USD after less than twenty years from its establishment date (Reese, 2010).

After early diffusion stage of internet technology, Edquist has pointed out another institutional change, namely liberalization that had profound effects on the later stages of internet usage and adoption rates in different countries. According to him, countries that liberalized their markets earlier achieved higher internet adoption (i.e., penetration) rates in their populations[109]. Without going into much detail, it can be stated that being an early adopter of liberalization policies, United Kingdom (UK) displayed better performances in terms of competition and resulting price/quality improvements, increasing network investments, coverage and penetration rates. In numerical terms, this market volume had grown from 7.5 billion British Pound in 1984 to over 31 billion British Pound in 2000. At the same time, quality, coverage and types of telecom services were increased considerably during this period (Department of Trade & Industry, 2001). Upon observing this market performance, both EU member and other countries from different parts of the world began to adopt these policies in various degrees. This case is similar to our previous discussion on Silicon Valley example, which virtually copied by almost all other countries (and lead to different

[109] Market liberalization and privatization are normally considered simultaneous policies. However, the implementation of these did not occur at the same time in several countries. If a privatization made without necessary institutional arrangements, a private firm monopoly could come into stage after state monopoly, without achieving market liberalization gains such as price reductions due to competition. In any case, our purpose is not to discuss the details of these policies of EU countries in a historical context. On the other hand, for our main subject, these discussions may give some insights for the current structure of the sector.

outcomes) without taking into account country specific factors and numerous other qualitative elements such as business culture and other environmental constituents.

Another point that closely related to market liberalization and convergence is the proliferation of access networks and technologies. Both technological development and service innovations have led to these multiple platforms.

Market liberalization enabled these platforms to serve end users in the same market. As the name of fixed internet services implies legacy telecom infrastructure-networks were the first access platforms.

As a matter of fact, the essence of digitalization process is also applicable in this sub sector. Table-14 summarizes all these technologies' evolution and the (unending) next objective as the quest for faster speeds and wider coverage.

Dial-up modems (analogue connections) and integrated services digital network (ISDN) being the earliest access types, were not used anymore in most parts of the world.

Later on, Asymmetric digital subscriber line (xDSL) had become the most dominant access type to increase the transmission capabilities of the existing copper lines. The CATV network and satellite TV with set-top boxes are also used for internet connection, depending on the coverage of these technologies in each country.

Satellite internet remains one of the least widely used technology and has found some demand mostly in rural areas and these are financed by universal service funds.

In fixed category, fiber technology represents the latest advancement and considered as one of the most essential components of digital transformation era along with ever-increasing capabilities in each successive (mobile telecom) generation.

Another product/service innovation is the fixed wireless access technology, which combines fixed network with some degree of mobility to end users.

Along with advances in mobile internet access, the use of fixed wireless access and combined use of fibre plus 4-5G solutions are increasing in developed countries in terms of internet penetration and usage rates.

Table 14- Internet Access Technologies

Market Definition	Types	Definition	Features
Fixed Access	Dial-up access	Simple modem up to 56 kbps	Not used anymore
Fixed Access	ISDN	Voice, video, and data transmission over digital telephone lines or telephone wires, connection speeds from 64 to 128 Kbps.	Not used anymore in most of the countries. First upgrade of telecom network, enabling connections of different devices to this infrastructure.
Fixed Access	xDSL	Technologies that enable transmission of high bandwidth services from traditional telecom network. Asymmetric Digital Subscriber Line (ADSL) is the most widely used one where bandwidth available in each direction is different. Connection speeds from 5 to 100 Mbps, depending on distance, number of users etc.	Currently most common way of accessing internet from fixed networks throughout the world. Each upgrade of xDSL provide Faster internet capabilities. For instance, VDSL can provide three times more access speed over relatively shorter distances.
Usually not included in any internet access market definition	Satellite	Internet access provided from satellites. Connection speeds up to 25 Mbps.	Not widely used throughout the world. It is useful in rural areas where there is not an alternative network available. More expensive to use and affected by line of sight, weather conditions etc.
Fixed Access	Fiber	Internet connection that sends data fully or partially through fiber (thin glass wires inside the larger protective cable) optic cables. Data transferred by light signals and can supply download / upload speeds of up to 1000 Mbps.	It is more expensive to deploy but provides the fastest internet connection without influenced by distance. Considered a prerequisite for digital transformation in combination with mobile internet access (i.e., 5G and beyond) / (in some countries new investments exempt from regulatory obligations for a certain period)
Fixed Access	FWA	Provision of wireless broadband using radio links between two fixed points, i.e., fixed wireless is an alternative to giving wireless internet access, minimizing the requirement for physical connections.	FWA presents an alternative where fixed network (cable or fiber) coverage is limited. It can also be used in combination with fibre deployment to enlarge the service coverage in dense urban areas.

Market Definition	Types	Definition	Features
Mobile Access	Mobile broadband	Internet access provided by mobile telecom operators. Each generation of mobile telecom technology gives faster and more reliable internet connection. For instance, 5G enable min. 100 Mbps speeds, while up to 1 Gbps is possible.	With 5G and later generation technologies, mobile access capabilities will be increased substantially and may decrease the demand for fixed line connections, depending on price and quality considerations. However, for a near future, next generation mobile access types require fibre connections to meet performance objectives of network coverage and reliability, among other issues.

Source: (ITU, 2001), (Patel S. , 2017), (Cooper, 2021) and (Ambersariya, 2019).

These access technologies have formed most of the alternatives to meet users demand in today's markets, depending on the availability of existing network infrastructures and/or investment capabilities (funds, business sector willingness to invest etc.) for new types such as fiber and more advanced mobile communications. As stressed in various parts of this study, the role of internet (access and use) has become an enabler to digital transformation and a vital instrument for every citizen in the world. In this respect, it is apparent that sectoral (innovation) policy objective should focus on both service part for provision of widespread internet availability and a sustainable service/product provision ability of national and domestic industry.

It is true that in most of the countries, (basic) internet access is now included in universal service concept. Universal service in telecommunications came from the fact that every citizen of a country should have some kind of communication rights, depending on level of technology. Historically this concept included telephone and postal services, but now even low speed internet is not enough for most of the people to take advantage of internet services to a considerable extent. Indeed, Berners Lee (Web Foundation, 2020) considers internet access should be a human right especially after seeing the unifying effect of internet in almost all aspects of daily life from work, education to leisure activities.

However, the so-called digital divide between who can access & use (broadband) internet and those who cannot is a problem in today's world. This divide exists between developed and developing (more critically low-income) countries. Moreover, it can be found even between different segments of population within developed countries like UK and USA. In fact, nearly 1.5 million homes have not an internet access in UK according to OFCOM, (Kleinman, 2021). Similarly, a recent FCC (of USA) report dated 2021 estimated that nearly 14.5 million people have not a broadband internet connection (according to latest predictions made in 2019) and the problem is more acute for those living in rural locations, (FCC, 2021). For this reason, governments should take the initiative to enable access and promote efficient usage of internet for disadvantaged people and/or areas. Most importantly, public policy should not only target urban area coverage but also rural areas where this problem is most serious. Furthermore, apart from coverage and/or availability of internet network, quality and affordability of such services needs to be considered in a regulatory framework.

Closely connected to this issue, governments can design and/or promote selective policies targeting digital literacy programs, inclusion of disadvantaged social groups to increase the efficient use of digital services and applications.

In essence, both public organizations and service providers have responsibilities in this undertaking. In other words, public policy must guide business firms with proper regulations including network coverage, quality of service requirements and use of universal service funds, provision of other incentives like tax exemption etc.

As another point in line with evolutionary economics for variety generation, Berners Lee (2020) recommends promotion of new technologies (innovations) like access with drone and balloon in addition to established (mature) access technologies.

For instance, Google has devised a balloon network called ‘Loon’ to provide coverage in rural areas where people do not have access to internet. This experimental project and the company performed various tests before launching commercial offerings. In one of them, this technology connected people online in Peru’s three cities that suffered from floods, an area nearly 40.000 km^2, (Lee D. , 2017). Later on, the company who got it the same name with the project started its first commercial operation in Kenya, collaborating with Telcom Kenya in 2018 (BBC News, 2018). On the other hand, another global internet company Facebook abandoned its drone project called 'Aquila' due to several problems occurred in the development of drones. Facebook has not continued drone building, and it can only be speculated by looking into company announcement[110] that it may use other specific drones (that are produced by other specialized companies) to use its internet access technologies, in case a similar project is undertaken in the future, (Lee D. , 2018).

4.5.2.1.3 Mobile Telecommunications

Before starting to discuss evolution of mobile telecommunications, it may be useful to look into the terminology used to show the upgrades and developments related to this technology[111]. As Tadoyani et al. (2017) indicate the terms 'generations, standards and releases' are interchangeably used for each other to indicate technological progress. Table-15 shows these different classifications for each generation of these technologies starting from first to most recent (i.e., five) one.

Table 15- Different Classifications of Mobile Telecommunications

Generations	(Sub) Systems	IMTs	Releases
1	NMT	NA	NA
2	GSM, GPRS	NA	NA
3	UMTS, HSPXA	IMT-2000	R-99, R4-7
4	LTE, LTE- Advanced, Wi-Max	IMT-Advanced	R8-9, R10-14
5		IMT-2020	R15-16-17 (2020)

Source: Tadoyani 2017, 3GPP, ITU

In basic terms, this evolution has started with voice communication in one network with no connection to other networks, (i.e., no interconnection) to increasing capabilities in data transmission with regard to speed, latency and communication with machine to machine, i.e., IoT and M2M. 'Generations' word in the meaning of a class of objects or system developed from previous types is one of the most common usage to categorize these transitions, i.e., from 1G to 5G. In addition to these, they indicate the fact that mobile operators or industry associations have sometimes introduced more blurry categorizations such as 2.5 G mainly for marketing purposes, at the same time

[110] Yael Maguire, director of engineering in this company said "…Given these developments, we've decided not to design or build our own aircraft any longer..." in a press announcement. (Wagstaff, 2018).
[111] Although, evolution of mobile technologies has been discussed in terms of some technical aspects in the previous chapter, here a brief summary is given to emphasise the evolutionary nature of this technology.

generating some kind of confusion in the market. On the other hand, International Telecommunication Union (ITU) institutionalized a more technical classification system, ‘International Mobile Telecommunication Standards (IMT)’. These standards are IMT-2000, IMT-Advanced, IMT-2020 and these are broadly corresponding to 3G, 4G and 5G classifications respectively. However, ITU itself declared that there is no formal definition in terms of generation usage. An ITU document states IMT-2000 that has been available since the start of 2000 and frequently referred as 3G. IMT-Advanced standards agreed in 2012 consist of such technologies as LTE, Wi-Max and HSPA+, (ITU, 2021). Actors in the mobile telecommunications industry have jointly developed IMT-2020 standards since the second half of 2010s with trials and tests, which increase the extent of digital transformation by enlarging the usage (in many areas) and (transformative) effect of machine-to-machine communication. In a similar manner, some other standardization organizations jointly established a consortium called 3GPP to provide specifications related to this technology. Changes and developments are categorized as ‘releases’ by this consortium. For instance, Release 15 delivered in 2018, deals with the initial specification of 5G standards. More recently, Release 16 finalized in 2019 and works related to Release 17 have been completed in 2022. These specifications have introduced additional functionalities to enhance mobile telecommunication network capabilities[112]. The industry is currently working on Release 18 to continue this upgrading process, (3GPP, 2023).

First Generation Mobile Communication Systems (NMT): Edquist has pointed out that Nordic countries developed first versions of mobile telecommunications technology (Nordic Mobile Telephone standard based on 450 MHz) in the early 1970s. One of the prominent reasons of this joint project was the need for compatibility especially between Nordic countries.

In other words, people could not communicate with each other who lived in other countries without a compatible and standardized communication technology.

To solve this problem, state owned and monopoly telecom operators (PTOs) from

[112] These include power saving, coverage and positioning enhancements along with various technological upgrades. In practical terms, these improvements mean increasing capabilities to handle higher number of IoT devices with more energy efficiency in several usage cases and provision of more dependable communication and usage capabilities in emergency situations, among other benefits.

Finland, Norway, Denmark and Sweden (in short Nordic countries) started this project. Number of other actors, various public organizations and especially equipment producers joined this undertaking. Since these PTOs were state owned firms, public organizations (e.g., the governments of these companies) directly involved in the project implementation and the manufacturers adopted a secondary role like researching technological problems and introducing solutions to the main actors. NMT Group was the main actor in the technology development phase, in which each country PTOs were directly responsible in their countries during implementation phase, (Seo, 2013, p. 58).

This success in the development of NMT (i.e., capabilities gained in the early development phase of 1^{st} generation mobile telecom technology) led to Nordic countries' progress in the transition to 2^{nd} generation mobile telecom technologies, namely GSM. In particular, since Swedish PTO (i.e., Sweden government) led the initiative, this involvement gave early (comer) advantage to the country's equipment producer, Ericsson. The company won the first auction for switches to be used in the network as part of public technology procurement policy. This does not mean that other Nordic countries did not pursue programs to strengthen their corresponding industries. For instance, Finnish government (Finnish Post and Telecommunications Administration, more specifically) guided Nokia to make a collaboration with a Swedish company (Radio System AB) in the production of base station combiners. Castells and Himanen (2004, pp. 56-61) linked the future growth of Nokia to this public guidance (among other factors) in the early market formation stage. Nokia's development history shows the joint outcome of collaboration with public sector, transferring expertise from other firms by partnerships and acquisitions, internal R&D efforts, networking with universities and recruitment of talented new graduates from engineering fields. Indeed, Darcy (2006) argues that as an enabler to development of these firms, Finland's unique system of innovation in information technology has showed different kind of policies are possible other than Silicon Valley case imitation attempts (prescriptions).

Both Castells and Himanen's analysis and review of Darcy are important for (our) the research study in that, especially in today's environment, where people live in the world of pandemics, global crises and inequalities, one should not only focus on the short-term economic issues (e.g., revenue, profit etc.) of an innovation policy. In digital era, any policy has to take into consideration other socio- economic issues related to access and usage of internet. That is to say, social inclusion and bridging digital divide objectives must be among essential points in devising regulations, policies related to internet access and digital transformation.

Like the case of fixed internet services and hardware sector development in USA due to being pioneers of these technologies and availability of sufficient demand, Nordic countries have made use of these advantages (i.e., technology leadership and availability of demand) to establish viable home markets with rapidly rising user penetration (adoption) rates.

Increasing demand for mobile telecommunications in turn helped equipment producers to achieve scale and scope economies, further decreasing both equipment costs for operators and service costs for end-users, (Figure-8).

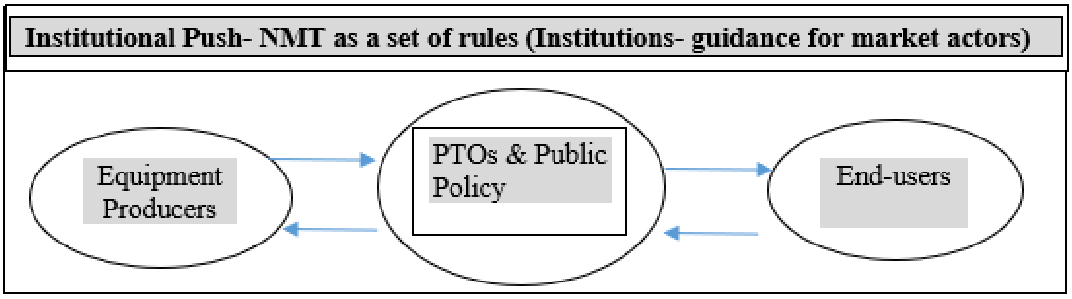

Figure 8- NMT Ecosystem

In sum, what was different for NMT case is that institutions guide the subsequent market formation as opposed to normal situations in which rules inhibit formation of market in various aspects such as technology development and diffusion, solution of compatibility, standards and achievement of scale economies. Another factor that supported business companies were user-producer relationships between equipment producers and service providers established within this institutional setting. As a result, institutions decreased the uncertainty for market actors and helped producers to achieve scale economies. Although similar technologies and standards were also advanced in other countries, these early comer advantages (i.e., early standardization and commercialization) brought economic and marketing advantages to Nordic countries and EU in general terms, (Seo, 2013, p.62). Some of the prominent 1G standards developed by different countries are presented in the below Table-16. Among them, AMPS and NMT achieved more widespread adoption and usage rates.

What is more crucial, NMT experience (know-how) established a jumping point to a dominant standard in second generation mobile telecommunications technology, Global System for Mobile Communications (GSM).

Table 16- Prominent 1G Technology Standards

Mobile System	**Commercialization Year**	**Countries**	**Frequency Band**
Nordic Mobile Telephone (NMT)	1981	Nordic Countries, Some other EU members, Saudi Arabia	450- 900 (later) MHz
American Mobile Phone System (AMPS)	1983	USA, Latin America, Korea	800 MHz
Total Access Communications System (TACS)	1985	UK	900 MHz
NTT-AMPS	1979	Japan	800 MHz

Source: (Seo, 2013), (IEC, n.d.)

Second Generation Mobile Communication Systems (GSM): Thanks to technological advancements like invention of the microprocessor and the digitization of the control link between the mobile phone and the cell site, second-generation systems were developed at the end of 1980s. These systems have both digitized control link and the voice signal.

As expected, 2G systems surpassed the prior generation in terms of better quality and higher capacity at a more affordable pricing to end users, (ITU, 2011). Like 1G, several different standards originated in different countries and competed for market dominance throughout the world. As Table-17 shows most prominent ones were European GSM, Japanese PDC, two USA's CDMA and D-AMPS, (Beise, 2001, p.139).

Table 17- Prominent 2G Technology Standards

Mobile System	Commercialization Year	Countries	Frequency Band
(GSM)	1991-2	Pan- European	900- 1800 MHz
(PDC)	1994	Japan	800-1500 MHz
CDMA	1995	USA, Korea	450 MHz
(D-AMPS)	1991	Americas	800-800 MHz

Source: (Kasera & Narang, 2007), (ITU, 2011)

Among them, GSM was one of the first systems to provide commercial service to consumers. Development history of this standard dated back to early 1980s. As an EU initiative, EC and other policy makers, telecommunication service providers (operators), hardware producers and other related sectoral associations were all involved in this project, (Beise, 2001).

On the other hand, public organizations did not support and/or mandate one standard (market guidance and formation function) in USA, disrupting the dominance of one-technology and diffusion rates of mobile telephone usage. Although earlier TDMA adopted by cellular operators' association as early as 1991, several operators opted to choose CDMA due to technological superiority concerns. Moreover, this country's telecom regulatory authority, FCC awarded frequencies to operators without mandating any standard to use in their networks. As another case, Japanese standard (PDC) was incompatible with other country standards and as a result did not achieve any world- wide popularity, i.e., adoption rates, (Beise, 2001, pp.145-146). Nevertheless, the number of GSM users surpassed 10 million in 1995, only after nearly 3 years from commercial inception. In 1996, GSM MoU membership surpassed 200 operators in almost 100 countries, (GSMA, n.d.-a). The subscriber base of this system had reached nearly half of the total number of mobile telecom users throughout the world in 1999. It is evident that (as indicated) public policy guidance had a defining role in the achievement of this market dominance. Edquist likened the collaborative nature of this undertaking to NMT case, but this time scale and scope of the system elements and their interactions were larger and more complex in various dimensions. On this occasion, regulatory authorities and EU organizations like ETSI (European Telecommunications Standards Institute) took part in implementation of the project, in addition to business firms like service providers and hardware producers.

Similar to the NMT case, Nordic country telecom operators (mainly Swedish Televerket) and hardware vendors Ericsson and Nokia led the collaborative effort to develop 2nd generation of mobile telecommunications standards.

This process of forming single digital standard (as opposed to USA case) had given EU firms scale and scope advantages to establish dominance in world markets.

Although the outcome is a success, the path to the outcome was not so smooth if one look into the inside mechanism of this process. Bach (2000) has emphasised the central role of EU Commission to overcome differences in member states technological preferences. He argued that apart from political leadership, assurance of sufficient returns on investments were the economic reasons for establishment of member states cooperation.

As a last remark in this subject, Edquist pointed out to the fact that GSM technology evolved in the monopolistic market structures of EU countries. On the other hand, success in the second-generation mobile communications technology paved the way for subsequent market liberalization throughout the EU member states.

Third Generation Mobile Communication Systems: Edquist has argued that third generation standards came after market formation stage of mobile telecommunications and especially oriented to increase functionality- usage ways of this revolutionary technology.

In fact, ITU defines 3G networks as a single standard consisting of several technologies (i.e., UMTS, CDMA-2000 and WCDMA) that have capability of communicating with everyone at any time and in any place.

Maximization of network capacity and ability of providing multimedia services are two core features of these technologies. In other words, 3G (IMT-2000) has offered bundle of voice, data and multimedia services for the first time in the evolution of mobile telecommunications.

Similarly, Edquist summarized the main difference between the former and latter ones as the complete integration of voice & data communications and fixed & mobile networks, utilization of broadband frequencies and delivery of uninterrupted global roaming.

Development of 3G traced back to the mid-1980s through 2000 in which ITU established a single standard for an umbrella of technologies called ‘IMT-2000’ with the contribution of different stakeholders in the sector.

In addition to this, an international and cross-sector organization called UMTS Forum was established in 1996 with the participation of diverse actors such as telecom operators, equipment producers and vendors, sectoral regulators, research entities and application builders to support the development and adoption of 3G/UMTS on commercial bases, (Bienaimé, 2005).

A Japanese firm (NTT DoComo) offered first 3G services in 2001 and other countries especially from EU started to make auctions for these kind of licenses in the same period.

It should be mentioned at this point that, these license fees were very high and caused some investment problems for telecom operators later on.

Most notably operators paid 50.5 billion Euro in Germany, 38.6 billion Euro in UK, 12 billion Euro in Italy.

Here, some experts (including Edquist) think these excessive fees negatively affected network investments by telecom operators. For instance, O'Brien (2006) argued that expenditures on 3G licenses depleted operators' resources and their ability to invest in network & application developments in the short term[113]. These governments mostly used licensing revenues for financing budgetary deficits and payment of public sector debt (e.g., UK public-sector debt reduced to £307.5 billion in 2001 from £342.6 billion in 2000).

Starting from 3G, the success of EU in the prior generations has not been repeated in the same scale due to increasing competition from other technology developer countries and structure of their internal markets. As indicated, public sector support (monopoly and monopsony situation of PTO's) led to the pioneering role for EU in second-generation mobile telecom as opposed to existence of more liberal telecom markets during the development of third- generation technologies.

These developments have also affected related market segments and actors as well. As Edquist projected both the number of service/production categories and the number of actors in these groupings have increased and this trend is continuing with the advent of recent technologies. There are –in most cases- three to four big mobile service operators in each country, together with numerous small-scale companies such as

[113] The effect of licensing policies (including fees) is discussed in more detailed terms in chapter 3.7.

virtual mobile providers that are increasing market competition in today's telecom service markets. In the equipment production part, Edquist has seen the position of vendors as relatively stable taking into account the fact that both entry barriers and scale economies play crucial roles in this market segment. Notwithstanding to this argument fully, especially after 3G relatively newcomers entered into sub segments of this sector. More strikingly, Apple has become one of the most dominant mobile telecom handset producers (but not actually a telecom infrastructure provider), destroying the other early comer market shares like Nokia and Ericsson in this segment.

In fact, people have witnessed more and more competition in this category with the inclusion of Samsung, Huawei and many other Chinese producers as related technologies became more standardized in recent years.

As a conclusion on Edquist's analysis, one can discuss several issues that are still valid in current market environment. It is already mentioned that convergence due to uninterrupted technological development (change) has continued to reshape telecommunications along with almost other sectors (industries) in varying degrees. What is relevant for this (our) discussion is the scope definition of the study.

In line with this analysis, although discussed more detail in the case study part, the (thesis) scope covers both telecom service producers and equipment providers since these two together make up the necessary and solid infrastructure base of digital transformation in any society (country).

For policy considerations, three subjects come into forefront among others. First of all, institutions are vital for the efficient functioning of telecom innovation systems whether national, regional, technological consisting of one or more than one segment at the same time.

It is seen that standards influence later market developments and might lead to dominance of some firms at the expense of others through scope and scale economies.

Other market regulations (and deregulations) such as entry barriers (in the form of licence fees etc.) and quality-safety requirements may also affect sector players performances-activities in various ways. Secondly, interactions between elements of the telecom innovation system (i.e., between organizations, between institutions, between organizations and institutions) have an influence on the performance level of the whole system.

For instance, government support in the development phase of internet technology through various means like research funding led to market dominance of USA firms later on.

Moreover, even in today's market conditions, EU member countries have increasingly resorted to public procurement methods to assist their companies to stay (or to become) competitive on a global basis.

On the other hand, one can give possible coexistence of high level of taxes and sectoral goals as an example for institutions that may have contradicting effects on the sector, e.g., high level of taxation on internet services and governments' objective of increasing internet usage numbers.

Thirdly, Edquist gave priority to timing of public policy intervention in the development of telecom innovation system.

As discussed in the previous part, market uncertainties are higher in the early market formation stage but the rewards for early commercialization is also crucial for later market stages.

That is to say, public policy and intervention may be more effective and influential in the market guidance role.

In this context, one can safely argue that the GSM market development process is one of the most striking success stories for the importance of early market guidance by public policy makers as opposed to USA's more liberal policy of not selecting and supporting one mobile telecom standard in the early market formation stage.

4.5.2.2 A Study on China Telecom Sector IS

Pasadilla and Zhu (2016) focused on a Chinese telecom hardware producer that has an expanding business globally in their case studies.

In this attempt, they firstly sketched a general picture of sector and supply chain overview, as shown in Table-18[114].

Table 18- Supply Chain Overview

Component Suppliers (Contractors) ↔	Equipment Providers (Vendors- Manufacturers) ↔	Service Operators (Providers) ↔	Users (Consumers, Other Businesses, Retailers)

Source: Pasadilla and Zhu (2016)

To start with, component suppliers, telecom hardware producers, telecom service providers and users of these services along with the public entities (related ministries, regulators etc.) comprise core actors of this supply chain. Contractors produce and/or supply raw materials, intermediary goods for final equipment production by vendors.

These companies in turn devise and advance telecom hardware by performing R&D activities both in-house, in cooperation with other firms and outsourcing some of them. They also set up their marketing and distribution lines on a global base. Due to tremendous pace in ICT developments, product life cycles are shortening and this is further increasing the importance of R&D and the coordination of this activity with final product design and commercialization.

Technological progress, most notably in internet and mobile telecommunications, is continuously changing the structure and domain of the hardware sector. Since the advent of mobile communications, product portfolios of these vendors have been shifting more to mobile handsets and wireless network (infrastructure) equipment like base stations.

Another important trend is the rising share of services and software-based parts, functions of these telecom products. Furthermore, especially after 4G newer services like big data management, cloud applications have been entering into product portfolios of these global companies.

As the scale economies, R&D intensities and capital investment requirements are high, the sector is also highly concentrated and small number of manufacturers dominate the

[114] This section draws heavily on Pasadilla and Zhu (2016) unless otherwise stated.

market. For instance, in 5G-equipment segment not more than five manufacturers make up nearly all the world's market in total (Figure- 9).

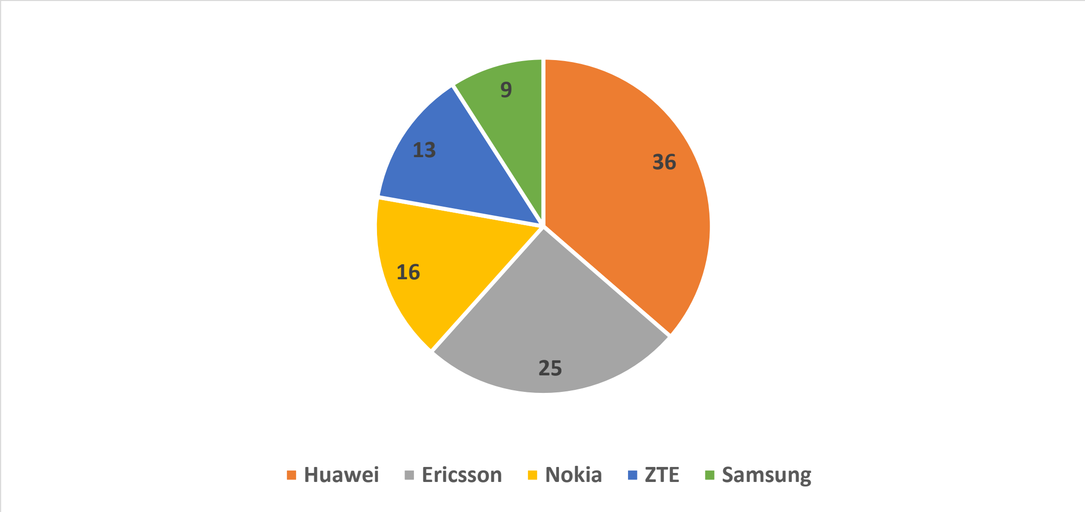

Figure 9- Market Shares of Telecom Equipment Producers (in 5G segment)

Source: (Zang, 2020)

With more than 35% market share, Huawei has been the market leader in the first quarter of 2020. Being second, Ericsson has nearly 25%, followed by Nokia with nearly 16%, ZTE with near 13% and Samsung with near 9% market shares (Zang, 2020).

It should be noted that the numbers are estimations by different organizations. The important thing is (and the common estimation) that few companies dominate the market.

Looking into overall telecom hardware market revenues for 2022, estimated by Dell'Oro Group (2023), seven vendors have over 80% market share in the world.

In this category, Huawei is the leading one, followed by Nokia, Ericsson. Remaining part is shared by Cisco, Ciena and Samsung.

Before passing to the (individual) company analysis, the authors briefly stated the global market growth and domestic market size as the important factors for this company's future prospects (market growth potential). Here, increasing number of 4G connections globally has given as an indication for the potential of mobile broadband (i.e., 5G) and network market trends and investments in the world, (Figure-10).

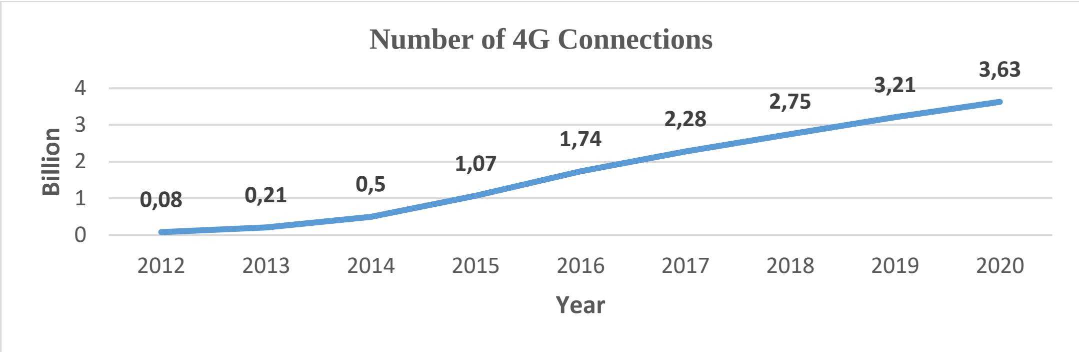

Figure 10- Number of 4G Connections (in the world)

Source: Statista web page

From the growth pattern of mobile telecom usage and future forecasts, it is evident that this sector has optimistic future growth pattern.

Cisco predicts 4G connections will reach nearly 6 billion in 2023 and 5G connections will rise from app. 13 million in 2019 to about 1.4 billion in 2023.

Main growth factor for 5G will come from mobile IoT connections and with the increasing availability of 5G coverage, these figures are expected to rise even further throughout the world, (Cisco, 2020).

In terms of coverage rates, ITU (2022) estimates that 4G network availability doubled to attain nearly 90% of the world's population between 2015 and 2021. For the market size and growth pattern[115], Pasadilla and Zhu referred to huge amount of base station instalments and fiber optic cable length investments each year.

This is especially important for the fact that the firm China's Ministry of Industry and Information Technology (MIIT) reported that base station numbers have surpassed 10,83 million in 2022 with an increase of 0.87 million from the end of last year as shown in Table-19. Here, 5G base stations comprise approximately 21% of this total amount.

Taking into account the need for more base stations in urban areas for 5G coverage,

[115] It is obvious that- without much detailed further argument- China with a population of nearly 1.5 billion people give huge internal market advantages to these country's firms and this is valid for almost every sector of her economy.

this type of investments will undoubtedly increase faster in the near future.

Table 19- China's Telecom Network Statistics

Categories	Total	Addition (in 2022)
Fiber Optic Cable Length (million km)	59,58	4,772
Cellular Base Stations (million)*	10,83	0.87
5G Base Stations (million)*	2,312	0.87
Broadband Access Ports (million)**	1,071	53,2
FTTH/O Access Ports (million)**	1,025	65,34

Source: (Marbridge Consulting, 2023), (*) Cellular base station numbers include 5G base station numbers. 5G base stations have accounted 21.3% of total base stations. (**) Broadband access port numbers include FTTH/O port numbers. FTTH/O has accounted 95.7% of total access ports.

Analysis of the firm and its value chain: The company (ZTE)[116], which is under study, has business presence in more than 160 countries.

This presence consists of different entities ranging from joint production plants, R&D centres to engineering service stations and sales offices. It has global production facilities in China, USA, India, Venezuela, Pakistan and Indonesia. The authors state the reason for establishment of global production facilities are reducing logistical and labour expenditures.

Furthermore, the firm formed joint corporations with the local telecom service providers.

For instance, a joint company (ZTE-Congo Telecom Corporation) established in Congo with fifty-one percent share owned by this global vendor. The company web site states that the joint venture delivers telecom services by installing their equipment including GSM systems and satellite earth stations (ZTE, n.d.-a).

From this, it can be inferred that the strategy is to capture other country markets by

[116] Pasadilla and Zhu (2016) did not mention the name of the firm explicitly but gave all other information related to this company and (it is clear that) ZTE is the focus of their study. The origins of the firm traced back to 1985 when established by former Ministry of Aerospace Industry to produce small electronic products. The firm reorganized as a public listed company and concentrated on the telecommunications hardware. It was also the first telecom equipment firm in the Chinese (Shenzhen) Stock Market as of 1997.

devising various strategies like establishing local plants and/or diversifying to other related segments in those markets. Apart from this, the company allocates nearly 10% of its revenue to R&D activities each year.

Likewise, it has R&D centres (over 18) all around the world including USA, France and Sweden. In doing R&D, the firm collaborates with other research institutions, universities and obtains research funds from the Chinese government. One indication (output) of these efforts are large numbers of patents obtained by the company.

By the end of 2019, the number of filed applications has surpassed 74.000 of which 34.000 are licensed (ZTE, 2019). The product portfolio of the company comprises nearly 80 kinds in 17 categories.

ZTE can provide complete telecom network solutions to even whole country level infrastructures including wireless equipment, base stations, switching systems, optical fiber, monitoring systems to name a few of them.

As already discussed, mainly due to technological development and convergence, video conferencing systems, data management and mobile handset productions are also getting more shares in its portfolio.

Table 20- Product and Service Classifications

Handset	Terminal	Mobile Phones, Pad, Data Card, Convergence Terminal
Networks	Wireless	GSM, CDMA Systems, 4G LTE, Base Stations
	Fixed Access	Integrated Service Access Platform, DSL Systems
	Core Network	Voice Communication, Packet Core, Convergence User Data
	Bearer	Optical Transmission, Data Communication, Routers, Ethernet Switch
Telecom Services, Software Systems, Others	Cloud Computing & IT	Cloud-computing infrastructure, operating support systems, Server, storage
	Services	Maintenance Support Services, IT Integration Services
	Energy & Infrastructure	Telecoms Power System, Telecoms Tower, UPS

Source: Pasadilla and Zhu (2016), p.317.

Pasadilla and Zhu (2016) put these outputs into three broad categories as shown in Table-20.

They argued that the company maintained its strong position in home market because of mainly established relationships with service providers, technical expertise and R&D supported broad range of product portfolio capable of giving integrated end-to-end solutions and capability of retaining stable operating profit margins continuously in the past years.

Indeed, the company has an extensive portfolio of commercial offerings and this trend is continuing to increase further recently as a result of starting 5G network deployments and related applications, services in several other sectors (vertical sector usages).

Currently, these offerings displayed in three categories as products, services and solutions, in addition to support function that applicable to all of them.

As the importance of 5G solutions and products are rising, the company gives them in separate categories. For instance, *5G Precise Planning, 5G Automatic Integration, 5G Intelligent O&M and 5G Intelligent Network Optimization* are the categories of 5G services offered by the company, (ZTE, n.d.-b).

Specification of Value Chain: The research emphasised that hardware producers offer their products (including services) by arranging them for a complete solution (i.e., end to end) to extract as much revenue as possible from bundled offering of equipment-network provision- installation, after sale services and other value-added applications like cloud data management.

In general terms, these vendors have two different production lines for network (which has more R&D intensity) and handset terminals.

In this context, Pasadilla and Zhu (2016) focused on wireless network products/services, since this group generated more than half of the company’s revenues and further market potential taking into account the growing significance of 4G and forthcoming (at that time) 5G technologies. Related supply chain in wireless equipment has five essential stages comprising of ‘R&D and product design’, ‘Procurement and sourcing’, ‘Assembly and manufacturing’, ‘Distribution, marketing and sales’ and ‘After-sales service’.

R&D and product design: The authors started supply chain process from R&D and product design. This phase is closely related to (or shaped by) international standards and customer (e.g., telecom service providers in different countries) demands (requests, necessities). According to this study findings, innovative (new) ideas often come from standard setting organizations and outputs of these organizations (standards such as GSM, 4G LTE). What is more significant is the firm's active involvement in the standard setting processes. It is clear that, like other global vendors, firm strategy consists of actively participating in these developments and even initiate new processes in this regard. By doing so, it aims to reduce the uncertainty of innovation activities (e.g., costs occurred from R&D, product design and compatibility issues) and to stay alert to other firm's technological innovations.

Each of (it's) R&D centres concentrates on different segment of product portfolio. However, there exist continuous knowledge sharing and interactivity among them to coordinate these individual (separate) efforts. The research centres based mostly in developed countries to benefit from the expertise (know-how) of these locations (i.e., regional innovation systems, knowledge spill overs). In the second place, accumulated knowledge is transferred to R&D centres based in home country to assist in final product developments. The company has a strong patenting policy to protect these know-hows and to stay competitive against other global industry players. On the other hand, getting licences from outside parties (like software developed by start- ups) are also important for this firm to reduce some of the operating and research costs as well. In every step following initial design, expert teams from all related departments like finance and marketing make feasibility studies. Here, senior management approves the continuation of any project after each step like prototype development etc. until commercialization of the product or service.

Sourcing and Procurement: From this study, it is observed that the company has a diversified procurement policy. For each input category, the firm in principle has an agreement with at least two suppliers and gets nearly 20% of these purchases from five suppliers.

Notwithstanding to this, there exists centralized procurement practices to benefit from economies of scale.

Main raw materials and inputs for final product offerings include "off- the rack hardware, software modules and applications, circuit boards and custom application-specific integrated circuits (ASICs)". Logistics (transportation of these inputs etc.) is outsourced to other specific (logistics) firms and the company's own resources perform only short-distance transportation.

Product Distribution, Marketing, Sales & After Sales: The study reveals that final packaging is made in-house and distribution of these products are done either by other firms or by affiliated companies. There are different marketing channels for telecom hardware and handset terminals due to reasons that each has different technologies, customers and after sale requirements. The company provides telecom hardware through business-to-business channels and mainly by making telecom systems contracts with customers. This is especially useful for the company since these sale agreements include various additions such as installation, integration and maintenance services that are providing long-term revenues.

This firm has also widespread sales and marketing channels in various parts of the globe. Through local offices, it aims to establish close connections with regional service providers. In some cases, where there are restrictions on working conditions (foreign firm participation restrictions etc.), the vendor set up cooperative arrangements with regional actors. As expected, after sale services are crucial for both short and long-term viability of the firm. These services comprise of mainly *installation, certification and commissioning, maintenance and repair, technical training and other consulting services.* One can easily see the importance of these services for the long-term commercial relationship between the vendor and customer firms taking into account the fact that technological developments continuously necessitate new upgrades and investments to the existing infrastructures, networks of customers (telecom service providers). An example given for overseas operations is the construction of base stations. The authors explain that construction of these stations usually outsourced to local companies.

In case of repair needs, regional offices can take care of simple maintenance and for complicated breakdowns (faults), required components and know-how are obtained from the related home country departments.

Services in the Value Chain: This study determines 72 services in the value chain of the company. These are grouped in 'R&D and product design', 'sourcing and procurement', 'assembly and manufacturing', 'product distribution, marketing & sales', 'after-sales' and 'business processes'. For instance, 'R&D and product design' category consists of product development R&D, market research, conception and design of product, hardware design, software development, patent acquisition, licensing services and prototype testing. Each of these service categories further include 126 sub-services. As an example, licensing category has three parts itself, licensing services for the right to use R&D products, licensing services for the right to use trademarks and franchises and licensing services for the right to use other intellectual property products.

The authors argue that most important categories are R&D and after-sales services. As the technological base of the sector changes uninterruptedly, every firm in this sector has to prioritize research and development activities (and investments) in its core competence to stay competitive among others. After- sale services are also vital (as already indicated) for maintaining long term relationships with telecom service providers, other than only selling hardware in a one-step selling and buying relation.

The company performs 37% (46 services) of the total (detailed) 126 services by using its own capabilities. The remaining 42% (53 services) partially outsourced and 21% (27 services) fully outsourced to other firms. Findings of the study stress main reasons for outsourcing as presence of activities lying outside of the core competencies such as advertising, overseas activities like storage, mandatory testing activities, market research activities and some services like logistics where economies of scale are important for cost minimization purposes.

On the other hand, some activities that lie in the core competence domain like 'R&D, product design, patent acquisition, quality assurance, maintenance and repair' provided by using in-house capabilities. In parallel to this, the number of working personnel in R&D related services account for more than 35% of total workforce.

Regulations that influence Firm Activities & Conclusion: Before concluding, the authors identified major institutions (regulations) that affect the company's activities. To start with, they have not seen standards and registration institutions as barriers (or problems) for the firm's operations, owing to the direct participation in such activities. In this context, majority of the problems occur in relation to overseas investments and operations. These are cyber- security issues, dumping allegations and competition related investigations (anti-competitive practices), local content requirements, intellectual property disputes and labour mobility.

It is already discussed that cyber-security has become one of the most vital parts of national security for various reasons. As digital transformation permeates every aspect of socio-economic life, control over data (e.g., transmission, storage and analysis) is getting strategic importance for every state in the globe.

Furthermore, it is evident that technologically advanced countries (especially USA and China) aim to dominate (control) other country markets and they even try to manipulate cyber-security threats for sustaining (protecting) the interests of her global companies. Hence, without going into much detail, one can easily point these issues as the most important risks for this firm (along with other Chinese companies). Dumping allegations and anti- competitive practice complaints could also bring some risks for international operations of the company, though not as serious as the first mentioned problem.

Local content requirements present barriers for the overseas expansion of this firm. For instance, it is stated that in one ASEAN economy, related regulation has necessitated 30% of local content in the production of 4G smart phones[117].

As it will be elaborated, Türkiye has also some kind of local production and R&D requirements for these global vendors. While these efforts are necessary for the establishment (and/or protection) of domestic industry, it has undoubtedly led to higher production costs and reduction of sales revenues from the perspective of these global vendors.

Intellectual property and labour mobility issues are other concerns mentioned in the study. The authors give attention to the practice that these global players use each other’s licensed technology and disputes may happen between them in some cases.

For this reason, a dedicated in-house legal team exist in the company to deal with these

[117] The study does not give the name of this country. Ten Southeast Asian states Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam are members of ASEAN (The Association of Southeast Asian Nations).

costly and time-consuming processes (e.g., legal cases over patent rights etc.)[118].

Lastly, this study considers restrictions on the labour mobility as another risk for the company's overseas investments.

However, it can be said that labour mobility issue is not as critical as the above-mentioned policy changes especially in USA and this government efforts to restrict the operations of the related (along with other Chinese companies) firm in other countries like UK and Canada, to name some of them.

In the light of these summarised arguments, the authors concluded by reiterating some of the points that are important for overseas operations of the company.

They have suggested (establishing) cooperation agreements with other firms, establishing (taking part) organizations in other countries to open each other's market to competition and to incentivize knowledge transfer.

They have considered embedded (to hardware sales) and after sale services as vital for the long- term profitability of the company.

According to them, protectionist policies and restrictions on labour mobility may harm the foreign country by increasing costs, reducing efficiency etc.

This is an expected observation from the view point of the authors but the importance of having a domestic capability and know-how as one of the most important pillars of digital society cannot be ignored by other (especially developing) countries. Of course, with a caveat that that innovation and technology policies should not be seen as only home sector protection and permanent import substitution disregarding efficiency and

[118] It is beyond the scope of this thesis study to look in IPR-patent related conflicts but a few examples may clarify the extent of these disputes. For instance, legal disputes between Quallcom and Apple related to patent royalty fee payments took nearly two years and only ended with the settlement between these two companies. In this case, Apple initially opposed the payment of license fees for Quallcom but the case ended before legal decision with the agreement of Apple to pay these fees to the other party. Analysts suggest that Apple resolved the issue earlier than expected since the company wanted to prioritize 5G transition process, (Faber & Leswing, 2019). As another case for showing the use of IPR, Huawei has started to change its patent policy in USA after the 5G disputes between these two countries. Previously, Huawei did not demand fees like royalties etc. from other producers but this policy has changed since 2019. What is more interesting is the fact that although this firm faced with bans in USA, its patented technology has been used in various companies operating in this market, (Kharpal, 2019). As a turning point for this strategy, Huawei requested from Verizon to pay more than 1 billion USD for over 230 patents, (CNBC, 2019).

need for achieving some level of competitive capability in the world markets within a dynamic perspective.

4.5.2.3 Analysis of USA Telecom Sector IS

Cohen et al. (2014) have analysed telecom equipment sector of USA by using a qualitative framework and making interviews (consultations) with sector actors (stakeholders)[119]. Initially, they have made two central observations.

Firstly, global competition influenced the sector structure leading to market consolidation and vertical integration between related actors.

Secondly, Federal Government (of USA) regarded this sector as having critical importance in national economy and security, especially due to its enabling (infrastructure) role in other sectors and services.

Within this background, the government has aimed to sustain (safeguard) capabilities of home (domestic) sector for the country's national security and economic competitiveness in international markets.

Other government objectives include promotion of IS ecosystem related to this sector (telecom hardware) and safeguard (guarantee) the provision of trusted (dependable) hardware to the domestic telecom infrastructure.

Having stated objectives, the authors defined the scope as comprising *"the optical core network, the router/switch and the wireless equipment sub sectors"* for the reason that these have been faced with more risk and under threat of global competition.

They have reached this scope definition (classification) after making interviews with the members of the *Defence Production Act Committee (DPAC)*.

In essence, the analysis consists of several steps. First step involves designation of public objectives as indicated through literature review and interviews. Then, the researchers have identified critical sub sectors. Afterwards, they have constructed a qualitative framework and made SWOT analysis. Finally, they have derived specific

[119] This section draws heavily on Cohen et al. (2014), unless otherwise stated.

policy recommendations based on these observations.

Determination of Public Policy Objectives: The study regarded telecom sector as a vital driver to many other industries that are important to the socioeconomic well-being of the country.

In this context, the researchers emphasised the competitiveness of domestic market is a prerequisite of global market competition for domestic companies.

Innovative capability and competitiveness of this market segment - considering this as a part of wider ICT environment- has an influence on both upstream and downstream markets.

For instance, the competitive levels of newly developed value-added services such as cloud computing has largely depended on the structure and capacity of telecom networks.

One can easily notice the fact that with the transition to 5G (vertical usages) and ever-expanding IoT adoption, enabling (leading) role of this sector has continued to increase in the near future.

Another essential point is supporting domestic companies to maintain and/or to improve their innovative capability by various means like R&D funding and supporting a suitable habitat for incubation of new firms and development of original (novel) products/services.

Here, the report indicated specific telecom infrastructure requirements for research organizations.

The upshot of this argument is that these organizations should have up to date ICT infrastructure and having strong hardware producers in the domestic market is certainly facilitates (helps) this adoption process.

Closely related to this, government officials (interviewed in the research) assumed the existence of domestic (national) production capabilities essential for national security (e.g., cyber threats) concerns. According to the study, they also thought that without a viable hardware sector, domestic technology developers in the cyber security area could be in a difficult position to find consistent demand for their products/services.

The Qualitative Framework: The framework incorporates sectoral risks, objectives, policy options, technology & market directions and desired results as shown Table-21.

The researchers then, determined (indicated) the relationships between these subjects.

Table 21- Qualitative Framework

<table>
<tr><th>Risks</th><th>Objectives</th><th>Desired Result</th><th>Policy Types (Methods)</th></tr>
<tr><td>Incapability of domestic sectors raise national security vulnerabilities</td><td>Rejuvenate (Increase) national firm’s capabilities</td><td rowspan="3">Expanding market share

Improving innovation rate</td><td rowspan="3">Regulations, Standards, Trade, Support to start-ups

R&D investments, public-private partnerships, cooperative research and production, public sector as first- time (early) user

National infrastructures</td></tr>
<tr><td>Decrease (Loss) of competitiveness</td><td>Strengthening global capabilities of national firms</td></tr>
<tr><td>Losing innovation leadership in vital industries</td><td>Support of innovation ecosystem</td></tr>
</table>

Source: Cohen et al. (2014)

Scope definition: The authors begin scope analysis by stating the overall structure of telecommunications sector.

As Table-22 shows, at the very general level, sector is divided into two parts; wired and wireless networks.

Wired part in turn can be sub grouped in wide-area network, metropolitan area network and access network that covers the last-mile.

All these three combines to provide various end-user services such as internet access, cable TV, voice over internet protocol and virtual private networks (VPNs).

The table below also shows wireless cellular network topics. Here, LTE include E-UTRAN, remote radio head and evolved packet core is included in this category.

Table 22- Wired and Wireless Telecommunications Segments

Segments	Characteristics	Common hardware parts
Wide-area network (WAN)	Combination of Local-area networks. A network of networks. Internet is the biggest WAN. Telecom, cable and satellite service carriers use/supply WAN to enable interconnection of remote sites for data, voice and video transmission. In general, it is fiber based and contains long-haul optical links that can transmit huge amount of data (in several terabits per second).	Common WAN/MAN/LAC equipment include modems, servers, channel-data service units, switches, routers (high-medium capacities), enhanced Ethernet equipment for long-haul and metro gateways, bridges, fiber optic cables etc. For core optical network, transmission, add/drop multiplexors, multiservice provisioning platforms, metro transport, metro ROADM, Long-haul transport, long haul ROADM and Long-haul submarine line terminating equipment.
Metropolitan-area network (MAN)	MAN stands between WAN and last-mile access. It consists of networked interconnections in a limited geographical area ranging 5 to 10 km in diameter. It enables sharing of regional resources and a shared connection to other networks	
Access network (last-mile)	This is a last leg of telecom network that links computers and devices within a small area like homes, business offices and universities. The devices belong to this network can access and control each other, utilize one internet connection, share files with others, use peripheral equipment like shared printers, together.	
Wireless Cellular Network	A mobile network for wireless communications. New technologies like GSM, GPRS and CDMA lead to tremendous changes and growth in mobile networks. Cells that have functional base stations make up these networks. Base stations through backhaul links join to metropolitan and then to the wide-area networks. Mobile telecom traffic can be re-directed through other mobile networks, the telephone network or the internet to connect the user to the requested service.	LTE include E-UTRAN, remote radio head and evolved packet core WiMAX include home agent, ASN gateways and base transceiver stations *(5G is not included at the time of the study)*

Source: (Cisco, n.d.-b), (Indiana University ITS, 2018) , (Cisco press, 2017); (Ramaswami, Sivarajan, & Sasaki, 2009), (Sivabalan, n.d.).

As pointed out, in parallel with the expanding presence of digitalization worldwide, usage numbers will certainly continue to increase with a tremendous pace in the near future[120]. The implications for this sector are obvious in the light of these trends.

Investment requirements (needs) in new and more efficient network components will continue to be present in the future to meet ever-growing usage and demand for more sophisticated mobile applications like virtual reality and fully automated vehicles.

Market Structure: The study has indicated a market consolidation trend in the previous years.

Vertical integration, consolidation in service markets (and resulting reduction in the number of service providers), long-lasting relationships between existing vendors and service operators are among the reasons for this trend. The optical, router/switch and wireless equipment sub markets are dominated by more or less five global vendors[121].

Application of Qualitative Analysis Framework: Even the basic observation of market structure in the sector over the years shows a stable trend and not much change in terms of actors.

For this (main) reason[122], the study advocates focusing on emerging technologies rather than mature technologies and established markets.

Parallel to this observation, it is imperative to find out early opportunities and upgrade domestic capabilities in these areas.

Having said this, the study proceeds with evaluation of the sectoral trends and determination of policy methods to take advantage of these future developments.

The first stage consists of a SWOT analysis, showing the strengths, weaknesses,

[120] Although precise (growth and usage) numbers are not easy to obtain, there exists many statistics showing these trends. For instance, one of these prediction states that 11 new internet users added to the total figure every second, making 1 million new additions in just one hour, (Dougherty, 2019). For future forecasts (trends), Cisco predicts 5.3 billion internet users and this amounts to near 66 % of world population by 2023. Even more striking is the projection for the number of device connections. According to this, there will be more than 29 billion networked devices in 2023, more than three times of predicted world population in this year.

[121] Huawei, Fujitsu, ZTE, Ciena, Alcatel-Lucent in optical network; Cisco, Alcatel-Lucent, Huawei, Juniper and ZTE in router/switch category and Ericsson, Alcatel- Lucent, Huawei, Nokia Siemens in mobile infrastructure categories.

[122] This does not mean that there are other factors like market consolidation, long-term contracts, scale economies etc. but the dominance of these five firms and relatively stable market shares itself indicates the difficulty of entering in this business.

opportunities and threats facing these sub-sectors, (Table-23).

From this SWOT analysis, the authors infer seven sectoral trends that has an effect on the market for the next decade (roughly 2016-2026).

The study is conducted in line with an innovation system understanding that not only competition between different technologies but also many other factors such as regulation, influence of global standard setting process, incentives to early user adoption and active public policy have influence on the final outcome of market structure, as well.

In the analysis, especially competitive threats from other countries have been emphasised along with a need for more proactive public policy in new technology development areas. Details of this is given in the below table in main topics.

Table 23- SWOT Analysis

	Strengths	**Weaknesses**	**Opportunities**	**Threats**
Optical Core Network	Increasing demand Growth potential (continuous growth experience) Strength of research activities in universities Leading position of one firm (Infinera)	Few national vendors Procurements strongly linked to service provider hardware renew cycle	Capacity increases of Optical Systems Performance increases of Metro Equipment (due to cloud computing etc.) Emerging areas like silicon photonics and availability of research and development potential Expansion of cloud computing data centres (to enable new firms to enter in this field)	Existence of long-term contracts Vertical integration Foreign competition and R&D efforts Possibility of overseas production (if innovative efforts are successful)
Router /Switch	Increasing demand Growth potential (continuous	Increasing market share of foreign firms	Demand for new equipment	Vertical integration

	Strengths	Weaknesses	Opportunities	Threats
	growth experience) Brand loyalty Competitive national firms Advantages in software defined networking (early comer advantages, leading position in R&D and standard setting etc.)	Product cycles linked to service providers refresh cycle Hesitancy of incumbents to compete with own products	Possibility of New entrants with innovative SDN technologies	Foreign competition and R&D efforts Unwillingness of service providers to use new entrant's products Reduction of profits in traditional firms due to new technologies like SDN
Wireless	Increasing demand Growth potential (continuous growth experience) Well-positioned firms like Qualcom Presence of advanced research capabilities (in related fields like cognitive radio and spectrum sharing)	Lack of major 4G suppliers Inadequate opportunities for outlets to innovation Financial advantages of foreign vendors	Emerging 5G technology and usage cases (Innovation opp.) Related hardware dev. opportunities in spectrum sharing, cognitive radio, smart antenna etc.	Leading 5G developers (early comers) like China, Korea and EU Foreign vendors' market power in 4G

Source: Cohen et al. (2014)

The analysis has categorized major factors of transformation (in related sub-sectors) into three; demand, market and technological innovation-oriented categories. Expanding consumer base, technology acceptance, shifts in technology utilization patterns and internet trends make up the first category.

Market related drivers include level of competition, consolidations, aggressive pricing, sectoral investments, other institutional factors like standards, interoperability and regulations.

Research and development work and objectives, disruptive innovations, new product/service diffusion rates, sunk costs and capacity constraints are in the last category. To start with, the first trend is the continuing expansion of internet, telecom devices and services that lead to tremendous increase in demand, as mentioned above[123]. It is certain that, prevalence (and diffusion) of services like IoT, M2M communications, AVR etc. will pass to another level that has never been experienced before, especially with the advent of 5G and beyond mobile telecom technologies. At the same time, the sector is experiencing vertical integration and number of big players are not changing (even decreasing). This highlights the crucial factor of scale economies in the sector. There exist technology related trends and they have an effect on the market structures as well. Indeed, if we take into account the effect of disruptive and/or emerging technologies, the impact of these will be even more crucial in medium to long term. Starting from roughly 2010s, 4G (LTE) technology has required new infrastructure investments, mainly upgrade (change) from a circuit-switching network to all IP- based packet switching network.

Cloud computing is another technology made possible due to high-speed networks and necessitates new types of hardware, capacity increases, data centres etc[124]. Moreover, software- defined networking (SDN) enables intelligent control of network operations and it brings in new business opportunities for the equipment producers[125]. Another

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[123] The market trends and forecast figures are already given and is not repeated here.

[124] It is already stated in the 5G (vertical) usages-applications part (of the thesis study) that telecom service providers are seeking to enlarge service portfolios to increase their revenue bases and cloud computing is one of them. Telecom service operators can offer these (increasingly demanded services) by making some investments (network upgrades) as add on platform to their existing networks as a service (PaaS), software-as-a-service (SaaS) and infrastructure –as-a- service (IaaS). What is more interesting is the fact that previously only content providers (from internet) such as Amazon and Google are beginning to provide other kinds of value-added services like cloud computing and management by building (constructing) high speed networks. These are, in turn further stimulating demand for related hardware/software and at the same time increasing the necessity of higher capacity network structures requiring software- defined and all- optical technologies.

[125] Moreover, software- defined networking (SDN) enables intelligent control of network operations and it brings in new business opportunities for the equipment producers. SDN is structured especially for data centre operators and content providers. The (cloud data) service providers had built their SDN based systems and the overall market size expanded from just 360 million USD in 2013 to 3.7 billion USD in 2016. More up to date statistics give eight billion USD market size in 2016 and predict to surpass 100 billion USD in 2025, (Global Market Insights, 2019). The study has indicated the acquisitions of start-ups made by traditional routing firms to diversify into this market field. In 2016, Big Switch (Intel invested), Arista, Cyan, Nuage Network (Alcatel/ Lucent acquired), Cisco One effort and Hewlett Packard are among the ten main companies in this field. As of 2019, it appears that new actors have been entering in related market segment all over the world and no less than twenty main firms shown in this segment on a more global level. These include, Anuta Networks, Arista Networks, Aryaka Networks, Big Switch Networks, Cato Networks, Ciena Corporation, Cisco System, CloudGenix Inc., Cradlepoint Inc., Cumulus Network, Extreme Network, HP Enterprises, Huwaei Technologies, iPhotonix LLC, Juniper Networks, Midokura Co. Ltd., Pic8 Inc., Plexxi, Pluribus Networks, Talari Networks, Teridion Inc., Versa Networks, VMware Inc.

closely related trend is the need for all- optical networks. These networks are also called fiber to the X (FTTx), covering all physical location connections like fiber to the building, fiber to the home and fiber to the curb. Network operators especially in developed countries like USA (e.g., AT&T), China (e.g., China Telecom) and Japan have been deploying these networks to meet increasing data transmission requirements as mobile technologies are demanding more and more such capabilities in the transmission part.

Lastly, 5G technology occupy the medium-term agenda of all sector players and both new types of hardware, software and usage-based applications (solutions) may bring a competitive advantage and new market opportunities for the firms (both established vendors and entrepreneurs in new market segments).

The report has asserted the fact that operators made considerable investments for 4G technology network but the crucial point (for them) is not one of the largest suppliers were domestic companies in the USA market.

In this respect, the authors have stated an observation that opportunities may come up in the diffusion stage of (early development) next generation networks (i.e., 5G). Since this new generation technology requires new hardware (these are also innovations in a sense) like cognitive radios, smart antennas, small cell base stations among others, existing and/or new (home country) firms may catch up with other country companies in the development of such products.

The study especially highlights the role of cognitive radios, small cells and IoT product opportunities. Cognitive radios [126] increase the efficient use of available spectrum (which is a scarce resource) by dynamically operating on a range of frequency bands. Its software- based structure can give new business opportunities for software development companies. In a similar fashion, small cell technology [127] also enable efficient use of the existing spectrum available to the service providers. Small cells are

[126] FCC defines cognitive radio as “A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system operation, such as maximize throughput, mitigate interference, facilitate interoperability, access secondary market”, (Akcay, n.d.).

[127] Small Cell Forum defines small cell as “a radio access point with low radio frequency (RF) power output, footprint and range. It is operator-controlled, and can be deployed indoors or outdoors, and in licensed, shared or unlicensed spectrum”, (Small Cell Forum, n.d.).

crucial component of 5G networks, because they increase network capacity, density and coverage, especially indoors. Considering the fact that widespread (and accelerating) use of IoT (and M2M) applications in 5G era, it is certain that market actors have rushed to capture market opportunities in this segment. Here, it is noted in the report that some of the domestic companies are well positioned to compete globally. For instance, Intel and Quallcom are among the forefront companies in IoT and wireless technologies. However, as a potential threat to the home country firms, the authors emphasise huge amounts of R&D spending and investments in overall 5G technologies in different countries contrary to more limited research activities in the USA. This undoubtedly presents a weakness for the competitive stance and (global) sustainability of the ecosystem (for this country), at the time of the analysis[128].

Policy Recommendations: One of the most critical suggestions of the study is the importance of early identification and prioritization of newly emerging technologies, markets where policy actions may have the largest impact[129]. Following this general observation, detailed policy actions grouped in *R&D investments*, *cooperative agreements, technology transition, investment in production, financing, trade, regulation, standards and tax categorizations*.

In this context, the researchers proceed with the recommendation of diversifying (increasing) collaborative research by establishing pre- competitive collaboration test centres supported through public funds, among others. There are already existing collaborative centres for routers/switches using SDN, advanced affordable photonics and applications, terabit optical networking, advanced wireless and smart antenna technologies.

The study, has further figured out specific areas that needs public sector support (targeted investments, financing etc.) including *"all-optical networks utilizing photonic integrated circuits and silicon photonics, intelligent optical networks, software for SDN products, wireless 4G and 5G technologies including cognitive*

[128]The report indicates that South Korea is investing about 1.6 billion USD in a joint public-private project, EU allocated 1 billion USD with the addition of 4.5 billion USD by the industry partners in a 5G Research program. These numbers show the importance given to this technology by countries even without mentioning China's efforts and Japan's efforts (works) in the 5G technology field.
[129] There are also additional reasons for firms including new business opportunities, providing competitive advantage etc.

radio, small cells and smart antennas". In these areas, along with R&D efforts (test centres etc.), the study recommends public organizations (government) to be early purchaser and adopter of new technologies. These organizations can incentivize the development of advanced technologies by preparing roadmaps with firms and use them in (firstly) public data centres, communication networks like terabit optical infrastructure and SDN hardware.

It is pointed out (in the study) that public funding, public procurement and being an early adopter has significant effects on the enhancement of domestic companies' technological and competitive capabilities. Here, the establishment of efficient public-private partnerships (including industry and university) considered essential for the success of public funding in product/service commercialization (i.e., main objective). It is also worth noting that tax incentives and financing instruments such as export credits and loan guarantees can bring about positive effects on domestic firms' competitiveness in global markets. As mentioned, the development of internet by ARPANET is an important example for seeing the role of these policies in one of the most notable technological breakthroughs in the history.

Another argument of the study points out critical role of standard setting process in new technologies. Relatedly, the public support (involvement) especially in SDN and wireless technology standard setting considered vital for the home country companies' long-term competitive positions in the world. In line with this argument, the researchers emphasise significance of sustaining and even increasing state efforts (public organizations lobbying) in the international standard setting bodies[130]. As another institution, like standards, regulations, which determine the rules of the game in a general sense, can influence market development in several dimensions. In addition to more technical regulations (such as spectrum allocations, licensing etc.), trade regulations can also be used as policy tools.

For instance, the report argues that some governments (e.g., China) subsidise their firms' products to provide (unfair) advantages in overseas markets. Some countermeasures can be considered for these practices and here more aggressive stance

[130] E.g., International Telecommunication Union (ITU), Telecommunications Industry Association (TIA), Internet Engineering Task Force (IETF), International Organization for Standardization (ISO) and Institute of Electrical and Electronics Engineers (IEEE).

is recommended in another (in a sense) standard setting organization, namely World Trade organization (WTO).

The authors finally indicate the need for (also in line with evolutionary economic thinking) continuous revisions and dynamic outlook to identify new trends, opportunities for the home industry.

4.5.2.4 A Study on Swedish Telecom Sector IS

Lindmark et al. (2004) have analysed telecom dynamics, history of the Swedish telecom sector and its innovation system under the project supported by Swedish Agency for Innovation Systems (VINNOVA)[131]. At the start, the authors have stressed the vital role of telecommunications in the economic development of countries. The Swedish case is particularly relevant because of the fact that (mainly) one company, Ericsson especially with its success in mobile telecommunications were the principal contributor to the country's economic growth (especially) during the last two decades of the 20th century.

However, at the start of the millennium, IT bubble caused financial and operational difficulties for the firm, leading to economic problems throughout the country. In this regard, VINNOVA and Chalmers University of Technology undertook a project aiming to analyse the telecom sector and the Swedish telecom innovation (STIS) system including its progress, structure, competitive capabilities and decisive factors that influence innovative activity both in a positive and in a negative direction (way). The methodology consists of two parts, evaluating existing information (literature and statistics review etc.) and qualitative analysis with interviews.

The authors, in the first place, pointed out the difficulty of scope definition (i.e., delimitation) in STIS due to abundance of players (firms, suppliers etc.), products/services, other actors (government agencies, sectoral organizations etc.) and related ICT sub sectors, to name a few of them.

Hence, they take a more pragmatic approach based on their and the other experts' discretion. Relatedly, STIS divided in to four segments: fixed telecom (telephony in 1970s), data communications (i.e., fixed internet), mobile telephony and mobile data

[131] This section draws heavily on Lindmark et al. (2004), unless otherwise stated.

(internet). These are in a sense followed each other in general terms thanks to the technological progress (innovations) in ICT (i.e., first conventional voice services, then fixed data communications via fixed lines, later on mobile voice and then mobile data communications). However, one can say that in each group, technological developments are continuing and taking into account convergence phenomenon, some of these differences have been vanishing and all these telecom services can be included in a single market currently.

After examining the theoretical basis of innovation systems and telecommunications (definitions of the basic concepts like carriers etc.), the researchers make a preliminary analysis on actor and functional categories.

Accordingly, hardware producers (e.g., Ericsson), service providers (e.g., TeliaSonera), standardization agencies (e.g., ETSI), consultancy organizations, regulatory bodies (e.g., PTS), retailers (e.g., the Phone House) put into most important actor categories. In line with this, producers of equipment, distributors and users of them, producers and users of services (delivered) given from this equipment, agencies that standardize the hardware and/or the services delivered by adopting these products and resource providers (e.g., financial, educational etc.) make up the actor/functional categories.

In terms of innovation, they identify actors that innovate and actors that support these processes by giving financial and educational resources.

Having stated some initial issues, the study proceeds with the historical assessment of telecom sector in more detailed terms.

Evolution of Telecommunications Sector (Industry): It is evident that communication between people is a necessity and even a means to survival since the very early days of humankind[132]. With the advancement of telephony technology, equipment industry had been developed to provide network parts such as switches, cables and integrated circuits. This trend brought in establishment of (some of the)

[132] Without going into forms that are more basic such as smoke signals and carrier pigeons, telegraphy (invented in the first half of 1800s) presents the first means of electrical communications to send very long-distance messages previously not possible (thinkable) in such scales. Although it revolutionized the communications (and socio-economic life) and thanks to several (product) improvements (innovations) like mechanical transmitters and receivers, invention and development of telephony eventually ended this (telegraph) era in the first decades of 1900s.

biggest companies of the 20th century. For telecom services part, in many countries postal and telegraph services merged with the late coming telephony services to establish monopolistic postal, telegraph and telephony (PTTs) service provider companies.

In brief terms, investment needs in nation- wide infrastructure, economies of scale and scope, universal service requirements (i.e., provision of telephony services to everyone in a country) led to public (state) monopolies with the few exceptions, notably USA where private monopoly existed until mid-1980s. Along with monopoly structures, state control over these companies (mostly state-owned enterprises- SOE- themselves) instituted on regulatory and operational issues.

In many cases also, governments (states) delegated these regulatory functions like facility sharing and rights of way etc. to these SOEs. Apart from this, many of them had presence in the whole telecom sector (i.e., vertical integration) including hardware production part[133].

Traditionally, there were three categories of telecom equipment: switching, transmission and terminals. As telecom networks became more pervasive and related equipment became more advanced, the underlying technology and R&D (expenditures) were getting more costly for the companies that failed to reach certain levels of scale economies and (technological) competence. Hence, quite a few large companies left to dominate the sector starting from 1970s[134]. This is quite striking considering the fact that some of these companies are no longer exist and the number of big players is even fewer in current market conditions because of mergers, acquisitions and simple closures etc. In this period, most of R&D made by SOEs (i.e., PTTs) financed by state budget either from their revenues and/or other public funds.

Here, the authors pointed out other roles for governments in terms of industrial policy. Often, public organizations promoted domestic companies and/or foreign vendors that had either production centres or partnership agreements with PTOs in their countries.

[133] To give a few examples, AT&T (USA), Televerket (Sweden) and Telefonica (Spain) all owned networks (to provide services) and manufacturing operations (branches). On the other hand, some other producers maintained close relations with home country operators (like GEC in UK) while few of them had more export-oriented focus due to (mainly) smaller market size of their countries and Ericsson was a notable example in this category (Fransman, 2001, p. 61).

[134] The report stated the most important ones as *AT&T, ITT, Siemens, Ericsson, GTE, Northern Telecom, NEC, Thomson, Philips, Alcatel, GEC, Plessey, Italtel, Fujitsu and Hitachi* making up fifteen in total.

In addition to this, governments began to use various policies like export credits to support their firms' competitiveness in global markets.

A Milestone in the Sector, Liberalization (and Privatization) Process: As the study emphasised, one of the (if not first) most important milestones in the modern era of telecom sector was the liberalisation[135] policies implemented in many parts of the world starting from roughly 1980s to the beginning of 2000s. These policies comprised somehow different meanings and stages (or components) when applied to telecommunications sector setting. Firstly, SOEs were privatized and the regulatory functions were transferred to newly established regulatory authorities and/or related ministries. In this sense, market liberalization did not mean unrestricted market access or operations in the sector. Certain market segments gradually opened to entry allowing competition but several institutions (rules-regulations) remained in place and continue to be present in today's market conditions, contrary to expectations of complete deregulation. Here, Noam gave several reasons for the liberalisation process beginning with the increasing importance of telecommunications for the knowledge economy in which service sector and the role of information were crucial (Noam, 1994). At this point, Li et al. (2001) singled out innovations in ICT as the most significant driver of telecom policy reforms in this era. In any case, technological advances led to alternative means of communication and this process eventually increased pressures on PTTs to reduce service costs for the end users.

As a simple example, consumers (end-users) paid excessive amounts just to compensate cheaper short distance calls. That is to say, consumer demand (for more choice, quality and at the same time more affordable costs) coupled with available technological capabilities ensured conditions for liberalization (i.e., end of monopolies) in the sector. Here, it is important that this transition should be seen in an evolutionary perspective. In other words, previous monopolistic structures established a widespread telecom network and knowledge base from which a second step could be made, i.e., service and product proliferation for the consumers. In fact, liberalisation policies have not reduced the need for regulation and in some respects, the coverage of institutional framework has even expanded to safeguard (and/or increase) competition and protect end users in the related markets. The study lists some of them

[135] In very broad terms liberalisation means *act of allowing more freedom in laws, system or opinions* (Cambridge Dictionary, n.d.)

as promoting competition like interconnection, carrier selection, number portability, local loop unbundling regulations. There are (one can add) numerous other regulations in areas ranging from national security to health protection. Taking into account recent developments, these regulations even extend to data privacy and protection of personal (sensitive) information that makes telecommunications one of the most regulated sector in the world.

Changes in the Hardware Production Part: The authors compared the innovation systems of PTT and more current (after liberalization) era by referring to Fransman's (2002) analysis. As indicated previously these PTTs made most of the R&D activity in the pre-liberalization era.

Fransman characterised the previous system as a closed one having few actors, high barriers to market entrance, dispersed knowledge base. Hence, there were not much incentive for innovation that followed (roughly) a research- prototype, experiments cycle.

In contrast, the current infocom innovation system has low entry barriers (at least in some segments), more innovators and a more common knowledge base.

In line with this, there are more rapid and concurrent innovation (e.g., cooperative innovation projects by remote innovators).

This does not mean that market entry has become easier in every segment, but as the number of areas and services are increasing, new opportunities occur for other firms (entrepreneurs) either newly founded and/or operating in other areas of ICT sector.

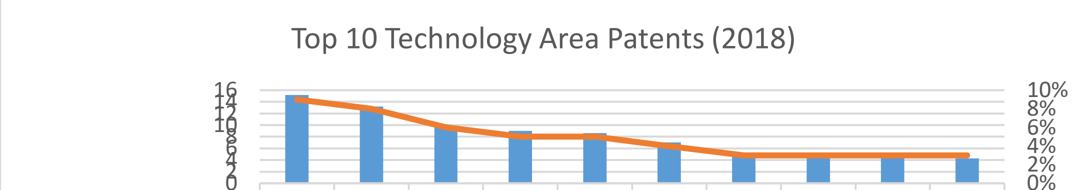
Another point that should be mentioned is the fact that as competition in the telecom services has been increasing, telecom operators started to reduce their R&D spending and increasingly preferred to obtain their hardware needs from specialized suppliers.

The role and importance of patenting has also changed after the market liberalization policies.

Before this, previous vertically integrated structure of PTTs and their exclusive relations between suppliers had rendered patents' role into secondary position.

However, again due to the tremendous pace of technological change in ICT and globalization of equipment industry, patents have become essential instruments of these large companies.

In current market conditions, ICT related patents represent majority of the total numbers obtained in total. A recent patent statistic shows that among the number of patents in the ICT related categories make up 70 % percent of total patents obtained in the USA by top 300 organizations, (Figure- 11).



	Semiconductors/Memory	Electrical Circuits and Systems	Multiplex and VoIP	Optics	Printing/Measuring and Testing	Thermal & Combustion Technology,…	Selective Visual Display Systems	Telecommunications: Analog Radio Tele…	Computer Networks	Cryptography and Security
Patent Numbers	15,153	13,215	9,875	9,003	8,641	7,017	4,855	4,761	4,544	4,311
Percentage	9%	8%	6%	5%	5%	4%	3%	3%	3%	3%

Figure 11- ICT Patents

Source: (Berndsen, 2019a)

Although almost all of these categories are related to electronic communications, one area is specifically called as telecommunications that covers “*Analog Radio Telephone; Satellite and Power Control; Transceivers, Measuring and Testing; Bluetooth; Receivers and Transmitters; Equipment Details”*, (Berndsen, 2019b).

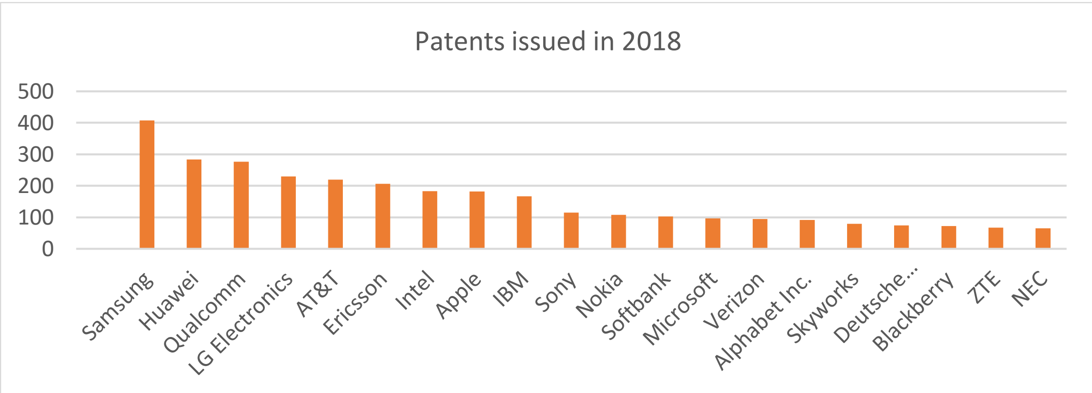


Figure 12- Patent Holder ICT Firms

Source: (Berndsen, 2019b)

The above Figure- 12 shows that global technology firms occupy the top lists, starting from Samsung and Huawei. Since these firms have widespread presence in ICT sector, they have a broad patent base ranging from equipment manufacturing to media and mobile telecom applications, software.

National sector study (methodology): Having examined the telecom sector in several dimensions (i.e., technology, structure etc.), the study proceeds with the more specific analysis of Swedish telecom sector[136]. In the first place, the authors review the importance of telecommunications (sector) for the Swedish economy and innovation system. Here, they have looked into (historical) export performance and R&D activities of the sector. Briefly, telecommunications sector has been main driver of the country's economic growth and mainly one company is the primary actor of this process. At the beginning of 2000s, transmission, switching and wireless equipment occupy more weight than telephone sets in the export composition of this country. For indicators of innovation, they have analysed R&D expenditures (as a share of GDP) and patent numbers. Apart from numerical observations, these statistics shows the extent of dependence for one company in the IS of the country. Owing to this dependence, the authors argued that analysis of Ericsson's evolution (capabilities, market situation etc.) is essential to understand the system dynamics.

With these initial observations, they passed to the historical assessment of Swedish telecom service and production (supplier) markets respectively. Swedish telecom services market analysis is divided in different parts. The historical evaluation starts with the early days (i.e., 1870s-1910s) of telecommunications service sector in which competition existed with several firms in the market. The second period encompassed the SOE (Televerket) monopoly until early 1980s. After this, liberalization in the sector was started mainly due to technological developments, new comers that wanted to enter the market by utilizing these innovations and political factors, e.g., liberalization in other sectors, policy recommendations of international organizations etc. In line with market liberalization, new regulatory package entered into force and the study investigated the details and effects of this between 1993- 2003 period. Apart from institutional analysis, they have reviewed structural change in the market such as competition levels in sub segments, characteristics of players (i.e., ownership

[136] These parts are evaluated in terms of methodology and country specific factors in detail are not mentioned with the exception of some general observations, policy recommendations and conclusions.

structures, internalization of operators) and some other market indicators like revenue, service prices etc. in this part.

For the supplier industry, Ericsson has always been a main actor historically (taking into account the fact that it was established in 1876) and has occupied a central role in terms of both domestic and international relationships in the market. Even in the beginning of 1900, the company had presence in international markets and extensive outsourcing agreements with nearly 30 suppliers in the home country. After Ericsson, Televerket had a large market share through its manufacturing affiliates (Teli and Telefabrikation AB) and some international vendors had also active (e.g., Siemens and Philips) during the 1970s. Between 1970- 1980, Ericsson developed a fully digitized SPC switching system which gave the company a competitive advantage over rivals, thanks to its capabilities not only in telecom but also in computing fields such as structured programming etc. Especially after the export agreement with Saudi Arabia in 1977, this switching system diffused rapidly in the world markets and adopted by more than hundred countries in the last half of 1990s. The authors indicate the significance of this know how (technological capability) for diversifying (passing) into mobile telecommunications hardware production. As a matter of fact, revenue share of this technology surged from below 10% to above 90% in just fifteen years (i.e., from 1987 to 2002). In general terms, the company designed and manufactured numerous essential equipment components like power supplies and microelectronic circuits in- house. With the increasing technological expertise (base-know how) and convergence of ICT, the company further extended its operational areas to military and space sectors such as advanced radar and satellite system hardware. Although some diversifications were not successful (e.g., information systems), the company aimed to develop competence in internet related technologies mainly by making acquisitions and collaborations with ICT firms. For instance, it acquired Oualcomm's infrastructure division and made collaborations with Intel and H&P.

Through this strategy, the company managed to expand its product portfolio in equipment like access routers and solutions for broadband internet access technologies like ADSL and CATV. In mobile (internet) part, it established Ericsson Mobility World in 2001 and founded joint venture with Sony (Sony Ericsson Mobile Phones), among other initiatives. In parallel to these developments, the company also initiated a business unit (Ericsson Global Services) to communicate telecom service operators and business customers by offering customized solutions. Besides this, it founded Ericsson Business Innovation to develop new projects in collaboration with entrepreneurial start-ups. However, the positive outlook ended in 2000s due to global crisis especially in the ICT (telecoms bust) sector. Since the report dated 2002, it only mentioned adverse effects of this on Ericsson. In brief terms, the company suffered financial loss and responded by restructuring in the form of cost and personnel reduction programs, among other measures[137].

Market actors and other innovation related issues: After analysing historical evolution, the authors stated important telecom sector actors in different categories and admit that they have not included smaller firms in some categories such as mobile data solutions. These categories were infrastructure providers, terminal manufacturers, operators, software companies, distributors and retailers, contract manufacturers, component producers and consultants.

Infrastructure providers formed the primary category by occupying more than 50% of the top 500 IT firms' revenues in 2002. Ericsson had 87% market share in terms of revenues in this category. In terminal equipment sub- sector, this company was the third largest terminal manufacturer in the world with 15% market share globally. Some other producers operated in niche segments like secure cellular phones for military uses and terminals for fixed telephony. In line with increasing software dependent equipment and telecom service solutions, new firms with an expertise in these fields had been entering in the market. Other smaller scale component producers that worked on contract bases and sub-suppliers were also active in the sector, along with consultancy firms giving assistance in product development, technology and business strategies etc.

Telecom service market had large number of operators ranging from fixed, mobile telephony (e.g., TeliaSonera, Tele2, Vodafone) to backbone network suppliers. What is more interesting is that an electricity (grid) and a rail company started to provide backbone networks that were useful for increasing network coverage of the country. Having examined actor categories, the report evaluated the role of public procurement

[137] A brief note on the current situation of the company is given in **Appendix- D.**

policies, collaboration between main actors, R&D activities and financial considerations (i.e., access to capital). As noted, public procurement policies and government's early user position supported innovations and formation of new markets. On the negative side, the authors argued that continuous (long-lasting) procurement relations could led to market inefficiency due to lack of competitive pressures. Notwithstanding to this, both public procurements and collaborative works had an impact on the evolution of the country's telecom sector. Indeed, cooperation between Ericsson and Televerket (SOEs in that time) started in 1950s to avoid inefficient use of limited resources (duplication of research). These two further established a joint R&D firm to develop switches, computer networks, digital transmission systems and sophisticated telephone devices in 1970. The fully digitized switching system (AXE) especially benefited both companies in the form of producer and early user (and public procurement) relationship. In a similar fashion, Televerket influenced (supported) Ericsson's efforts in mobile telephony through public procurement and being early user and developer (i.e., through its own customers). Military has also been a customer of telecom firms especially radio communications systems and influenced the evolution of the sector by public procurement policies.

Apart from these observable factors, the report indicates the educational support role of SOE of the country historically. Indeed, Televerket also functioned like an educational organization and gave telecom courses from introductory to advanced level through its telecom school. This practice undoubtedly increased the human resource and knowledge base of the sector in the medium to long term. Here, one may assert that such practices (to the extent that they are used) are still useful for both firm's efficiency improvements and for expanding skilled work force in the sector. Hence, it may still be relevant to examine the effects of such educational practices employed by large organizations for an innovation system as a whole.

Having observed the general trends, the report focuses on fiber optics, mobile and data communications sub sectors in an analytical framework to study system functions and to identify strengths & weaknesses of each one. At this point, main findings of this framework analysis summarized without going into examination of historical developments, in more detail.

Framework of Analysis (related to sub-sectors): Each of the sub-sector analysis consist of production of knowledge, guidance and direction of search, supply of incentives to innovation and exploitation, supply of resources, establishment of networks and its effects and finally formation of markets.

In the fiber optical communications, the authors stated that production of knowledge (related to this sub-sector) was fairly successful and in nearly a decade (1970s) the industry caught up with the rest of the world thanks to the cooperation with related actors such as educational organizations, government and companies. As in other sub-sectors, Ericsson and Televerket supported these efforts together with research organizations like the Institute of Microwave Technology. The sufficiency of knowledge level confirmed by statements of related people, news articles and number of working personnel in the field. Another way to look at this is to investigate the patents and publications in this subject. For guidance and direction of search, there was no ambivalence since fiber technology and outlook (usage etc.) already known and the Swedish sector (industry) aimed to catch these innovations. One could then divide the process in two, first to catch-up and then upgrade and/or enhance existing hardware components (e.g., reducing costs at the same time not quality degradations). Apart from technological collaboration projects, SOE (Televerket) procured required network components from Ericsson, increasing commitment of the company to this technology. This was like a stepping-stone for this firm to expand into international markets in the second place. Later on, some other firms funded by venture capital has also entered in more specific segments of the value chain.

The report identifies some problems for these smaller firms such as tax burdens, cost of obtaining necessary certifications and access to testing equipment.

For the supply of resources, the report looks into funding, skilled labour and physical facilities. As in other supporting issues, funding of projects (in this field) had been mainly provided by Ericsson and secondly by Televerket from the beginning, though in a decreasing trend after 1990s. Besides this contribution (by SOE), the Swedish government has provided (given) financial support through several funding organizations like STU[138]. Another (later) funding mechanism is EU joint technology programs. These have gained more importance after the second half of 1980s in line

[138] National Swedish Board for Technical Development, STU.

with the increasing attention given to ICT development programs by this Union. In the skilled labour category, educational programs were mainly provided in-house to the working personnel.

In addition to this, research institutes and universities started to open PhD and master degree programs (e.g., in photonics, optical communications etc.) with the help of several government actions like National Microelectronic Program, which also involved in funding such undertakings. Similarly, these programs made possible the establishment of laboratories (in this field) in universities and research organizations. Ericsson and Televerket set up such kind of research facilities as well. To support the sectoral development, Ericsson assisted the formation of testing facilities in ACREO[139]. Here, other firms made some tests, designed and improved their products. Lastly, establishment of networks like collaborative projects undoubtedly influenced the sector's evolution in a positive manner. These cooperative works were initially started between two of the largest companies as usual and only after market formation stage new comers started to benefit from these interactions in the form of getting access to testing equipment, learning market opportunities etc. In a nutshell, market formation began with the SOE's demand for optical communication technology to modernize its network and government support to achieve widespread and fast internet for the people further accelerated this process. Secondly, Ericsson entered international markets (e.g., USA) to capture scale economies. Third phase saw some kind of vertical disintegration and new players entered in specific segments of this sector. Currently, it can be said that Ericsson has changed market priorities and is no longer a dominant player for this specific segment in the global arena.

In data communications (especially internet through fixed networks), the report mentioned that Swedish equipment providers supplied necessary components to a large extent starting from the early days of market formation. Furthermore, the SOE realized coming of the internet age (i.e., convergence phenomenon) and launched research & competence programs (projects) in other several areas of microelectronics and computing technology. These efforts enabled a knowledge base on which the home country companies further developed data transmission technologies. In spite of

[139] It is an independent non-profit research organization, which is operating in mainly Nanoelectronics, Printed Electronics, Fiber Optics and Sensor Technology fields, (IDTechEx, n.d.)

this, there existed a criticism regarding the composition of R&D programs. That is to say, R&D for telecommunications have been more emphasised (prioritized) at the expense of computer communications. On the other hand, this knowledge base and evolution of mobile communications have brought opportunities for these firms to strengthen their capabilities in the data communications field.

For the direction of search, one interesting point was the early preference of circuit-switched network rather than packet-switched one, which became the dominant technology later on, in the market study undertaken by the SOE. At this point, the authors admit the fact that they were not in the position to analyse the effects of this study, but it is important to note that even most experienced actors in any sector can make erroneous market analysis (or forecasts) and periodic revisions are useful to minimize such mistakes and to revise related programs.

In this context, Videotext services constituted a more important failure of the SOE (along with several EU countries). Although, they tried to support this technology, internet was established itself as the dominant (if not only) mode of data communication network. These lock-ins and relatively weak competence in computing technologies led to failures in innovation (activities) and exploitation in this field.

To compensate this, telecom sector with more dense networks between producers, service operators and research institutes initiated joint projects and tried to support the formation of domestic market in the earlier stages.

On the other side of the coin, both SOE and the public organizations (government) stimulated the demand side by subsidizing some equipment and implemented several action programs to increase IT adoption and usage, as it is seen in almost all other country programs such as national broadband plans and digital transformation strategies.

Thanks to these initiatives (programs), Sweden has achieved one of the highest penetration and IT usage rates in the world, when looking at the service side of data communications (internet) sector.

In spite of these developments in above-mentioned segments, real stimulus for the Swedish telecom sector (in fact for the whole economy) has come from mobile communication technologies. The study divided evolution of this technology (in

Sweden) into four stages including rapid market growth with GSM. Briefly, the history started with the (again) SOE's and Ericsson's innovation of the world's first fully automatic mobile telephone system named MTA in the later part of 1950s. The telephone was used in a car and weighted nearly 40 kg. As in most other innovations, several upgrades were made to improve product/service qualities until the advent of another technology named NMT in the 1970s. Then came GSM in 1980s with worldwide success and adoption in several countries of the globe[140]. Apart from other factors, the authors emphasized the vital role of standardization in this area. As a matter of fact, standardization of mobile technology made possible market internationalization and led to global success of few companies, including Ericsson. This company, along with few other EU vendors (e.g., Nokia), took advantage of NMT and then GSM acceptance as international standards to capture scale economies in the sector.

The one important thing to note is that these organizations competed with other country organizations in the international arena by every means possible (including working in forming of standards) to achieve their objectives.

In line with these, equipment production for mobile communications has become a significant industry for the country. By the time of late 1990s, it is reported that there were more than 100 companies active in this sector together with the main actor, Ericsson. Many of these firms worked as suppliers to Ericsson while several numbers of foreign ones have established their development centres in the country. During this time, other remarkable occurrence was the proliferation of the venture capital firms, start-ups and clusters (e.g., radio-antenna technology cluster) specialized in mobile communications field. At this point, the authors asked an important question related to the reasons of Swedish success relative to other similar countries Norway, Finland and Denmark in terms of mobile infrastructure industry in the early periods. The main reason given in the study is the competence build-up of Ericsson in three related areas (i.e., mobile radio, switch and systems) at the expense of other countries that had mainly one competence in land mobile radio industry. They argue that only after developing these competencies, Nokia (of Finland) managed to establish stronghold

[140] The effect of regulations and public policy in successful market application of these two successive technologies are already discussed and not repeated in this part.

(a strong presence) in the related market.

The report lastly analysed mobile data communications. Here, it should be noted in current terms that there is no difference exist between different services in a packet-switched and digitized network environment. Indeed, the volume of data transmission has far surpassed the share of voice transmission in the total network traffic. The evolution of this sub segment is not much different from mobile communications part in the study and it may be more relevant to analyse them as a single sector, mobile telecommunications in today's market conditions. In any case, historical evolution of the sector is crucial for the formation of knowledge base upon which further competence can be developed to stay competitive in the world markets. In the Swedish case, it is understood that the cooperative efforts of SOE and the other largest equipment provider Ericsson, together with the supporting role of public organizations has affected the evolution of the sector to a very large extent. Here, even the wrong policies had some learning effects to guide market actors in the long- run. That is to say, in an evolutionary sense, innovation policies should be constantly revised to avoid lock-in problems in the long term. For this, research activities should be extended to cover alternative paths as much as possible within the scope of resource capabilities.

For the policy implications, the report by referring to Edquist paid particular attention to several policy measures. Accordingly, the effectiveness of organizations should be revised and if necessary, they should be restructured, abolished and/or new ones should be established. Connectedly, institutions should be continuously reviewed and similar procedures should be undertaken if there is a bottleneck etc. because of these rules and regulations. Apart from this, any system and/or policy study should focus on not only organizations by themselves but also their relations (interactions) with each other. Another point is the need for the early identification of negative lock-in situations.

There are several mechanisms to avoid costly lock-ins such as active involvement in standard setting process, continuous technology and demand forecasts, diversification of research agenda, and establishment of user-producer relations. Besides, it is already observed that public policy (intervention) might be more effective in the formation stage of any innovation related market development.

As discussed in the previous sectoral study (of USA), policy interventions in most cases loses their effectiveness when a technology is well established and markets are more mature.

Here, policy methods should be proactive and accompanied by structural changes (if necessary) to assist origination and development of products/services in new areas.

In this context, the authors have considered mobile (broadband) communication services and applications are the main (future) growth drivers of the sector.

This trend will certainly continue with the coming of 5G and expansion of digitalization in virtually all segments of socio-economic life throughout the globe.

Accordingly, one of the most important objectives is to further increase the adoption of these technologies and incentivize the development of innovative services/applications in different sectors. In the light of these, any innovation system (public policy) should support new venture formation and experimentation that lead to diversity.

In the Swedish case, the report indicated the weakness of support mechanisms like (early) financing aids for these ventures and some other problems such as lack of coordination and adoption of short-term oriented business models.

For the role of institutions, the study emphasised significance of an effective regulatory framework. More specifically, this kind of framework should minimize uncertainty, prolonged delays and at the same time should respond to ever-changing (dynamic) requirements of the converging sector.

The authors have given the experience of 3G licencing process as an example of regulatory failure leading to investment problems in EU. Hence, they have pointed out the necessity of establishing a dynamic regulatory framework that provides an environment, which supports innovation and technological change in the long term.

In this attempt, the authors recommend more responsibility for regulatory authorities to oversee the condition and level of these activities (investment levels, innovation, research and development) in these key sub sectors.

Another important function for public organizations is to become lead users in the technology development process. By establishing such relations, domestic (home country) firms may upgrade (develop) their products/services in a shorter time- period to compete on a global basis.

4.5.2.5 A Qualitative Analysis on Ericsson

Liden A. (2016) in her thesis has adopted a system of innovation framework by putting an actor perspective in central role of the analysis. This actor is a global telecom equipment vendor, Ericsson within the context of home country, Sweden. As central players in any innovation system, firms do not make innovation alone.

That is to say, firms are not black boxes to decide everything according to neoclassical assumptions and on the contrary, context (i.e., environment) shapes innovation activities of any firm under the IS (system of innovation) perspective.

Here both internal (like history, culture of the firm) and external factors (like regulations, incentives) influence these processes. Furthermore, the author argues that innovation literature has given more emphasis on the role of start- ups and SMEs, neglecting the position of large companies in the era of globalization.

Accordingly, she selects a global company to observe the relationship of this multinational firm with her home country innovation system. Indeed, the firm had a considerable influence on the development of the national telecom sector by various means including private and public partnerships.

One can also add the importance of reciprocal influences (interactions) between the company and other elements of the national innovation system. That is to say, this system nurtured the company and the feedback (contribution) of Ericsson to the whole sector has started to increase only after this initial phase. In this context, the Swedish state's role came into forefront of this process.

Freeman himself emphasised the state's role in this country's success of design and production of telecom equipment, at the same time sustaining widespread social services, i.e., not neglecting welfare policies. According to him, Sweden gave priority to ICT earlier than most other countries and established leading edge training system in Europe, (Freeman, 1987, p.90). Within this background, Liden argues that one should utilize an actor based (i.e., centric) system of innovation approach to discern the dynamics. In short, Ericsson and the Sweden's telecom sector (other actors, institutions) has largely influenced each other and the evolution of each and the system as a whole could not be analysed separately.

As a key actor in telecom sector, the company is also an important player in the country's (national) innovation system and member of the Innovation Council.

The author gives two explanations for this presence (one can imply apart from the obvious ones like legal requirements etc.) from the firm's perspective. The first one is to comprehend the government and other members' thinking and plans about innovation policy. The second one is to influence the council actions to its own advantage. Apart from this, Ericsson had nearly 24.000 R&D personnel and 1.000 of this were responsible for pure research only[141]. The company had extensive linkages with universities for recruitment purposes. In many cases, (potential) future working personnel selected during the university education through research projects. Main project partners were KTH Royal Institute of Technology, followed by Chalmers and Lund University. Ericsson gave high priority to collaborative research projects to reduce some of its R&D costs. In addition to universities, the firm preferred public organizations as main funding partners and as a risk taker in new technology projects.

Ericsson also participated in EU projects like Horizon 2020 and international ones involving China and USA based companies.

Another finding of the research in this subject is the establishment of telecommunication oriented educational programmes by the company. Here, the author pointed out that Ericsson also found *the professor privilege principle* (owning patent rights by professors) as negatively affecting the company's technology programmes. It has regarded the number of patents as the outcome of innovation activities and several methods (are) introduced to support the main objective. The collaborative idea management, the "IdeaBoxes" and business incubator initiatives were among these programs mentioned in the study.

The firm aimed to increase collaborative working and interactive learning of its employees. As a part of collaborative idea management, an IT tool called IdeaBoxes

[141] The company has 29,499 R&D personnel as of Dec 31, 2022 according to its web page information.

established in 2008 throughout all its branches. It can be seen that the people extensively used the platform and the number of ideas surpassed 35.000 in one year after initiation.

In short, Ericsson's innovation strategy has one overall objective in terms of patent numbers. The author's interview results confirm this as a key factor for innovation. With various supporting policies, what counts in the end is the new patents obtained by the firm. To this end, employees are awarded bonuses for successful patent activities. The company considers government as a risk taker in new technology projects and universities as partners in collaborative undertakings. Another positive spill over is the provision of human resources from these projects, especially from the students who are preparing their thesis.

Lastly, the author analysed one of the joint initiatives as Ericsson one of the most important members. The initiative called "Mobile Heights" which is a non-profit ICT cluster and networking organisation fostering innovation and growth in the digital world by interconnecting related actors of the ecosystem. Sony, Ericsson, Telia Company, the Regional Council of Skåne and the universities of Lund and Malmö established it in 2009, (Mobile Heights, 2021a). Linen saw the case as an interplay of territorial and functional innovation systems and asked the reasons of the company's entrance to this local innovation system (IS).

According to interview results (of the study), there were two main impetuses for the establishment of this initiative, in the first place. Firstly, the local research institute (Lund University) had been experiencing with difficulty in finding sufficient number of students and decreasing amounts of public funding. This, in turn, led to recruitment problems (shortage of qualified engineers) for Ericsson. Secondly, stakeholders in the region thought that strengthening of external linkages were necessary to avoid lock-in and to diversify its knowledge base.

In searching solutions for these problems, leading shareholders from the region such as firms, research organizations, sectoral associations and government bodies established this non-profit organization. Briefly, the aim of the organization was to promote the whole value chain of mobile telecommunications ecosystem including equipment, software and services. In this context, the author emphasised the importance of local embeddedness for the sustainable (and efficient) knowledge sharing, interaction and development of new ideas. For instance, a business centre established as a part of this organization where entrepreneurs met with the member firms to use their patents and set up their businesses by also receiving support from business consultants.

Additionally, entrepreneurs can present their projects, ideas at the sessions called “power hour” from which they obtained support services such as technical guidance and assistance, facilitation of marketing lines, connection with potential customers. What is even more interesting is the reverse application of this event in the name of “Beyond Power Hour”.

In this event, the roles are changed and the attending corporations make presentations of their innovative ideas and projects to entrepreneurs, (Mobile Heights, 2021b). Finally, as a central actor in the Swedish innovation system, public agencies (state) actively participated in the workings of the organization.

In particular, public sector mostly demand new solutions for society’s needs such as digital health services and as a lead customer and early user facilitate the market formation process of these digital technologies.

Having observed the central role of Ericsson in the country’s innovation system and economy, examination of the current structure and operations of the company may also be helpful for seeing recent developments in telecom equipment sector.

In this regard, a short evaluation of the company is given in **Appendix-D**.

4.5.2.6 Analysis of Nigeria Telecom Sector IS[142]

Bubou et al. (2012) used sectoral innovation system model to analyse the diffusion of mobile telephony in Nigeria. The scope of this study covers telecom services provision and diffusion issues in a developing country context. Even though this type of studies is beneficial for seeing the development of digital services usage in developing countries, one can indicate the fact that each country should have a policy of developing home country capability in the context of evolutionary economics

[142] This section draws heavily on Bubou et al. (2012), unless otherwise stated.

understanding. In parallel to this, the research studies related to these issues will undoubtedly benefit the policy formation of technology development in such areas.

In any case, the authors have started their analyses by emphasising the importance of (diffusion and usage) mobile telephony in the knowledge-based economy to address digital divide (information and knowledge asymmetries) problem in latecomer countries. After stating the sectoral system of innovation concept in general terms, they defined the Nigerian telecom SIS elements as including mainly providers, institutions and users. Additionally, social system, the institutional setting and technology put into socio-technical system. It is argued that the government (of Nigeria) has established necessary preconditions for the sector to grow in line with her liberalization and deregulation strategy.

Having compared these two eras (i.e., pre vs. post liberalization period), they concluded that there was limited mobile service availability and the number of mobile lines were just 25.000 in 2000. In the previous period, a state-owned company had a monopoly like the other country cases of this era. There was slow rate of network investment, long waiting lines for customers and service availability confined to mostly urban areas of the country.

Afterwards, in line with global trends, the regulatory authority was established in 1993 and telecom market liberalization completed by 2000. GSM Licenses awarded to three operators and national operator (NITEL) got one, making four licensed operators in the market at the start of 2001. One year after, regulatory authority also auctioned fixed wireless access and second national carrier licenses that ended the monopoly position of NITEL in traditional fixed line segment as well.

In this process, the Country achieved one of the highest growth rates in terms of usage, operator numbers among the African countries and became the second largest mobile market after South Africa in 2004. Similarly, Nigeria was one of the earliest African countries to auction 3G licenses in 2007. According to the authors, Nigeria government established a supportive environment for these developments by enacting the National Telecommunications Policy in 2000 and National Information Policy in 2007.

In that year, National Information Technology Development Agency was founded to expand the availability of internet services throughout the country.

This agency planned a national information infrastructure backbone consist of optical fibre, wireless network and satellite technology.

Additionally, Tele-centres were starting to be established for people living in rural areas.

The target group was especially those who did not have internet access and necessary ICT equipment.

The authors labelled the period after 2010 as intense competition phase with the increasing number of both new entrants (to the market) and users.

In fact, the country had above 75 million mobile subscribers in this year and became the largest mobile market in terms of these figures, in Africa.

In 2011, mobile subscribers comprised almost 99% of all telephone lines in the country, the number of telecom operators reached to 25, five GSM, four CDMA, and sixteen other (fixed and fixed wireless) operators.

Additionally, the study pointed out the benefits accrued to users as well. Decreasing usage costs, bundled services, higher quality of service and increasing network availability (coverage) benefited the users and increased consumer welfare.

In sum, the authors divided the evolution of telecommunications (services) into three phases and made comparison by using some basic statistics of adoption (usage) and market entry numbers.

Firstly, they gave the expansion of subscriber base from just five hundred thousand to over 95 million as the main indicator of market growth.

Secondly, (cost) reductions of telecom services were used as another indicator for the market development from the viewpoint of consumers.

For our research purposes, one can comment on the paper being too reliant on few indicators (statistical) to derive some conclusions on the evolution of the country’s sectoral innovation system.

In more detailed terms, although the authors supposed to adopt SIS approach, there is no discussion on the working of the system with regard to functions, weaknesses and relations between organizations to name a few of the missing points of the study.

In short, one can say that the main weakness of this research is not a separate focus on telecom service part but on the very inadequate application of IS framework in the study, making it only a brief basic statistic based historical analysis without any further identifications and policy recommendations related to this technological innovation system.

4.5.2.7 Summary Evaluation of the Case Studies

After reviewing several studies, it may be appropriate to summarize main points of these works in brief terms. There are seven cases and although they all cover telecommunications sectors; their focus and scope are different in certain respects. In fact, they have been selected to account for this variety at the first place. They are mainly qualitative studies that are more suitable for this research as well. Another reason for this selection is that some studies have analyzed the role of historical developments (e.g., path dependencies) and public policy in the sector. Furthermore, repetition of similar topics has been avoided in the study, by addressing these issues in the context of these case studies. For instance, explanation of the liberalization policies and its effects on later developments of the sector has been summarized in this part, removing the need for mentioning these (topics) in another section. In the light of these discussions, Table-24 gives a summary of selected case studies in terms of several aspects. Without repeating above arguments, it can be said that case studies cover either a whole sector or a dominant firm in their (mostly) qualitative analyses.

Edquist's (2004) sectoral analysis are particularly useful in showing advancement of internet & other mobile telecom technologies (up to 3G), formation of different sub markets in the sector like fixed & mobile internet services and different actors like internet service providers and mobile telecom operators. Historical developments as shown in Swedish case indicates the importance of path dependence phenomenon in the sector. This sectoral IS study shows historical developments can shape current market structure by forming various assets and experiences like technological capabilities, knowledge base and availability of qualified human source that are vital for further R&D works. Provided that these capabilities exist, sectors can get over with economic crises and possible setbacks.

Table 24- Brief Summary of Studies

General Title	Authors	Scope	Brief Tech. Description
ESSY Project	Project partners including universities, research centers etc.	Different sectors including telecommunications in EU	Analysis of Fixed and mobile telecommunications up to 3G, Satellite and TV subsystems
Internet and mobile telecom IS	Edquist (2004)	Telecom sectors including fixed internet, mobile telecom equipment production, access and content provision	Evaluation of historical developments in related sectors up to introduction of 3G technologies.
Study on China telecom equipment sector	Pasadilla and Zhu (2016)	Firm level	Analysis of a firm and its value chain
Analysis of USA's telecom equipment sector	Cohen et al. (2014)	Sectoral level in a country (including wired and wireless segments)	Focus on hardware part of telecommunications, with particular emphasis on recent developments
Study on Swedish Telecom IS	Lindmark et al. (2004)	Sectoral level in a country (including several sub-markets)	Evaluation of country's telecom sector in a historical perspective
Qualitative Analysis on Ericsson	Liden (2016)	Firm level and it's interactions with environment	Examination of a firm's role in an IS framework
Telecom SIS and diffusion of mobile telecom in Nigeria	Bubou et al, (2012)	Nigeria mobile telecom services sector	Analysis of market development and market adoption rates

Source: Compilation of case studies and researches that are mentioned in the text.

Another critical issue is path dependency and technology lock-ins that can be experienced in the history of telecommunications sector.

Here, case studies point out necessity of diversifying research portfolios and involvement in standard setting processes in the industry. In fact, EU level success in establishment of second-generation mobile technology standards (GSM) gave several advantages for European firms like Ericsson and Nokia.

Furthermore, irrespective of study focus (i.e., whether on a firm or sectoral level), firms have played lead roles in these cases. From the beginning of mobile telecom technologies, these firms in their countries have either operated in service and/or equipment part of the market.

For instance, Ericsson, being the oldest telecom firm in Sweden, has taken advantage of both EU and country level supports to become one of the leading firms in international markets since the introduction of GSM standards in the sector.

Here, size of home country market would not be sufficient and these firms from smaller countries need overseas market presence to continue their operations. This situation is the same with Ericsson, Nokia or Samsung from South Korea.

In fact, although bigger home markets give scale advantages for Chinese firms, they have also pursued aggressive international marketing strategies to capture overseas markets.

As seen from Pasadilla and Zhu's analysis, these vendors (most notably ZTE and Huawei) implement strategic plans to gain foreign markets by using several policies including making partnerships with firms that are established in these countries.

One of the most profitable revenue areas for these global vendors is to establish long-term business deals with operators. Once established, these firms can provide nearly all infrastructure components and continue maintenance services in the lifetime of these networks.

Of course, this is not a single reason for other developing countries for their technology adopter statutes, but certainly play a role in resulting weaker technologies capabilities.

In this respect, an example from a technology adopter case (e.g., Bubou et al, 2012 study of Nigeria) shows emphasis on technology adoption objectives by these (group of) countries. That is to say, follower countries such as Nigeria has mostly focused on increasing availability of internet & mobile telecom network access for their citizens.

With the increasing pace of digitalization and essential role of data, strategic importance of telecommunications has even surpassed earlier considerations as shown in the USA telecom equipment sector study of Cohen et al. (2014). Indeed, considering the fact that nearly all service & production processes are being digitalized, control and security of data transmission highways (i.e., networks and related components) begin to occupy political agendas of even developed countries including USA and UK.

In this context, the study (of USA market) clearly shows security concerns of policy makers on the eve of 5G transition in the country. Coupled with market dominance concerns, these actors have been devising several policies (even directly banning use of Chinese products) and support mechanisms to gain technology leadership in related technologies including mobile telecommunications.

Apart from these considerations, the study advocates locating new opportunity areas where related technologies are not mature yet.

These suggestions can also be useful for developing countries in locating market entry points in the sector. In other words, software related components in 5G technology might provide alternative market opportunities for companies that cannot compete with global vendors in mature hardware segments.

Notwithstanding to this, one should take into account the fact that these global vendors with huge R&D budgets are also active in these segments.

This is undoubtedly making market entry more difficult for new comers and companies from developing countries. Indeed, above-mentioned case studies show global companies' preference of providing point-to-point network establishment in foreign country markets.

By this, they -in a sense- try to capture these markets with long term after sales services and logistical dependence for their equipment.

Apart from above considerations, it is evident that evaluation of these studies, projects in different contexts provide valuable insights for this study case, as well. In essence, the author has benefited from them in two broad aspects for the following chapters. Firstly, as the study on Swedish Telecom sector and Edquist's analysis were mostly undertaken by following innovation system approach, the author has adopted their content (framework) while doing his work. As an example, historical developments and analysis of statistical trends are given emphasis in the following chapter similar to mentioned studies in different contexts. Secondly, the (thesis) study has analyzed important regulatory topics that played important roles in these countries telecom innovation systems.

In this context, Edquist's analysis has showed some important lessons which can be applicable even in today's sectoral ecosystems. To start with, telecommunications as a whole requires considerable amount of R&D expenditure and collaboration between various actors both from sector itself and from other actors in a national setting. It is also a necessity that sector actors should be active in international arena in the form of joint development projects, should participate in standard setting processes actively and academic events, to name a few of them.

This (thesis) study has taken into account these points and aimed to analyze R&D levels of the sector and policy tools applied by public organizations in this regard. At this point, almost all these studies, which are covered in this chapter, point out essential roles of several specific regulatory policies to pursue (governments) objectives in both services and equipment part of the sector. One of them is public procurement policies for supporting domestic firms' capabilities in the development of new products. The other one is the use of universal service policies. The author has also taken into account importance of these policies and evaluated implementation details in this study. Moreover, the studies related to USA and China (a firm level study) telecom sectors has given more perspectives to this study in highlighting growing importance of security concerns and necessity of increasing domestic firms' production capabilities.

Analysis of these works has further emphasized critical roles of telecom networks and technologies, which are established by using domestic and national capabilities. In the light of these observations including global vendor firms' strategies, the study proceeds with the examination of regulatory policies in a historical perspective. As a last remark before concluding, it can be said that this part has provided a foundation for analysis of Türkiye's telecom sector IS and derivation of main assertions (findings), which constitute topics of the next chapter.

CHAPTER 5

5. ANALYSIS OF TÜRKİYE'S TELECOM SIS

Having observed development of especially mobile telecom sector and related case studies in IS framework, the study proceeds with analysis of Türkiye's[143] telecom sector IS in a detailed manner. In what follows, service and hardware production segments are evaluated separately.

Although each of them has common actors, there is some advantage to study these segments in different subsections. By this way, the study aims to indicate the peculiarities of these markets and at the same time linkages between them.

5.1 Telecom Service Provision IS

One can state main objective of innovation system analysis as to advance, spread and exploit product/service novelties in any market to bring several socio-economic benefits. In a systemic understanding, elements of an IS toil in an interactive way but not necessarily in a pre-planned context and with a central director (leading actor). Relatedly, principal aim of the 'telecom service provision innovation system'[144] can be defined as increasing adoption, availability and quality of these offerings by making use of new technologies, investments and internal improvements.

In essence, actors in this ecosystem have not produced hardware but increasingly involved in quality improvements, software developments and devising new (innovative) services especially due to advanced mobile telecom technologies.

Within this context, starting point of analysis is to limit the scope by following a legal definition of telecommunications services and service provisions. The Electronic Communications Law (Law no.5809) defines services as "*the transmission, exchange*

[143] Please note that Türkiye's and Turkish words are used interchangeably in the text.
[144] Simply IS abbreviation is used when it is clear that service provision sector is referred in the text.

and receiving of all kinds of signals, symbols, sounds, images and data which could be converted into electrical signals, by means of cable, radio, optic, electric, magnetic, electromagnetic, electrochemical, electromechanical and other types of transmission systems.” Electronic communications service operators[145] provide these services by constructing (electronic communications) infrastructure in general terms[146]. More broadly, this sector (together with the production part) includes *“provision of electronic communications services over electronic communications networks and the production, import, sales, maintenance and repair facilities of electronic communications equipment and systems*.”

With the advancement of technology, there is no difference left between voice, data, and video transmission, in general terms. Furthermore, innovative use of them (in the form of value-added services like cloud applications etc.) lead to eradication of previous boundaries, what is known as convergence. For this reason, it is becoming less and less important to discuss separate service categories such as fixed line voice, mobile line voice and data services.

Notwithstanding to this trend, market entry regulations (of this country) are still based on platform distinctions like mobile and fixed networks. Following this distinction, the regulatory authority (Information and Communication Technologies Authority-ICTA)[147] gives authorisations in the form of notifications or rights of use, depending on the use of scarce resources, i.e., spectrum allocation and usage. In line with this, many firms have more than one authorization for different service categories and/or affiliate companies in these segments.

5.1.1 Identification of Actors in IS

There are 460 operators and they have 833 different authorizations as of June 01, 2023[148] as indicated in Table- 25. These authorizations cover *GSM and IMT-2000*

[145] Operators, providers, companies and firms are used interchangeably in the text.
[146] Building and operating a telecom network is one alternative (though most important) for providing services in addition to using (renting, sharing etc.) other- already established- networks.
[147] ICTA, regulatory authority, sectoral regulator and regulator are used interchangeably in the text. Please see Footnote 20 in page 15 for a more detailed explanation.
[148] Since getting some authorizations are relatively easy to obtain (i.e., not a scarce resource), these numbers may change continuously apart from licences given by auction methods (e.g., mobile telecom services). For instance, there were 450 operators, which had 815 different authorizations as of March 2, 2021.

mobile network roll out and services, satellite and cable TV services, satellite communication services, satellite platform services, infrastructure operating services, internet provision services, fixed telephony services, wired broadcasting services, GMPCS mobile phone service, mobile virtual network services, public access mobile radio services, directory services and mobile phone services for air vehicles. From these, the scope is restricted to mobile, fixed telecom services and to (a lesser extent) satellite, cable TV and infrastructure services because these service providers have large market shares and multiple authorisations covering virtually all of the above-mentioned services in their portfolios. For instance, although there are nearly 50 authorizations for 'mobile virtual network services', there is no service given to end users in practice.

Table 25- Number of Authorizations based on Authorization Type

Authorization Type	Services	Number of Authorizations
Authorization Agreement	Satellite and Cable TV Services	1
Concession Agreement	GSM Services	3
	IMT-2000/UMTS Services	3
	Several Telecommunication Services	1
Authorized by Notification	Satellite Telecommunication Services	30
	Satellite Platform Services	10
	Infrastructure Operation Services	181
	Internet Service Providers	323
	Cable TV Services	17
	GMPCS Mobile Telephony Services	6
	GSM 1800 Services on Air Vehicles	2
	Mobile Virtual Network Operator Services	25
Authorized by Right of Use	IMT Services	3
	GMPCS Mobile Telephony Services	2
	PMR/PAMR Services	52
	Infrastructure Operation Services	14
	Fixed Telephony Services	128
	Directory Enquiry Services	8
	Mobile Virtual Network Operator Services	24
TOTAL		**833**

Source: ICTA web page, https://yetkilendirme.btk.gov.tr/Yetkilendirme/ , (*) As of June 01, 2023.

Currently, there are three mobile telecom operators (Turkcell, TTMobil and Vodafone) and one company is working under a concession agreement (Turk Telekom) to provide several telecom services including fixed telephony, fixed internet and wholesale access to other firms. The difference for the ‘satellite and cable TV services’ is that the provider of this category is a wholly state-owned company (Turksat).

In addition to this classification, one can look at market trends to observe (what can be called) oligopolistic structure of the sector.

It is seen from the below Table-26 and Table-27 that three companies (Turk Telekom and TTMobile plus the other two mobile operators) dominate the market beginning from the formation phase (mobile telecom services, especially mobile internet) apart from some specific (and very small in terms of revenue) segments.

Table 26- Main Actor (firm) Revenues in the Sector

Actors	2017	2018	2019	2020	2021	2022
Turk Telekom	9.667	10.370	11.726	14.576	17.067	16.360
Turkcell	12.177	14.188	16.154	17.970	20.853	30.071
Vodafone	10.963	12.909	13.814	15.133	17.836	22.061
TTMobil	6.646	7.568	8.939	9.873	11.466	26.727
Others	11.695	13.996	16.050	19.536	25.155	35.089

Source: ICTA Quarterly Market Statistics. (Numbers are rounded to nearest million digits), (*) Million TL

Table 27- Market Shares of Actors (%)

Actors	2017	2018	2019	2020	2021	2022
3 Operators*	77,1	76,3	75,9	74,7	72,8	73
Others	22,9	23,7	24,1	25,3	27,2	27

Source: ICTA Quarterly Market Statistics. (Percentages are rounded to nearest digits), **(*)** Please note that Turk Telekom and TTMobil are in the same group.

This market dominance is even more striking taking into account the fact that these three companies have affiliated enterprises in other sub- segments, which are not shown in the main revenue classification.

In fact, these three providers have presence in the internet services market. TTNet is an affiliated company of Turk Telekom, Superonline is an affiliated company of Turkcell and Vodafone Net is an affiliated company of Vodafone. This is further increasing the market concentration in the (telecom services) sector. Adding these to three biggest operator total, their market share together approaches well above this figure, approaching 90% in the whole telecom services sector. Within this context, it can be said that the sector has a highly concentrated market structure where scale and scope economies play decisive roles. In this regard, Table-28[149] shows market diversification of these bigger operators, further proving this observation. It can be said that they are using their dominant positions in the sector to expand their presence in the other sectors like energy, advertising and insurance, to name a few. This is also in line with increasing amount 5G use cases and developments all over the world, as shown in **Appendix- B** and in **Appendix- C**.

Table 28- Main Actors' Presence in the Sector

Main actors	Group (Affiliated) firms*	Market areas
Turk Telekom	Turk Telekom, Turk Telekom International, TTMobile, TTNet, Innova, Argela, Sebit, AssisTT, TTVentures Proje Geliştirme (TTVentures Project Development).	Fixed and Mobile telecom (including internet) services, (wholesale) network access provider, international telecom services (internet, fiber infrastructure, roaming etc.), value added services like call center management, content services, innovative project development.
Turkcell	Turkcell, Superonline, Rehberlik Hizmetleri (Telecom Directory Services), Turktell Bilişim Servisleri (Turktell IT services), İnteltek İnternet Teknoloji Yatırım ve Danışmanlık Ticaret (Inteltek Internet Technology Investment and Consultancy), Lifecell Dijital Servisler ve Çözümler (Lifecell Digital Services and Solutions), Lifecell Müzik Yayın ve İletişim (Lifecell Music Broadcasting and Communication), Lifecell Bulut Çözümleri (Lifecell Cloud Solutions), Lifecell TV Yayın ve İçerik Hizmetleri (Lifecell TV Broadcast and Content Services), Turkcell Ödeme ve Elektronik Para Hizmetleri (Turkcell Payment and Electronic Money Services), Turkcell Finansman (Turkcell Financing), Turkcell Sigorta Aracılık Hizmetleri (Turkcell Insurance Brokerage Services), Kule Hizmet ve İşletmecilik (Tower Service and Management- Global Tower), Global Bilgi Pazarlama Danışmanlık ve Çağrı	All of the above-mentioned services. Furthermore, it is seen that this company has diversified into numerous areas ranging from finance to energy and real estate business. The company has also several firms' overseas in telecommunications and digital data services.

[149] Please note that, the names and number of affiliated firms may change continuously and the information in this table has been mainly used to show diversification strategies of these companies.

Main actors	Group (Affiliated) firms*	Market areas
	Servisi Hizmetleri (Global Information Marketing Consultancy and Call Services), Turkcell Enerji Çözümleri ve Elektrik Satış Ticaret (Turkcell Energy Solutions and Electricity Sales Trade), Turkcell Teknoloji Araştırma ve Geliştirme (Turkcell Technology Research and Development),Turkcell Gayrimenkul Hizmetleri (Turkcell Real Estate Services), Turkcell Satış ve Dijital İş Servisleri (Turkcell Sales and Digital Business Services), Beltel Telekomünikasyon Hizmetleri (Beltel Telecommunication Services), Other Overseas Companies (in Holland, Belarus, Ukraine, Turkish Republic of Northern Cyprus)	
Vodafone	Telecom group (as the core) has mobile (Vodafone Telekom) and fixed internet (Vodafone Net) service providers and Vodafone Tower. Services group includes Vodafone Provision, Information and Technology firms (three separate ones). Later additions are Vodafone E-Para (E-Money) and Insurance firms (two separate ones) in the finance group. Lastly, Vodafone TV and Content Services firms lie in media & TV category	The company as a part of Vodafone Global Group has fewer affiliated firms (in the country) compared to the Turkcell. In any case, it has extensive range of telecom service authorizations covering all main kinds of related services (licenses) obtained by these firms**. Furthermore, the company has established presence in different vertical usage sectors recently, as shown in the first column.

Source: Company and ICTA web sites. (The list is used for indicative purposes given the reason that some of the web sites may not disclose complete information. English names are translations of the author and shown in brackets.)
(*****) These firms are in the form of incorporated companies, for this reason 'Inc.' abbreviation is not used after each one. (******) Vodafone (Türkiye) web page does not give any information related to group companies and this information is obtained from ICTA web page.

Having seen current structure of market in general terms, it may be appropriate to ask two questions. One is the question that *how is the current structure of the market has been formed?* and the other one is *what are (if any) the problematic issues or areas that block the development and/or efficient functioning of the IS?*

In what follows, the study endeavours to answer these questions both by looking into historical evolution of the sector and by examining policy papers related to the sectoral issues.

5.1.2 Historical Evolution of Mobile Telecom Services IS

As the main objective of this section is to identify main market actors, a brief historical analysis is necessary to understand evolution of these actors (mainly firms) along with institutional structure of the IS.

In this regard, Box-1 shows major developments in this area.

Box-1: Major Developments in Market Actors

Milestones in the Sector with regard to Market Actors (Companies)

- Turk Telekom Inc. was founded by separating telecom and postal services in April 1995.
- Second Generation (GSM) licenses were transferred to Turkcell and Telsim in April 1998.
- Cable internet (provided through cable TV network) services were started in 2000.
- A new mobile telecom provider Aycell (a subsidiary of Turk Telekom) was founded in January 2001.
- Another mobile telecom provider became operational under the name of Aria (owned by Telecom Italia and Is Bank) in March 2001.
- These two merged in one company named Avea (especially due to financial and operational difficulties of Aria) in February 2004.
- Cable TV and satellite services were separated from Turk Telekom and given to a newly established company Turksat in July 2004.
- Turk Telekom was privatized by selling 55 % of its shares to Oger Telecom in November 2005 for 6.55 billion USD.
- Vodafone bought Telsim for 4.55 billion USD in December 2005.
- Turk Telekom bought İs- TİM shares in the company (40,56 %) for 500 million USD, increasing its shares to 81,12% (in Avea) in September 2006.
- Turk Telekom’s 15% shares were offered to public (in Istanbul Stock Exchange) in May 2008.
- Third Generation (UMTS) licenses were awarded to Turkcell, Avea and Vodafone for a total of app. 1 billion Euro at the end of 2008.
- 4- 4.5 G (IMT-Advanced) licenses were awarded to same operators for a total of app. 4 billion Euro in August 2015.
- Creditor banks acquired ownership shares of Turk Telekom (55%), with the remaining shares in the State (30%) and publicly traded (15%) in August 2018.
- Creditor Banks authorized the selling of their own (Turk Telekom) shares in September 2019.
- Türkiye Wealth Fund acquired the control of Turkcell in July 2020, increasing the state control in the sector actors (i.e., Turkcell with majority shares, Turk Telekom with golden share, Turksat as a state company).
- Finally, TWF has bought remaining shares of Turk Telekom (55%) from creditor banks for a 1.6 billion USD in March 2022.

Source: Compiled from press news and various web sites of journals including ‘t24.com.tr, habertürk.com.tr, bbc.com, hurriyet.com.tr, ntv.com.tr’

One could trace origins of Turk Telekom to the establishment of the Post Office in 1840s, (Turk Telekom, 2021). With the enactment of Telegraph and Telephone Law (No.406), telecom network establishment and service provision duty were given to

PTT (Post, Telegraph and Telephone) in 1924, (Bezaz, 2006, p. 121). The company was transformed into a state-owned economic enterprise in 1953. Works related to privatization of this enterprise started in 1983 by enacting legal provisions that enable transfer of operating rights with the Law No. 2983, (Malkoç, 2009). At the same time with these developments, infrastructure investments increased by funding from mainly self- financing methods including cross subsidization and tariff policies[150]. In fact, the company (and the country in turn) had achieved the highest growth rate in terms of telephone lines during the 1982-1992 period, (Ardıyok, 2002, p. 165). Wollcot et al. (2001) argue that the need for both modernization and expansion of telecommunications network for mainly attracting foreign investment led to modernization projects in this sector.

Owing to telecom master plan, not only network coverage expanded but also new services and technologies like first generation mobile telecom NMT, fiber- optic cable, packet switched data network services were introduced by the company. PTT, being a state economic enterprise, continued provision of these services under the control of the Ministry of Transport[151] until 1994. This year, the Parliament enacted a new law that split PTT into Turk Telekom, and PT, (Official Gazette, 1994)[152].

In other words, postal and telecommunications functions separated and the government began the privatization works of Turk Telekom. This company became operational in 1995 as the sole telecom operator, possessing whole telecommunications infrastructure including conventional telephone lines, satellite communications, cable TV lines, submarine lines and the internet backbone, (Wolcott et al., 2001).

In addition to these events, mobile telecommunication technology introduced (to the country) in the year 1986, during the initiation stage of "Nordic Mobile telephone" (NMT) system’s utilization. Due to its weight, the device was suitable for mainly in-vehicle use and NMT’s analog technology permitted only voice transmission. For

[150] In the monopoly period, PTTs (in all countries) could price some of their services above cost to finance other operations, e.g., very expensive international telephone calls.
[151] This name had been changed to Ministry of Transport, Maritime and Communications in 2011. Afterwards, another change has been made in 2018 and the current name is Ministry of Transport and Infrastructure.
[152] https://www.resmigazete.gov.tr/arsiv/21964.pdf

these reasons, adoption rates did not reach to mass market. At its peak, subscription numbers increased to 160.000[153] range before replaced by 2nd generation GSM technology later on, (Hürriyet, 2003). In this regard, it can be said that more widespread mobile telecom usage began with the adoption of GSM in the country. Turkcell and Telsim provided these services firstly in Ankara, İstanbul and İzmir by making revenue sharing agreements with Turk Telekom beginning in 1994, (Milliyet, 2004). These two operators obtained separate GSM licenses in 1998 for 25 years period. Burnham (2007) point out that acceleration in the adoption rates after 1998 was invigorated by increased competition following the termination of Turk Telekom's (incumbent operator) control over mobile phone tariffs and the issuance of 25-year licenses to these service providers. There were two operators in the market until 2000 and as the Table-29 shows adoption rates increased substantially after 1998.

Table 29- Number of Mobile Telecom Users

Years	1994	1995	1996	1997	1998	1999	2000	2001
Subscriptions*	0.081**	0.33	0.69	1.48	3.33	7.5	14.7	19.5

Source: ICTA Annual Report (2001), (*) Million, (**) Since subscription numbers are not decimals (.) used in figures, e.g., 0.081 million equals 81.000.

There were not any other operators until 2001. The bidding for the third license for installment and operation of a GSM 1800 network won by a leading national bank (Türkiye İş Bankası) and Telecom Italia Mobile consortium (Aria) in 2001. Finally, Turk Telekom started to operate the fourth mobile network as Aycell in 2001. However, Aycell and Aria established AVEA mobile telecom company after their merger in 2004[154]. Since these two operators entered the market as latecomer firms, they had difficulty in competing with the already established firms in the market. Furthermore, between these two early-comers, Telsim went into legal and financial troubles due to illegal operations of the main group, Uzan Holding at that time. In fact, Savings Deposit Insurance Fund (TMSF) seized the company in 2004. Later, TMSF

[153] Please note that the information source does not give exact date of this peak number. Notwithstanding to this, the author has found some figures giving 121.811 in April 1998 and 11.517 in March 2000 according to Turkish Grand National Assembly (TBMM-GNAT) general meeting minutes dated April 14, 2000, (GNAT, 2000).

[154] The name of the company (Avea) changed to TTMobile in 2016 due to Turk Telekom's marketing strategy.

sold it to the highest bidder, Vodafone (which is an international operator) for an amount of 4.55 billion USD in an open auction tender, (Reuters, 2005). Figure-13 gives the historical evolution of mobile telecom technologies and corresponding market actors in the IS.

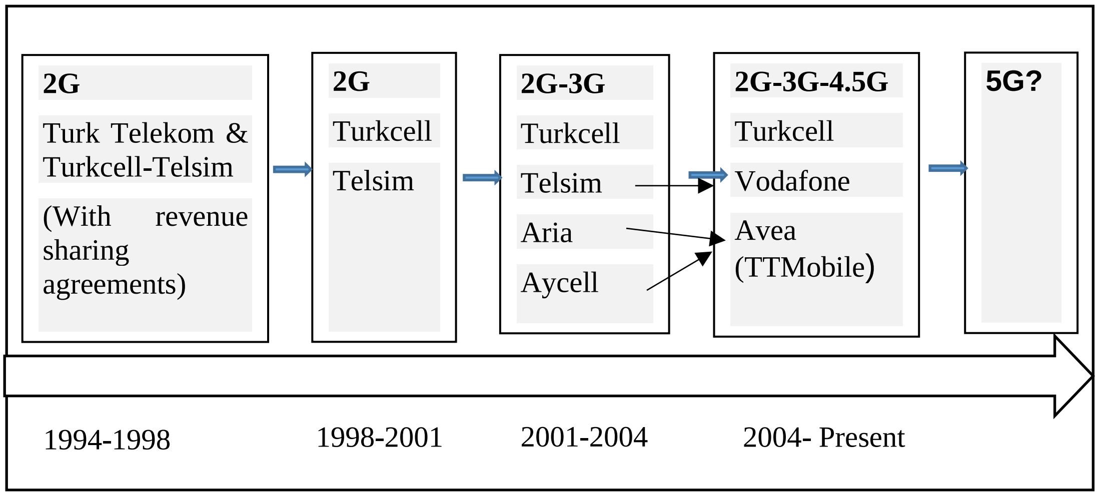


Figure 13- Historical Evolution of Mobile Telecom Generations and Actors

As another milestone in this period, Turk Telekom was privatized (i.e., 55% of its shares) after a lengthy process to Oger Telecom[155] for 6.55 billion USD in 2005. Afterwards, Turk Telekom (Oger Telecom) acquired the shares of Telekom Italia for 500 million USD to achieve the control of Avea mobile operator in 2006.

Since then, the number of market actors has not altered with the exception of new technologies introduced in the sector.

These same operators entered in the 3G (UMTS) spectrum auctions (made by the regulatory authority ICTA) at the end of 2008. In total, the auction revenue amounted to 970 million Euro (including VAT), (Dünya Newspaper, 2008)[156]. Apart from the introduction of more advanced technology suitable for data transmission, the auction aimed entry of fourth operator (a new comer) to increase competition in the market.

[155] Oger Telecom Ltd. provides fixed-line and mobile communication, internet access, data, dial-up, and value-added services in several countries. Saudi Oger Ltd. owns the firm and has telecom businesses in Türkiye, Saudi Arabia, Lebanon, Jordan, and South Africa.

[156] Turkcell got type A license for 358 million Euro, Vodafone got type B license for 250 million Euro and Avea acquired type C license for 214 million Euro, without including VAT in each of them. These types gave different spectrum capacities to each operator. Type A covers 45 MHz, Type B covers 35 MHz and Type C covers 30 MHz of spectrum. Unused Type D covers 25 MHz of spectrum. (Özdemir, 2009/1).

However, this objective did not materialize and type D license was cancelled due to lack of bidder in the process, (Timeturk, 2008)[157]. Finally, ICTA awarded IMT-Advanced (4.5 G) licenses for a total amount of 3.960 (nearly 4 billion) million Euro in 2015[158].

Notwithstanding to this, two (of these three) players have both faced with major ownership changes in recent times. The biggest shareholder (of Turk Telekom) Oger Telecom transferred its shares to a banking consortium (Akbank, Garanti and İş Bank) due to financial difficulties in paying debts to these banks. More specifically, this company borrowed nearly 4.75 billion USD from banks by showing its Turk Telekom shares as a collateral and had difficulty in paying these credits beginning from the second half of 2016. As a result, creditor banks established a joint venture (special purpose vehicle) to control the Oger Telecom's shares in the company (i.e., 55%) in 2018, (Sputnik News, 2018). Afterwards, these banks have authorized an international finance company (Morgan Stanley) as an advisor to sell these shares in 2019, (NTV, 2019a). These banks owned 55% represented through an incorporated company named 'Levent Yapılandırma Yönetimi', Ministry of Treasury and Finance (MTF) owned 25%, Türkiye Wealth Fund (TWF) had 5% with the remaining 15% in the public ownership, (Turk Telekom, 2021).

Until the first quarter of 2022, there had been no change in the ownership status of this operator. Finally, TWF acquired these banks' shares for an amount of 1.650 million USD (1.65 billion USD) in March 2022, (Cumhuriyet, 2022). In a sense, it can be said that the journey is back where it started in 2005. What is more problematic is the fact that creditor banks took over Oger Telecom's shares because of its unpaid debts. Furthermore, a public organization (TWF) acquisition of these shares means nationalization of the company.

Apart from accusations of Oger telecom's financial operations during 2005-2018 period, some economists point out to the fact that ownership of the company's network

[157] In fact, one other firm (Net GSM) entered the initial procedures but did not attend the auction process, (IT Network, 2015).

[158] In this auction, Turkcell paid 1.916 million Euro for eight packets, Avea paid 1.127 million Euro for five packets and Vodafone paid 918 million Euro for five packets of spectrum blocks, (ICTA, 2015). It should be noted that packets mean spectrum blocks in this auction. For instance, D1 packet included 2100 MHz spectrum.

infrastructure will pass to state in 2026 and have questioned the timing and amount of this acquisition that may lead to public loss, (Karatepe, 2021).

Although our purpose here is not to discuss the details of this lengthy and problematic privatization experience, it is evident that one should –at least- take some lessons from this process. This is even more important taking into account the fact that Turk Telekom’s licenses for 2G and fixed telecom services will expire in 2026 and 3-4.5 G licenses will expire in 2029 for all operators, (Ergün, 2015).

In general terms, more efficient control mechanisms and at the same time establishment of more transparency in the financial decisions of new ownership will undoubtedly benefit the public interest if another group gains the company’s control in the near future. In short, public organizations should make necessary preparations to minimize various misapplications encountered in the previous period, if a new sale (re-privatization in a sense) will be made in the near future.

In fact, and as a counter argument to criticisms of this last financial operation by TWF, General Manager of this organization (Mr. Arda Ermut) has alleged that state ownership can reduce possible legal disputes when the concession agreement ends in 2026.

Moreover, he implied that creditor banks would be unwilling to invest in upgrading existing networks because of remaining relatively short time period until 2026.

Apart from these issues, he has preferred secondary public offerings instead of block sales in the near future, (Munyar, 2022). However, this is of course not a binding statement and a block sale may be quite possible, considering revenue potential of this company.

Besides this, without a block sale to private investors, undertaking 5G investments may become more difficult by TWF. Here, a more realistic scenario would be a block sale with some favorable clauses extending (or renewing) operating license durations for a suitable period.

At this stage, it is even more difficult to comment on possible 5G licensing auctions and process. In other words, if related authorities decide on resale of TWF shares, then another decision should also be made for 5G auctions. One relatively simple alternative is to sell the company with current portfolio (i.e., existing network rights) without taking into account 5G spectrum allocations.

Afterwards, this company may enter a separate 5G spectrum auction, whose value will be determined by market (i.e., supply and demand) conditions.

Being another dominant player, Turkcell had also experienced with continuous ownership changes and struggles for the control of the company by different groups. For nearly fifteen years, major shareholders (i.e., Çukurova, Sonera and Alfa Group) competed with each other to gain control of the company and the struggle intensified in the last years leading to problems in the management of the company, (Sağlam, 2020). In the end, TWF bought 24,02% of the company (shares) from Telia Company for 530 million USD. Additionally, Çukurova Group Company also sold its shares to exit from Turkcell, (Sözcü, 2020). As a result, none of the original (founder) shareholders remained in the firm. Currently, TWF has 26,2% (15% of this in the form of preferred shares enabling control of the company) IMTIS Holdings S.A.R.L (owned by LetterOne) has 19,8% and 54% is in the hand of public, which is traded in the stock exchange, (Turkcell, n.d.-a). In this regard, Arbay (2020) has drawn attention to the heavy state presence and its possible complications in terms of state aids in every strategic sector including telecommunications, banking and energy. Similar to (our) discussions, he has particularly pointed out the dominance of state control in both mobile and broadband telecom markets through TWF. Relatedly, he argues that this market structure may distort competition and give rise to accountability and transparency problems, (Box-2).

Box-2: History of Deregulation/Liberalization in the Sector

In the journey of mobile telecom history (of the country), it is obvious that state presence (ownership and the control) has reached to very high levels in the recent years, only leaving one operator (Vodafone) where there is no direct state ownership in this company. Whether this provides some kind of advantage or disadvantage on the eve of 5G technology adoption will depend on the government policy in the near future. In fact, government policy on the situation of state-controlled operators (i.e., reselling shares of these companies), conditions and timing of 5G licenses will certainly have a profound effect on future developments of the sector.

5.1.3 Market Developments and the Current Structure

Apart from revenue shares, market formation and usage levels can be observed from several indicators in the market. With regard to this specific sector, user numbers, adoption of different services (e.g., 3G, 4.5G), service coverage (availability), quality of service and price/quality developments may be used as relevant indicators to see the market development.

It is evident that (as already discussed) mobile telecommunication services have been increasingly adopted by all kind of users from consumers to firms that are using these (as an input) to provide their services. This process is same for our case as well with very high adoption rates reaching to all levels of the society, i.e., near whole population excluding 0-9 years old category as shown in Figures-14 and 15.

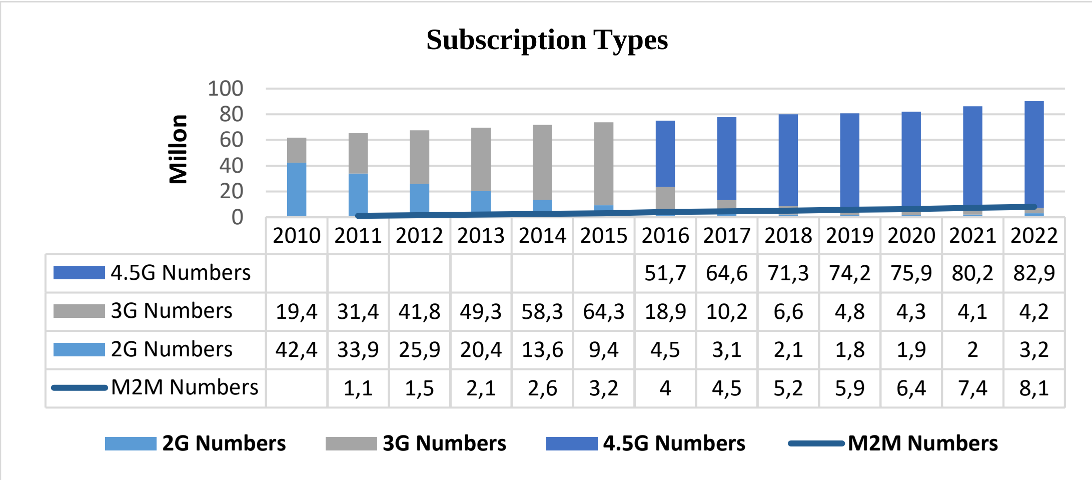
Figure 14- Mobil Telecom Usage Growth

Source: ICTA Quarterly Market Statistics.

Even just observing above trend shows that demand has nearly reached to saturation level in terms of population but if we take into account M2M and other device connections, the usage (and connection) numbers will undoubtedly continue to increase in the near future. Moreover, higher data transmission capabilities of next generation technologies will further raise the usage in terms of volume as well, (i.e., more data consumption)[159]. If one looks into a more detailed manner showing the adoption of technologies (generations) in Figure-15[160], it can be seen that users have a tendency to upgrade their subscriptions and want to use the available latest services

[159] Data usage trends analysed in the internet services sector part together with fixed internet usage developments.
[160] Please note that (as summarized in the footnote of the table) M2M subscriptions cover different generations. Hence, it should not be added to total number.

immediately (without much delay after introduction)[161]. In the light of these, it seems fairly obvious that, as soon as 5G will be available, people want to use the latest technology without much hesitation (unless, of course there will be no extreme price differential).



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
4.5G Numbers							51,7	64,6	71,3	74,2	75,9	80,2	82,9
3G Numbers	19,4	31,4	41,8	49,3	58,3	64,3	18,9	10,2	6,6	4,8	4,3	4,1	4,2
2G Numbers	42,4	33,9	25,9	20,4	13,6	9,4	4,5	3,1	2,1	1,8	1,9	2	3,2
M2M Numbers		1,1	1,5	2,1	2,6	3,2	4	4,5	5,2	5,9	6,4	7,4	8,1

Figure 15- Mobile Telecom Subscription Types (in terms of Generations)

Source: ICTA Quarterly Market Statistics, (*) Please note that M2M subscriptions can be from different generations (G) and included in these categories

From these trends and seeing the 5G as a continuation and update of mobile telecom services, it is evident that market demand and formation will not be a problem for this sectoral system.

Here, revenue developments and financial considerations can be seen a more problematic issue for (potential) operators that want to obtain 5G licenses, i.e., the cost of license fees, (Box-3).

In this respect, the crucial question for the market actors will be the level of license fees. Following this, regulatory obligations such as coverage requirements and the timing of the auction for 5G-service provision certainly effect present and/or potential actors' decisions. Market demand and alternative business & value-added services play positive roles but the macro-economic conditions, lower ARPU levels (demand)

[161] Here, it should be mentioned that some of the customers may not be aware of the subscription type, especially for the reason that operators are not providing subscription packages depending on different technologies (generations). Furthermore, the availability of latest generation for consumers depends on the coverage of these networks (i.e., where there is no 4.5G coverage, the customer has to select previous (available) technologies or receive by default.

and other financial issues such as higher exchange rates may negatively affect this process.

Box-3: License Fee Developments

License Fees
2G- 1 billion USD (for 2 operators, Turkcell- Telsim) in 1998.
2G- 2.5 billion USD for Aria in 2001. Aycell- State owned (i.e., no fee) in 2001.
2G- 4.55 billion USD (Savings Deposit Insurance Fund sold Telsim to Vodafone in 2005.
3G- 0.97 billion Euro*** (for 3 operators) in 2008. (App. 1.426 billion USD) *
4.5G- 4 billion Euro (for 3 operators) in 2015. (App. 4.440 billion USD) **
5G-?

* OECD average exchange rate was 0,680 in 2008.
** OECD average exchange rate was 0,901 in 2015. (OECD, n.d.)
***Before this date, related auctions were made in USD terms. As far as the author knows, there was no official reason for using USD until 2008. One explanation might be the fact that Euro has been introduced in banknotes form from 2002 (i.e., Euro was introduced in January 2002 for commercial use) and countries have started to use this currency more widely after this date.

Another concern (that may be negative for consumer welfare) seen from the historical analysis is the stable (unchanging) number of actors in the market.

In the early days, there were four operators for a short time period but after 2004, three operators have established their presence due to sunk costs, scale and scope economies in the sector.

Even between these three operators, there exists some differences owing to asymmetric entrance in the market. Because of different entry dates, financial and legal problems, other actors have lagged behind Turkcell in several respects.

Thanks to these operators late marketing strategies (low-cost pricing, price differentiation etc.) and other regulatory policies (most importantly number portability regulation) market share differences have reduced to a certain extent, increasing the competition level in return.

Notwithstanding to this, it may not be wrong to say that Turkcell still has a relatively superior market perception in various dimensions. As seen from the below market share trends (Figure-16), although declining from 70% to 40% ranges in terms of subscriber numbers, Turkcell is still the leading company in mobile telecom services sector and has considerable market power.

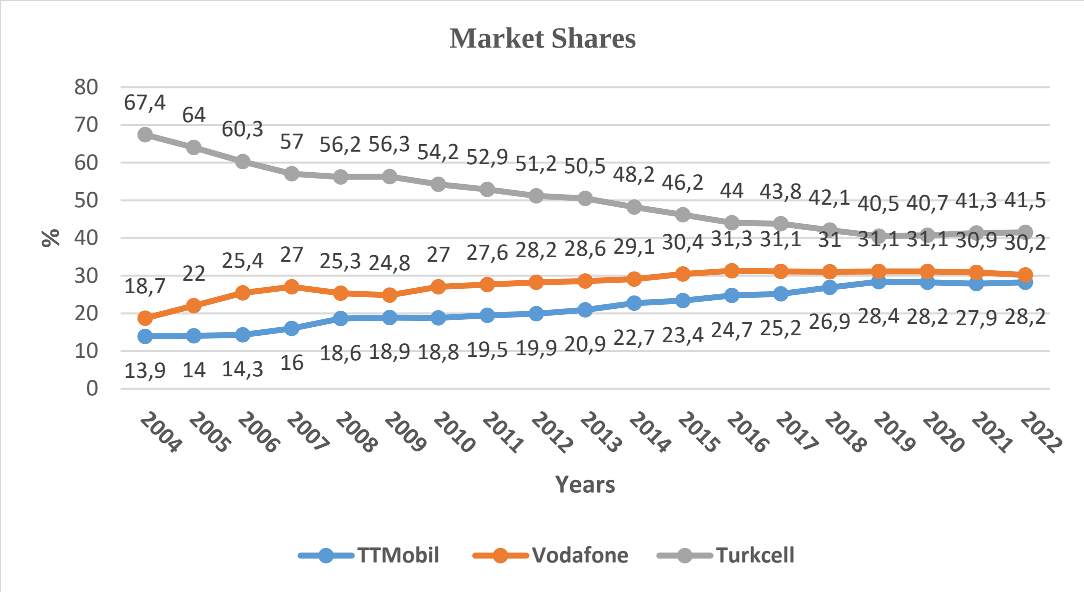


Figure 16- Mobile Telecom Operators Market Share Developments

Source: ICTA Quarterly Market Statistics, (*) In terms of subscription numbers

Without mentioning historical trends in other categories, it can be seen from Figure-17 that this company has also the largest share in terms of revenues as of 2022. Only in voice traffic minutes, market shares of these operators are similar but this category may be a misleading indicator considering the increase of data traffic at the expense of voice in the mobile networks.

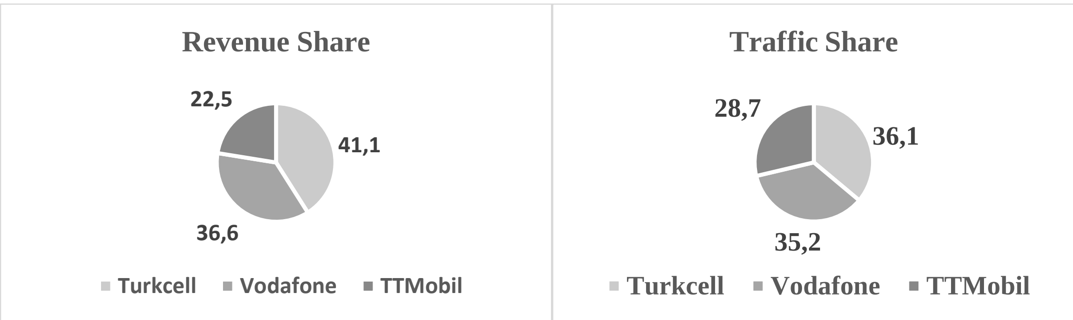


Figure 17- Mobile Telecom Operators' Market Shares (2022)

Source: ICTA Quarterly Market Statistics.

What is more significant is the fact that each of these three firms (operators) have networks including technical infrastructures and marketing channels covering nearly all parts of the country. Moreover, they have more than two decades long market presence with high levels of advertising leading to brand perception and widespread consumer awareness. In the light of these developments, it may not be wrong to infer that there will again be three operators in the 5G market (auctions) unless public authorities strongly assert the conditions for another market entrant to compensate possible latecomer's disadvantages.

However, to repeat, under the existing conditions and reading the lessons of market history, this scenario will be difficult, if not impossible.

For the timing of 5G licenses, it is difficult to predict any definite date at the time being. In any case, senior level policy makers have emphasized the necessity of domestic and national production capabilities before making transition to this new generation of mobile telecommunications.

For instance, Minister of Transportation and Infrastructure (MTI) has recently declared that '*unless related domestic technology infrastructure capability is achieved, we will not adopt 5G system'*, (Anadolu Agency, 2020). Most important of all, the President of Republic of Türkiye has pointed out the vital role of domestic production capabilities in the digital transformation process and declared the requirement of attaining these capabilities before any 5G service introduction in the country, (ICTA, 2020b). From these declarations and similar statements in all levels, it can be assumed that 5G license auctions will be made when critical components of this technology are produced at home indigenously.

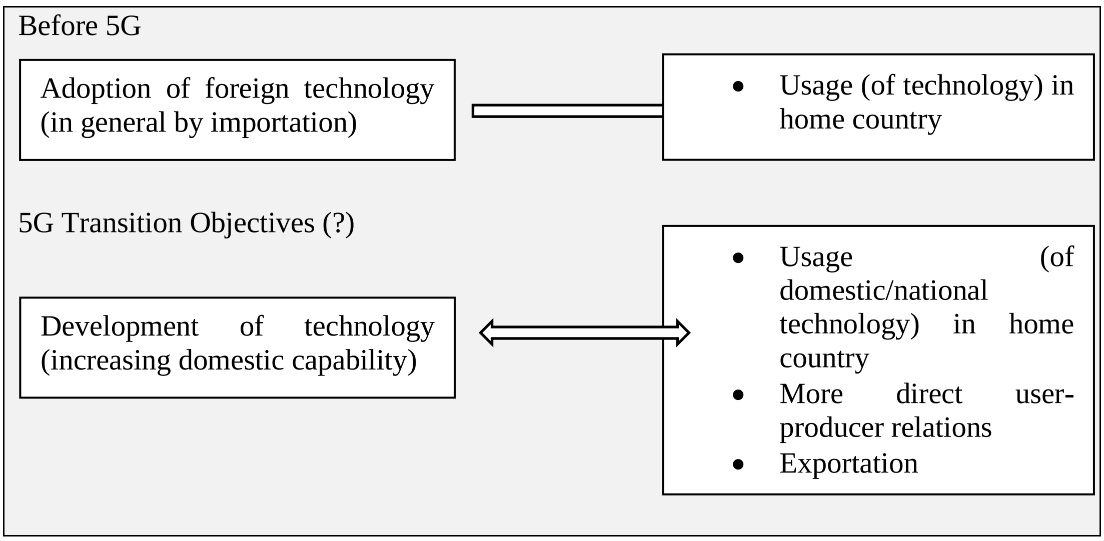


Figure 18- Linkages Between 5G Service & Production Capabilities

Source: The author's compilation.

Although objectives (Fig-18) are important by themselves, they are not easily achieved and, in some cases, the outcome is a mixed result or other than the planned one. Apart from this, these political statements can also be taken as a general framework to follow rather than detailed prescriptions. In other words, domestic and national production capability does not necessarily mean complete production of all components of a new (technology) network. In fact, in this global and interconnected world, this may be impossible to obtain due to various reasons. In sum, (at least in this part) one can think that this objective is a general policy framework to follow, since it is difficult (if not impossible) to produce all parts (components) of this technology domestically.

Moreover, this objective necessarily (though implicitly) includes the exportation (opportunities) of these components. Otherwise, there will not be a long-term sustainability given only domestic production with above competitive costs and subsidized or compulsory procurements[162].

5.1.4 Historical Evolution of Internet Services Market

Internet services had been firstly established as a dedicated 64 Kbps Internet connection between USA and Türkiye in the scope of project supported by The Scientific and Technological Research Council (TUBITAK) of Türkiye on 23 April 1993[163]. At the same time, Middle East Technical University (METU) and TUBITAK formed an informal organization known as TR-NET to promote the use of internet technologies throughout the country. On September 28, 1995, Turk Telekom announced a tender for the establishment of an internet backbone for the country.

The consortium of GlobalOne, Satko, and METU was announced as the winner of the tender. Then Satko and METU ended the consortium, only GlobalOne carried on establishing and operating internet backbone called TURNET. It began offering services in October 1996 and provided the foundation for private, commercial internet service providers (ISPs).

Afterwards, GlobalOne left the consortium and Turk Telekom undertook the development of a national internet backbone through a subsidiary company called

[162] These issues will be explored in the hardware production part.
[163] Brief history of (the beginning of) internet service introduction is drawn from Wolcott et al. (2001).

TTNet. Starting from 1998, this company began to operate the internet backbone and to provide internet access services in the retail level, at the same time.

As opposed to mobile telecommunications services, the entrance in the market (for retail-end user services) were very easy in terms of investments consisting of some hardware, connection fees and other operating expenses, (Walcott et al., 2001). In addition to this, there were no considerable license fees since no scarce resource like spectrum were required in the service provision. Accordingly, the number of internet service providers (ISP) had proliferated in a short period after the formation of the market. ICTA put ISPs in the general authorization category in which there was no need to distribute scarce resources for a limited number of firms. With the start of market liberalization, the number of ISPs had reached to 66 at the end of 2002 (ICTA, 2002, p. 68). From this date, the number has shown an increasing trend and currently there are 323 (as of June 01, 2023) providers in this category. Although these numbers are impressive by themselves, they do not have much importance in the working of market. That is to say, most of the ISPs have local presence, have very few subscribers and some of these firms do not even give service to the end users at all[164].

Table 30- ISP Market Shares

ISP	**Subscriber (%)**		**ISP**	**Revenue (%)**	
	2021	**2022**		**2021**	**2022**
TTNet	59,3	56,4	TTNet	63,4	58,0
Superonline	14	14,6	Superonline	16,3	14,1
Vodafone Net	7,1	7,4	Vodafone Net	8,0	7,8
Turksat	6,5	6,5	Turksat	1,7	1,9
D-Smart	3,2	4,8	D-Smart	2,5	5,3
Turknet	4,0	2,9	Turknet	4,2	2,0
Millenicom	1,5	1,8	Millenicom	1,6	1,6
Others	4,2	5,7	*Others*	*2,4*	9,4

Source: ICTA Quarterly Market Statistics.

The above Table-30 shows that one provider itself has nearly 60% market share and four providers together have nearly 85% of the total market volume. Furthermore, these are all subsidiaries of three dominant operators in the sector as discussed previously. In fact, several market actors have concerned about competitive level of this sub-sector since the early days of (market) formation period. One of the earliest

[164] According to ICTA, nearly 190 firms are actually giving internet services at the end of 2022.

ICTA statistics showed above 95% market share of TTNet in 2007. This market share has gradually declined to 65% range at the end of 2020. This declining share has mostly come from the entrance of these two mobile telecom operators in this segment rather than the gains of other smaller ISPs.

Starting from the early market formation dates at the beginning of 2000s, several competition investigations were undertaken by the Competition Authority (CA). In this period, Atiyas (2005) singled out the most important case as the CAs investigation of the company's (TTNet) abuse of dominant position allegations in 2001. Without going into details of these investigations, one could point out the respective roles of CA and ICTA in this period. It seems that, these two regulatory authorities had trouble in sharing responsibilities regarding the competition issues of the sector.

According to Atiyas (2005), CA refrained from intruding in ICTAs regulatory domain by declaring some of TTNet's tariffs approved by ICTA and for this reason considered outside the scope of CAs area of responsibility. From these observations, Atiyas concluded that CA would not interfere in the area of ICTAs regulatory domain after some investigations in the early periods of this telecom sector regulatory organization.

Notwithstanding to this, it is evident that the dominant position and near monopoly power of Turk Telekom led to major concerns (especially of CA) before its privatization. In fact, this authority decided two important prerequisites concerning the internet service sector as a necessary precondition of the privatization approval. One of them was the establishment of TTNet as a separate legal entity from Turk Telekom (although it remained in the holding group).

The idea behind this decision was the fact that Turk Telekom as a holder of internet backbone had a dominant position in the market. In other words, while giving wholesale services to other ISPs, the company provided retail services to end users as well. CA aimed to block possible anticompetitive behaviors of this dominant operator by separating these segments.

However, it is open to discussion to what extent this accomplished since TTNet remained in the same group ownership after this legal separation. In any case, irrespective of competition problems, the market has evolved to an oligopolistic structure with a continuous dominance of Turk Telekom in the backbone segment[165].

The other (decision of the CA) one was the separation of Cable TV network ownership (also satellite operations) in another company not affiliated by Turk Telekom, leading to the establishment of Turksat Inc. in 2004. As a separate network, cable TV infrastructure provided a valuable alternative in the diffusion of internet in some other countries depending on the coverage rates. However (in our case), Turksat had a very limited coverage from the beginning and the increase in subscriber numbers has remained low accordingly. Starting from below 1% range (0,8% in 2007), there has been an increase, especially in recent years, to approximately 6,5% market shares in terms of subscriber numbers at the end of 2022. Currently, this company has a cable TV infrastructure covering 24 cities[166] in the country with nearly 1.4 million subscribers, (Turksat, 2022).

In spite of that, many experts see this increase as unsatisfactory and propose some other policies to further expansion of the network. Indeed, 'Information Society Strategy and Action Plan (2014-2018)' has a separate policy regarding the Cable-TV network of the country.

The plan has stated the importance of this network for enabling infrastructure-based competition by providing an alternative to the fixed telecom network. Relatedly, privatization of Cable-TV put into the agenda (objective, action plan no.11) of this strategy paper. Another sectoral association (Telkoder[167]) also welcomed this proposed action for the (further) development and more active use of this platform, in turn aiding the widespread and more affordable adoption of internet as an information society goal, (Baş, 2016). However, to this date, there is not much data for the outcome (also including whether there is a policy change) of this topic. As a more recent development, Türkiye Wealth Fund has acquired full ownership of the company,

[165] Later on in 2016, these firms are given a single name "Turk Telekom" for marketing reasons. However, they are considered as different entities by the regulatory authority and are subjected to different regulations as a result.
[166] This does not mean that the cable network covers all areas of these cities. This coverage capacity should be understood as a general approximation. In other words, a city is included in the covered category even only some part of it has access to this network.
[167] Serbest Telekomünikasyon İşletmecileri Derneği in Turkish, (Turkish Competitive Telco Operators' Association)

which is also a state enterprise, (Akyıl & Gönültaş, 2017). Owing to these developments, the country's internet service sector has a highly concentrated structure with three operators that are also present in the mobile telecom services segment. What is more interesting, the state role has been getting more direct through the control of two of these firms and sole ownership of Cable TV infrastructure, apart from (more indirect) other regulatory roles.

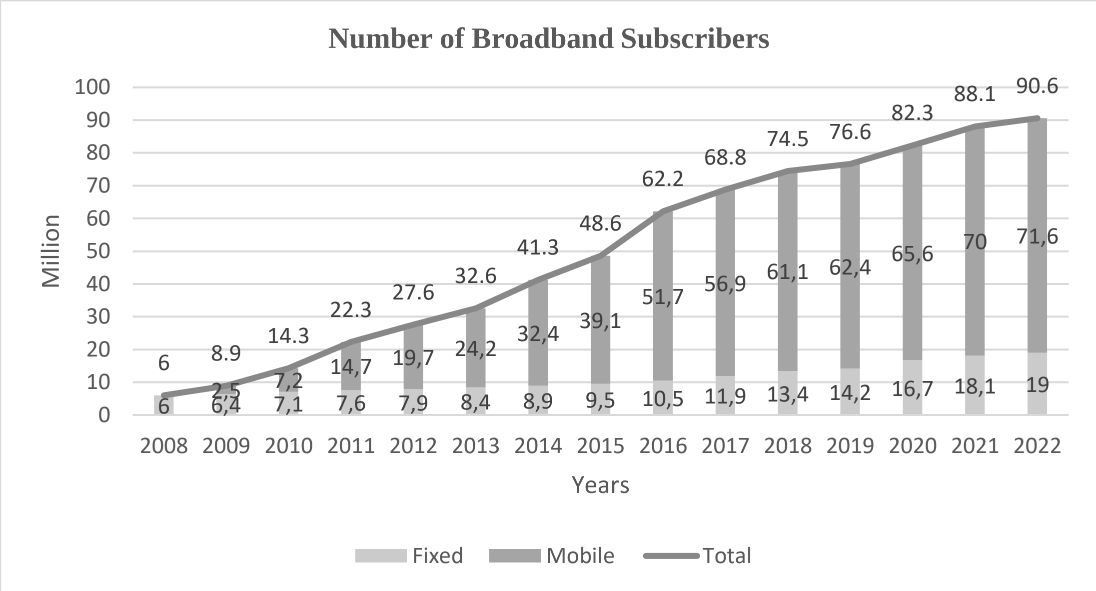


Figure 19- Development of Broadband Internet Usage (Subscriber Numbers)

Source: ICTA Quarterly Market Statistics.

At the end of 2021, the number of internet subscriptions have surpassed 90 million level (Figure-19), taking into account all network access (two) types together[168]. As the mobile internet (technology) was latecomer and technologically inferior compared to fixed internet, conventionally only fixed access methods included in the broadband internet category. Only after the advent of mobile access technology starting from 3G networks, this type of access has begun to be included in this category. Indeed, definition of broadband is still a problematic issue and there exists different classifications by several organizations.

For this reason, some people criticize the country's broadband usage numbers. However, one of the most important telecom regulatory organization, ITU[169] defines

[168] Fixed (Xdsl, Fiber, Cable) and Mobile Networks.
[169] International Telecommunications Union

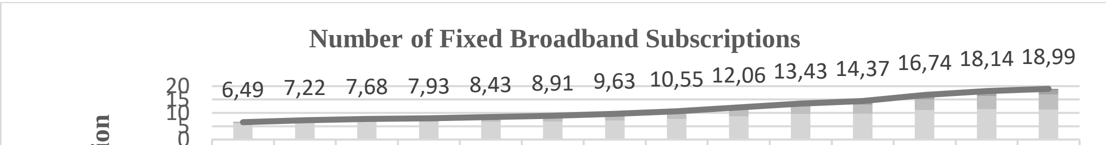
(mobile) broadband as download speeds of at least 256 kbit/s[170]. OECD also employs similar categorization with this minimum internet speed, i.e., 256 kbit/s, (OECD, n.d.-a). In any case, one can see this definition as a lower threshold limit and some other organizations are free to define their categorizations.

For instance, USA's telecom regulatory authority, FCC define this as a minimum download speed of 25 Mbps and upload speed of 3 Mbps provided by fiber optics, wireless[171], cable, DSL and satellite, (Verizon, n.d.).

In the light of these examples, it can be said that although this minimum threshold (i.e., 256 kbit/s), which is still valid in international definitions, is increasingly become unsatisfactory for many countries to include in the broadband category.

Notwithstanding to these arguments, in our case, although the main increase has come from mobile broadband user side, the alternative methods of fixed broadband subscriptions are showing increasing trend in varying degrees.

In this respect, expanding fiber access (share) in the fixed category and introduction of 5G in the mobile category will undoubtedly raise the connection speeds in the near future.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Other	0,02	0,16	0,14	0,14	0,11	0,09	0,09	0,12	0,14	0,2	0,3	0,4	0,5	0,7
Cable TV	0,18	0,27	0,46	0,5	0,49	0,56	0,65	0,74	0,8	0,93	1,14	1,3	1,4	1,42
Fiber	0,07	0,15	0,3	0,65	1,19	1,46	1,73	1,93	2,46	2,8	3,35	4	4,84	5,7
XDSL	6,22	6,64	6,78	6,64	6,64	6,8	7,16	7,76	8,66	9,5	9,58	11,04	11,4	11,17
Total	6,49	7,22	7,68	7,93	8,43	8,91	9,63	10,55	12,06	13,43	14,37	16,74	18,14	18,99

Figure 20- Fixed Broadband Usage (Subscriber Numbers)
Source: ICTA Quarterly Market Statistics.

[170] Access technologies include WCDMA, HSPA, CDMA2000 1x EV-DO, WiMAX IEEE 802.16e, LTE etc. and exclude lower-speed technologies such as GPRS, EDGE and CDMA 1xRTT etc., (ITU, 2017)
[171] Wireless broadband (Wi-Fi)

Currently, the bulk of internet subscriptions are in the XDSL category with nearly 60% of the whole market. As seen from the above Figure- 20, in spite of high-speed internet transmission capacity of Cable TV network, the market share is still well below 10% (i.e., 7%) with near 1,4 million subscribers.

Although there has been some development in the Cable-TV network availability, the usage and adoption rates remain low compared to other countries. The question is whether one can utilize this network more effectively to increase broadband adoption and market competition. This leaves nearly 30% share to fiber connections. The trend is replacement of XDSL technology with fiber but the transformation pace is slower than other country experiences[172].

In the subject of mobile broadband internet capability for matching and/or substituting fixed access methods, there still seems to be only a partial substitution despite progress in mobile internet technologies.

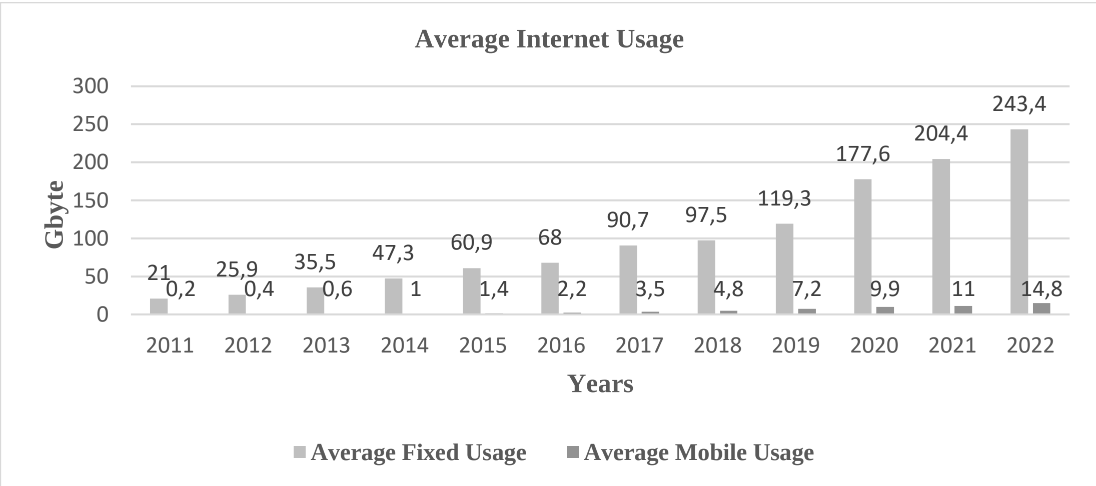


Figure 21- Development of Monthly Average Internet Usage by Network

Source: ICTA Quarterly Market Statistics.

From the above Figure-21, one can deduct two trends. One is the faster increase in the rate of mobile internet usage compared to fixed access over the years. While the average mobile usage has grown nearly from 0.2 Gbyte to above 10 Gbyte (nearly 50 times from the base number), average fixed internet usage has increased from near 20 Gbyte to well above 200 Gbyte (nearly 10 times from the base number) in the last

[172] Objectives related to fiber access and policies are discussed in the institutional framework part.

decade. On the other hand, as a second observation, there is still a big gap between the usage capacities (capabilities) of these two access technologies, meaning full substitutability is not achieved by existing mobile telecom networks. Here, taking into account the fact that more advanced mobile networks introduced with 3G and especially 4.5G in 2016, the difference seems less striking than the first observation. That is to say, the bulk of the increase in mobile internet usage has come in the last five-year period. What is more important, this trend is showing the potential of coming 5G technology. It is apparent that both supply and demand characteristics work together to further increase mobile internet usage. In fact, in the medium term, the distinction between these two platforms may lose its importance as the operators are beginning to provide integrated internet services, i.e., usage of fiber and 5G base stations to provide 5G Wi-Fi and fixed wireless access at homes.

In this context, another criticism is concerning internet access speeds in recent years, (Box-4). Currently, majority of consumers (users) are preferring speeds between 10-24 Mbps in the fixed segment while there is no pre-selected speed category in the mobile access. Some measurements of ICTA show speed ranges between 7,8 to 10,5 Mbps for downloads and 2 to 3,5 Mbps for uploads in some periodically selected cities.

Box-4: Mobile Internet Usage Trends

Having observed internet usage and access speed developments, it can be said that mobile internet use has been rising in line with developments in related technology. Starting from trivial amounts, average monthly usage volume approached to nearly 15 Gbyte range especially after the introduction of 4.5G technology after 2016. It is clear that 5G will bring further expansion (in percentage terms) in mobile internet usage and internet access speeds in line with the historical evolution of the market data and upgrading of technology. Accordingly, substitutability of the two (previously distinct) networks will increase (fixed and mobile) in the country thanks to more advanced capabilities of this technology.

Notwithstanding to these arguments, these improvements should not be expected to happen automatically since introduction of a mobile technology necessitate considerable investments nationwide. In fact, there exists various criticisms concerning inadequate coverage of existing mobile telecom networks leading to internet access and low usage-speed problems. These issues are further discussed in the next chapter.

A similar situation can be observed in the context of fixed internet services category. Although access speeds are considerably higher than the mobile internet services, these should be assessed in comparison with other country statistics. Indeed, as shown in the next part these are considerably lower than international averages.

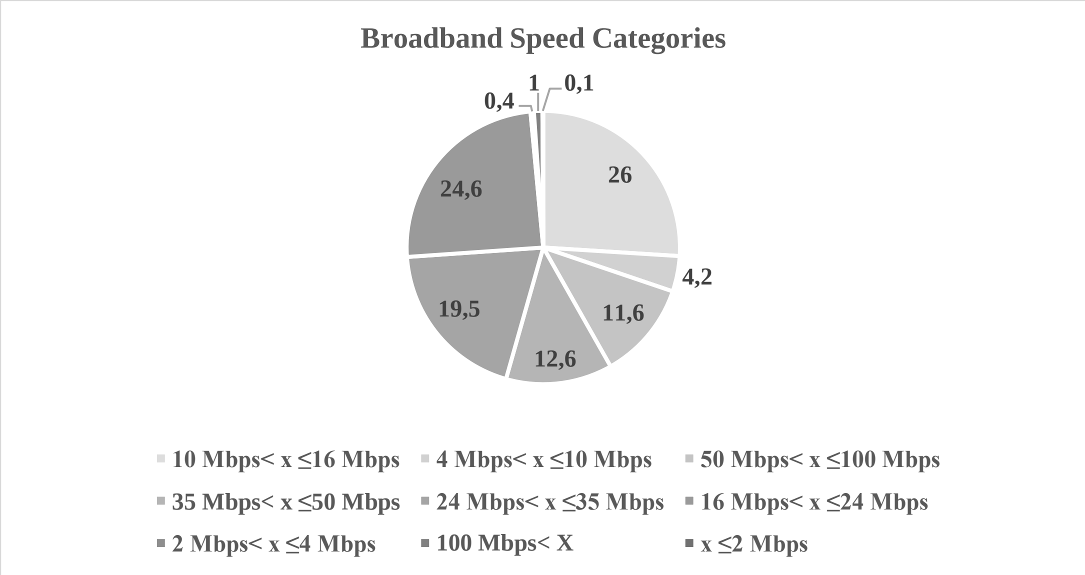


Figure 22- Broadband Speed Categorization (in the Fixed Segment)

Source: ICTA Quarterly Market Statistics.

As seen from the above Figure-22, users are mostly in lower internet speed categories. Majority of them are in the category of 10-16 Mbps with 26% and in the category of 16-24 Mbps with app. 25%, which makes half of the total picture.

It is especially remarkable to observe the share of ‘above 100 Mbps category’ with 1% and between ‘50-100 Mbps category’ with 11,6% in the total figure.

While, these lower speeds are enough from some household usage needs, they are definitely not adequate in the context of digital transformation process. On the contrary, it can be said that people in a sense forced to choose these (lower categories) because of the very high prices of upper categories.

In any case, although there has been progress and widespread adoption in the internet service market since its formation, some criticisms (or weaknesses) exist in various dimensions. In this context, inadequacy of fiber access is especially considered as a crucial bottleneck on the eve of 5G transition in the country.

As discussed later on, this access technology can provide very high access speeds and is also an integral part for the efficient functioning of 5G technology. As shown in Figure-20, there are approximately 5.7 million subscribers with fiber connections[173]

[173] Including both fiber to the building and fiber to the home connections (FTTH and FTTB).

and the fiber length has been reached to about 517 thousand kilometres at the end of 2022, (Figure-23).

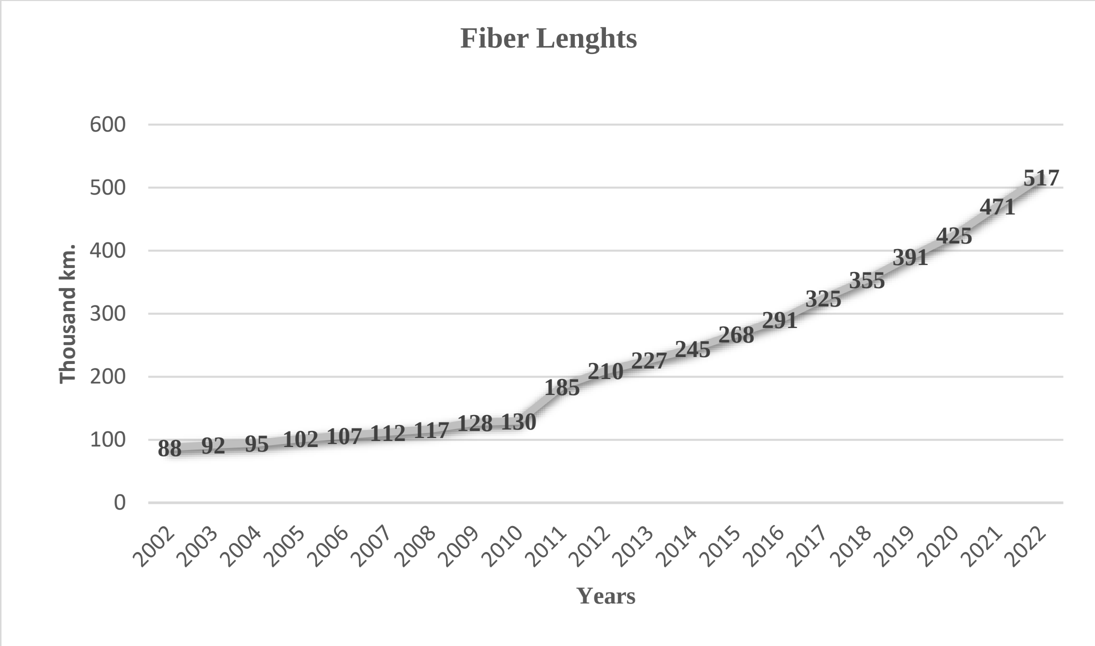


Figure 23- Fiber Length Developments

Source: ICTA Quarterly Market Statistics, (*) Figures are rounded to nearest thousand.

This figure has been increasing with roughly 10% each year recently[174] but the topic of discussion lies in the question of *'how many km is enough for the country's network to provide widespread access and serve in the future mobile infrastructure?'* Indeed, various actors have criticized the inadequacy of this capacity to meet the (high- speed internet) needs of the country. In this respect, Telkoder has argued that fiber capacity is not enough to meet the requirements of 5G provision in the country and its coverage needs to be enlarged nearly 200 times. Although the calculation method is subject to some discussions, they compare the population of different countries and fiber coverage figures in their study to shed light on the problem. In this regard, the organization has calculated that Istanbul has 3,1-metre fiber per person while Stockholm has 770-metre fiber per person in 2019 figures, (Telkoder, 2019a). Some others are similarly stating that 'the fiber infrastructure is not adequate and it should be extended' by comparing with other countries. For instance, a member of parliament (TBMM) compared the fiber coverage length with one African country, Gabon, which

[174] More specifically, the rate of increase has fluctuated between nearly 9% to 11% starting from 2015.

had 600 thousand km fiber, to argue about the lack of investment in this area, (Turk Internet , 2019).

Apart from these, another important sector actor (Turkcell CEO Mr. M. Erkan) also argued that current fiber infrastructure is not enough for the transition to 5G era. In more detailed terms, he highlighted the fact that close to 400 thousand km. fiber capacity (at the that time) should be increased to 1 million km. to establish required (and satisfactory) infrastructure for the next generation mobile telecommunications. According to him, some 15-16 million USD investment needed for this network capacity considering nearly 21 million residents (in total) of the country. Relatedly, he has pointed out the necessity of establishing a joint company to deal with fiber network investment and consisting of all big operators to share these costs, (Topcu, 2019).

In fact, a joint infrastructure project had been initiated before these more recent arguments. As early as in 2016, three of four big operators, namely Turkcell, Vodafone and Turksat with the participation of Telkoder (in the name of its members) announced their plan of establishing a 'joint infrastructure company' to avoid duplicate investments, (Milliyet, 2016).

However, the plan did not materialize and they could not establish this (joint) company due to (mainly) non-participation of Turk Telekom according to the Telkoder President (Mr. Y. Ata Arıak), (Telkoder, 2019b).

After two years (in 2018), another attempt had been made to set up a 'fiber infrastructure joint usage and cooperation protocol' with the signature of (this time including Turk Telekom) three big operators under the leadership of Prime Minister (Mr. Binali Yıldırım) and related Minister (Mr. Ahmet Aslan), (Hurriyet, 2018a).

Even the top-level commitment of public authority (government) again did not achieve the joint investment projects aimed by this protocol agreement.

More recently, a journalist has recalled this failure and indicated continuing separate (individual) investments by these operators, (Levent, 2021).

Furthermore, the President of the country declared that the fiber investment levels are not adequate and he would personally stand up to those who form obstacles for this process in several public speeches (NTV, 2019b), (Box-5).

Box-5: Increasing Importance of Fiber Access Coverage

It is evident that fiber coverage issue (problem) has been attracting much interest from all actors ranging from state officials and CEOs of the sector to the journalists and technology experts. In spite of this, continuous attempts have not been successful to this date. Notwithstanding to this observation, one should (most certainly) expect other policies and/or projects in the short term to increase the coverage of fiber network taking into account further increasing attention of top- level state actors to this matter.

Currently, Turk Telekom has the largest share in the existing fiber infrastructure. The company has nearly 78% of total with the remaining part owned by different firms (though separate figures are unavailable most probably Turkcell Superonline and Vodafone together has the largest share in this smaller pie, i.e., 114 thousand km length). Out of Turk Telekom's 403.3 thousand km fiber length, nearly 131.7 thousand km is used in the backbone with the remaining one is used in the access part. Apart from (sufficiency of) length considerations, one should also highlight the fact that the total amount (nearly 517 thousand km) does not necessarily imply that there is no duplication in this network. That is to say, it is normal that operators have prioritized metropolitan and more densely populated areas in these investments. The logical conclusion of this is that most of the other operators' fiber network is coincided with large part of the Turk Telekom's infrastructure. This does not mean that there should be no duplication of the network.

On the one side, efficiency considerations prefer no duplication (for cost saving etc.); on the other side history shows us the fact that competition has not developed (or increased) in the sector where 'service-based competition' introduced since the early part of 2000s. Instead, market competition has begun to increase only after some other operators have entered into the market by making investments to own their networks. After observing some of the important telecom service adoption/usage indicators, the study will continue by comparing the available country statistics and evaluating the sectoral policy paper objectives.

5.1.5 Some International Comparisons and Remarks

To start with, it may be a case for any topic (issue) that reliable and at the same time, comparable statistics are very difficult to find throughout the world. This is also true for the ICT, especially internet usage statistics to determine the extent of digitalization among the countries.

Digitalization or digital transformation phenomenon consists of several indicators, but undoubtedly as a starting point, information about the internet usage (adoption) is accepted as an important statistic.

In this context, especially two international organizations' statistics employed to get an idea of internet usage in the (available) countries.

These are Organization for Economic Cooperation and Development (OECD) and International Telecommunications Union (ITU).

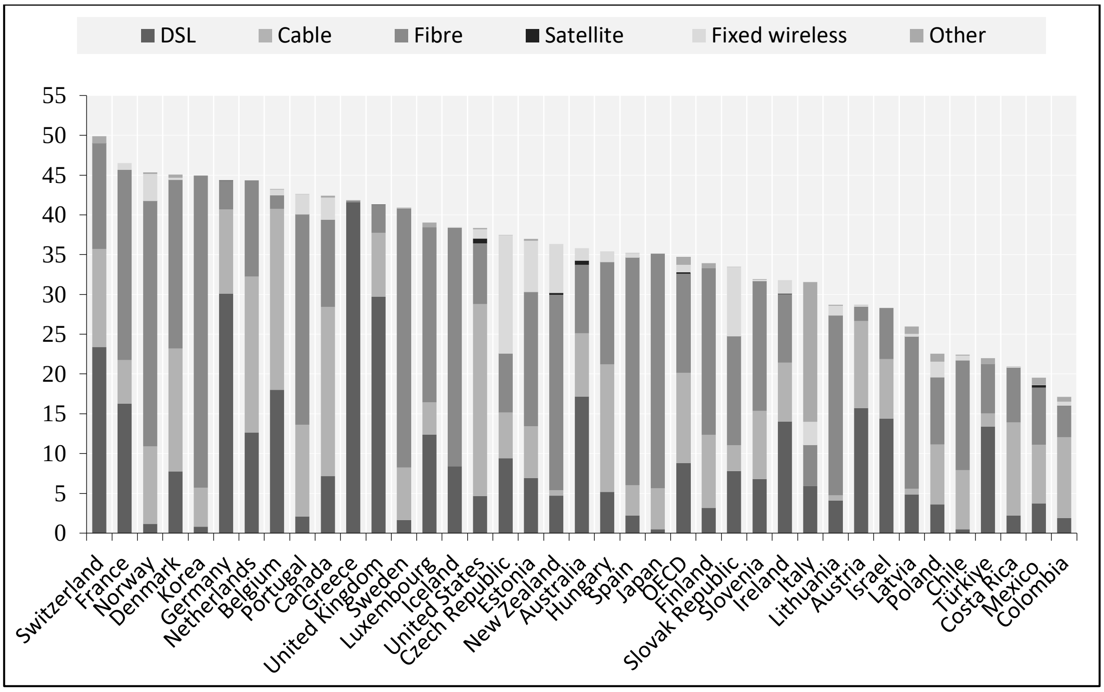


Figure 24- OECD Fixed Broadband Statistics

Source: OECD Broadband Portal, June 2022, (per 100 inhabitants)

Statistics in Figure-24 show comparative ranking of (OECD) countries in terms of fixed broadband subscriptions per 100 inhabitants.

While there is a lag of more than one year in periodic revisions, it gives a general knowledge of fixed internet adoption by different access methods. Here, OECD average is 34,69 as compared to Türkiye's average of 21,99 per 100 inhabitants. In terms of country rankings, she occupies 35th place among 38 countries. Apart from time lag consideration[175], one can comment on different average household sizes that have an effect on ranking.

For instance, Türkiye has an average household size of 3,35, (Palabıyık & Ünal, 2020), while EU-28 average is 2,3 according to recent surveys, (Eurostat, 2021).

Even this basic comparison gives hindsight in evaluating these figures.

In general, one can indicate the adoption ceiling as between 25 to 30% for our case[176] compared to other countries where corresponding figure (av. household size) is smaller.

For this reason, it may be better to revise these statistics by taking into account (average) family size of different countries.

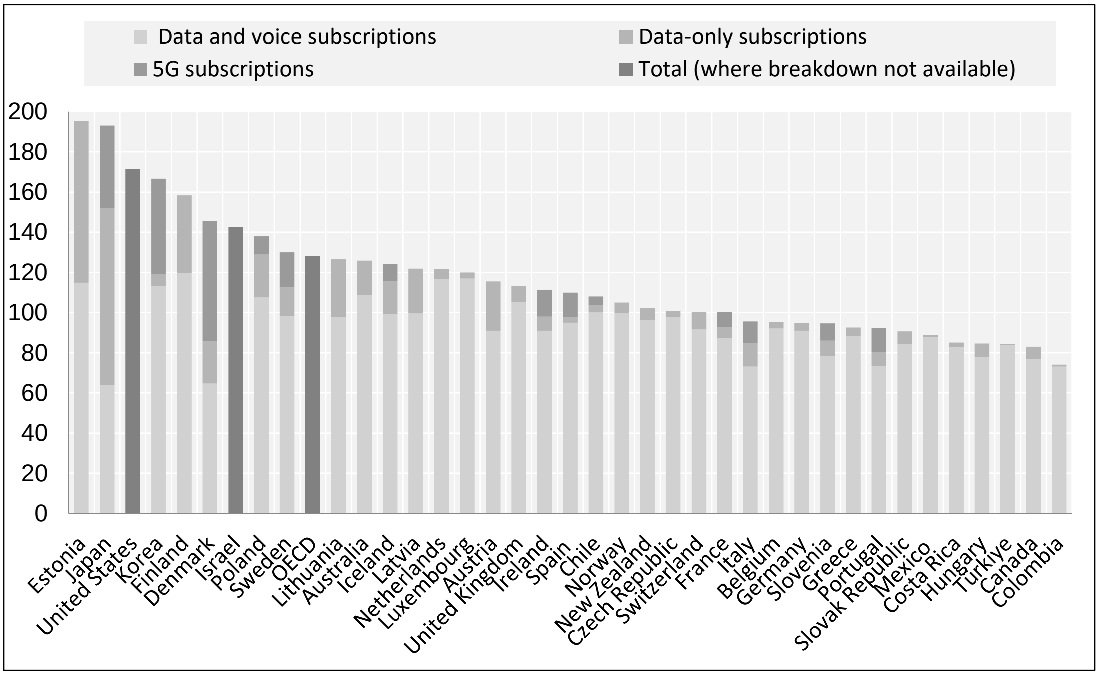


Figure 25- OECD Mobile Broadband Statistics

Source: OECD Broadband Portal, June 2022, (per 100 inhabitants)

Turning into the mobile internet adoption side (Figure-25), one can see a different

[175] It is expected that considerable time needed to obtain all these statistics, taking into account the fact that there are 38 countries in total.
[176] Assuming population of 83 million with the average household number being 3.3, without including non- residential (business and other public organizations) subscriptions.

picture of usage rates throughout the world. In fact, immense popularity and easer adoption of this access technology has led to proliferation of market size even in the less developed countries that still have uncovered internet service areas (with fixed connections). Here, OECD average is 128,2 while the study case average is 84,4 as of June 2022[177]. Developments indicate rapidly increasing trends of mobile broadband subscriptions, which are surpassing 100%[178] adoption in many countries throughout the world. In a short period, almost all countries will obviously reach this level of usage rates taking into account these trends in the world. As pointed out, the main challenge is becoming provision of more capable broadband services in terms of speed, latency and other quality of service improvements.

Indeed, 25 out of 38 OECD member countries are above this threshold rate. Some countries are even approaching 200% like Estonia with 195,3%, Japan with 193,1% and USA with 171,6% rates.

At the same time, however, there still exist differences in terms of capabilities (speed, use of multimedia content etc.) between these two technological categorizations.

Although mobile internet adoption rates are very high in general terms, this does not mean that capability of mobile networks are similar in different countries.

Apart from this, as observed, capabilities of mobile telecommunication technologies upgraded in each generation but the real transformations expected with the introduction of 5G and later generations.

In this regard, accepting that the main objective is to make high- speed digital services available to society as a whole, the introduction of 5G including timing and license conditions will be crucial for any country in the world.

Accordingly, OECD has just started to publish 5G subscription statistics for the first time in 2023. Although the number of countries that are providing 5G related data, it is certain that they will continue to increase in parallel with the expanding coverage and usage of this new technology. At this point, it is observed that 14 countries

[177] The previous statistics were 121,4 (OECD) and 81,9 (Türkiye) as of June 2021.
[178] Please note that, percentage (%) term is mainly used for abbreviation. Exact meaning is for instance, 100 people have 195 subscriptions.

provided related data, which is showing fluctuating penetration rates between very low figures, e.g., Lithuania with 0,3% to relatively higher ones, e.g., Denmark with 59,7% penetration rates.

In addition to these statistics, OECD also provides usage data related to broadband usage, as well.

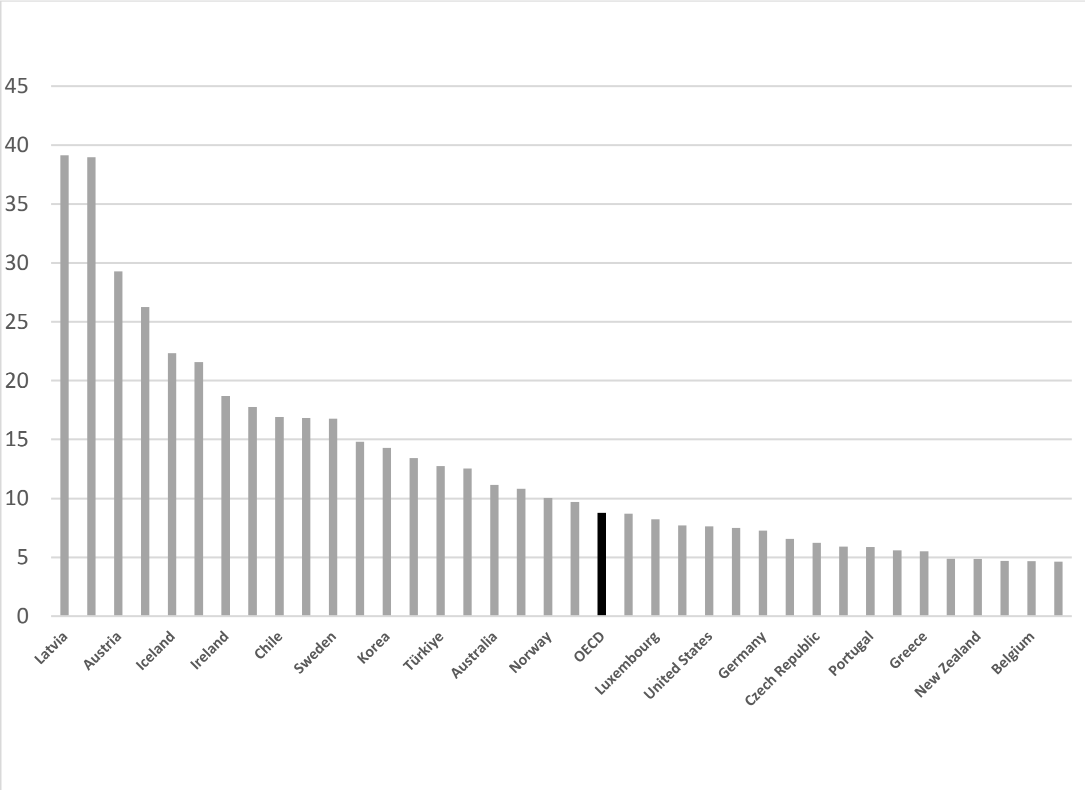


Figure 26-OECD Mobile Broadband Usage

Source: OECD Broadband Portal, June 2022, (per user/GB per month)

Figure-26 shows that mobile internet usage has been continuously increasing in each country.

In this category, it can be seen that Latvia and Austria is the leading countries with nearly 40 GB per month.

What is more important, the rate of change is also accelerating in recent years. Here OECD average becomes 8,79 GB, while in Türkiye usage has surpassed this average with 12,73 GB per user as of June 2022[179]. One of the interesting points in this category

[179] The previous statistics were 7,39 GB (OECD) and 8,92 (Türkiye) as of June 2021.

is the relatively lower amount of data usage in higher ranking countries in terms of broadband internet adoption in general terms.

For instance, Japan (with 7,72 GB), USA (with 7,62 GB), Germany (with 7,27 GB) and UK (with 6, 57 GB) are all below the OECD average in this category[180]. While there is no specific explanation found in this source, it can be said that one reason may be preference for mainly using fixed internet connections[181].

Apart from mobile-fixed internet access and broadband coverage discussions, the availability of fiber infrastructure (access) has extensively debated by sector actors and politicians in the media recently. The importance of fiber- as mentioned- stems from mainly two reasons. One is the (currently) highest capability of this medium among all existing methods and the other one is its role in the fulfillment of 5G technology as an infrastructure element in the network. Accordingly, OECD has starting to give more importance to this category in recent years.

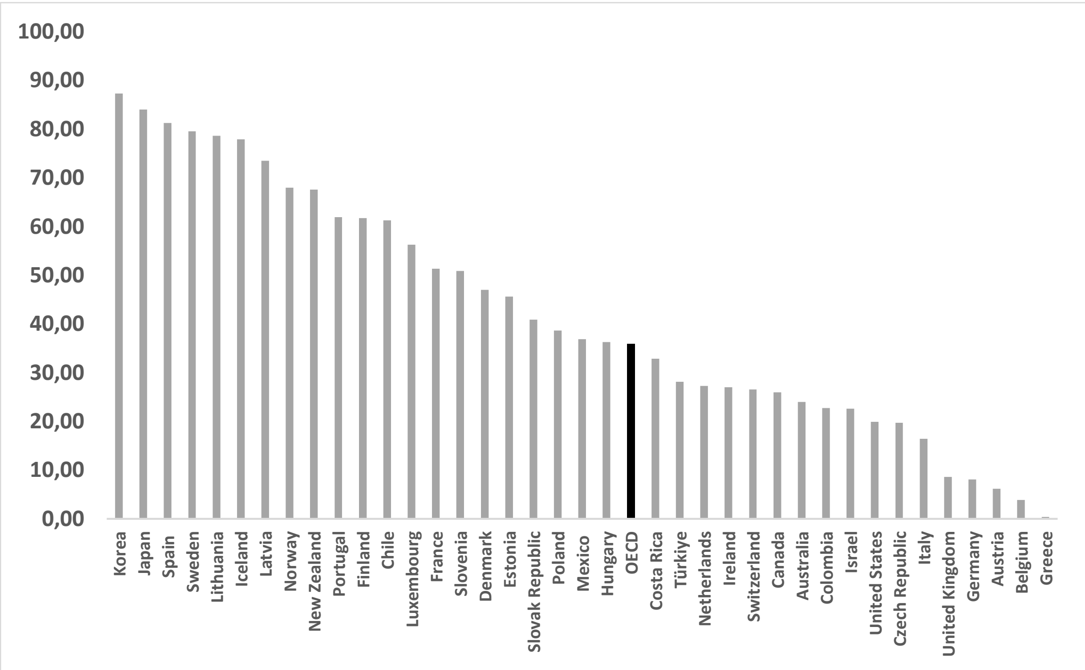


Figure 27- OECD Percentage of Fiber Connections in Fixed Broadband

Source: OECD Broadband Portal, June 2022.

[180] Please note that, data collection difficulties and some other problems are already mentioned beforehand. Here, it can be added that some countries provided data covering end of 2021, as indicated by OECD.
[181] It should be noted that there is no specific statistic related to fixed broadband usage in OECD portal.

In this regard, one comparison of OECD statistics (Figure-27) shows Türkiye staying below the average of member countries. Here OECD average is 35,8% while Türkiye has 28,13% fiber connections in the total broadband adoption statistics[182]. As expected, some of the leading countries (in terms of digital transformation) like Korea and Japan will most probably reach to 100% rates in the near future.

One should also mention some country peculiarities in this context. More specifically, USA has a rather low fiber connection rates but cable TV has a widespread coverage, leading to very high adoption rates of this access technology, i.e., penetration rate of 24,1.

While the country position is still below OECD average in the above category, growth in annual subscriptions is above this average as a positive remark. For June 2021- June 2022 period, the country's growth rate is 20,4% as opposed to general OECD average of 12,3%, (Figure-28)[183].

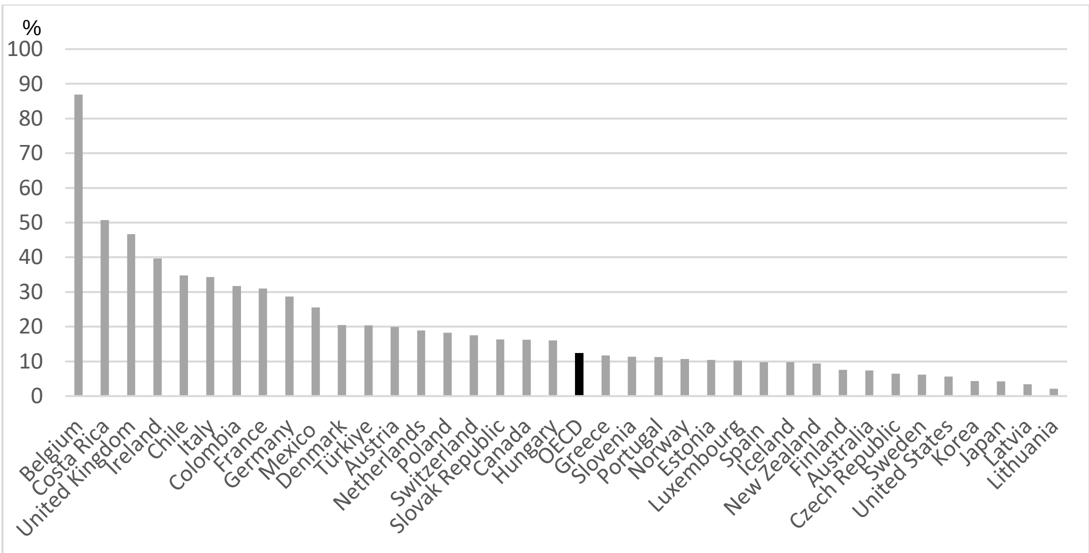


Figure 28- OECD Annual Growth of Fiber Subscriptions

Source: OECD Broadband Portal, (June 2021-June 2022)

Apart from much discussed fiber coverage issue, internet access speeds are another

[182] The previous statistics were 32,8% (OECD) and 24,9% (Türkiye) as of June 2021.
[183] The previous statistics were 12,3% (OECD) and 20,4% (Türkiye) as of June 2021. Furthermore, the country has captured one of the above average growth rates among member countries in terms of fixed broadband subscriptions with 1,17% as opposed to OECD average of 0,81% for June 2021- June 2022 period.

critical topic in efficient use of digital services and applications. It is evident that lower speeds and inadequate coverage can reduce benefits of internet usage.

Indeed, mere access to basic internet is certainly not sufficient for realization of digital economy/society goals at this stage.

For this reason, internet usage speeds are starting to take a prominent place in digital economy infrastructure statistics among countries.

However, obtaining related data seems to be even more difficult than other more standardized categories like subscription numbers.

Accordingly, OECD itself collects information from different (relatively) more established data sources without obtaining them from national organizations.

More specifically, OECD provides related statistics by combining speed tests of three different sources, namely Ookla, M-Lab and Steam. These sources show disadvantaged position of (our) the IS in comparison to other ones, (Figure-29)[184].

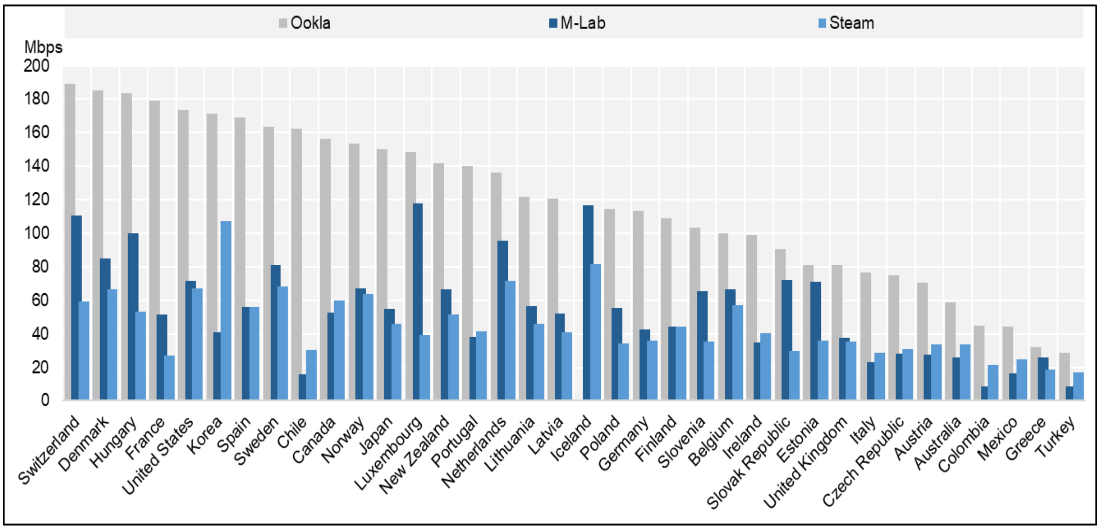


Figure 29- Average Experienced Download Speed of Fixed Broadband

Source: OECD Broadband Portal, June 2022, (2020-2012)

While OECD does not give an average, it is easy to calculate average figures in this category as well. Türkiye, being in the last position in all three, has an average of 28,9,

[184] Please note that this category has not been updated and OECD still gives data for 2020-2021 in this subject.

8,9 and 16,7 Mbps as opposed to OECD average speeds of 119,1, 55,1 and 45,4 respectively in Ookla, M-Lab and Steam tests, (Figure-29).

Furthermore, OECD also provides subscription information in terms of speed tiers. Although there is not a calculated OECD average in this category, it can be seen (from the below Figure-30) that subscribers in many of OECD countries have been transferring above 100 Mbps speed tiers and even above 1.000 Mbps (1 Gbps) are beginning to be witnessed in these countries. On the other hand, the bulk of subscribers have been in the moderate speed category (between 10 and 30 Mbps) in Türkiye.

Besides above-mentioned indicators, cost of internet services is another essential factor in adoption of broadband services. However, OECD has not been published up-to-date statistics related to mobile and fixed broadband internet prices since 2017. The reason may be difficulties in obtaining diverse information related to these services in member countries. On the other hand, OECD provides external links to broadband maps of member countries in its portal. These portals can give information about coverage and access capabilities of networks in each country and can be beneficial for consumers as well as firms in various ways. Unfortunately, there is not a publicly available broadband map in Türkiye as of this date, i.e., September 2023[185].

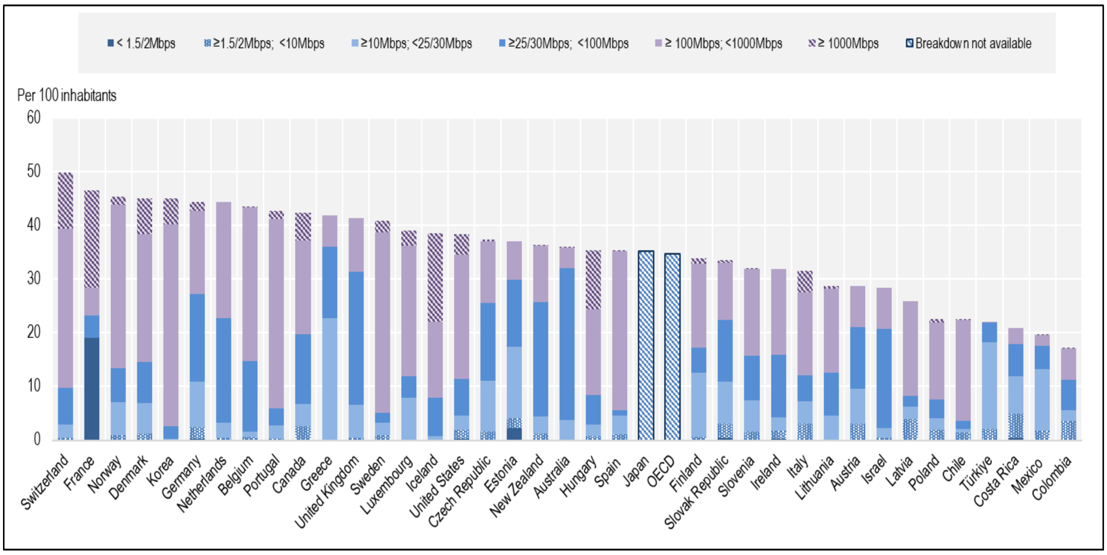


Figure 30- Fixed Broadband Subscriptions according to Speed Tiers

Source: OECD Broadband Portal, June 2022

[185] This topic is discussed further in the next, 'evaluation of policy papers' part.

Apart from (human) user related indicators, M2M numbers can show the extent of advanced digital services used in an economy. Here, OECD provides country M2M statistics for comparison purposes. In this regard, Figure-31 gives M2M cards per 100 inhabitants and number of cards in total.

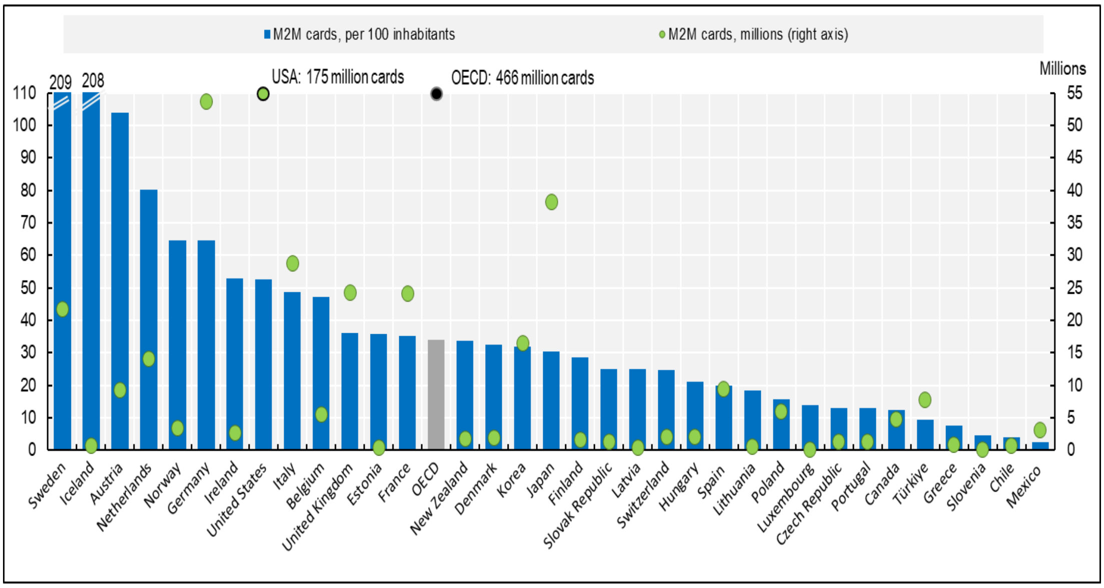


Figure 31- M2M Subscription Numbers (June 2022)

Source: OECD Broadband Portal, June 2022.

According to the above figure, Türkiye has 9,3 M2M cards compared to OECD average of 33,9 (M2M) per 100 inhabitants as of June 2022[186]. The importance of this category stems from the fact that –as emphasised before- M2M communications are at the centre of digitalization and up-to-date telecom technologies and networks are enablers of this process. In this context, main role (and at the same time benefit) of 5G technology is in M2M domain owing to the fact that these new technologies can support much more dense machine communications compared to previous ones, e.g., 4G.

In an ever-expanding digital world, it is normal to expect newer statistics and data representing development trends throughout the world. Indeed, several organizations are working on these categories and provide new kind of data categories. For instance, OECD publish statistics related to entrepreneurs' use of internet like broadband connectivity and digital applications like utilization of cloud, big-data services etc.

[186] The previous statistics were 8,4% (OECD) and 28,1% (Türkiye) as of June 2021.

Lastly, this organization gives linkages to external sites providing information about broadband coverages of member countries in the form of national broadband maps. Unfortunately, there is no publicly available information source about Türkiye in this matter. The importance of these maps stem from the fact that they provide more detailed information than consolidated nationwide statistics. In other words, one can locate which areas of the country are underserved and/or have inadequate access technologies by looking into these maps. Accordingly, it will be beneficial to publish such kind of data in Turkish context as well.

One can deduct some conclusions from observing these statistics and comparing them with other country indicators, in general terms. In the first place, it can be said that in line with evolution of telecommunications technologies, many countries have made significant progress in internet adoption rates of their citizens. Especially, mobile telecommunications enabled internet access are rapidly enlarging even in less developed countries as shown in Nigeria case. Within this context, adoption rates in Nigeria, while still lagging behind OECD averages, are approaching near to more advanced country levels, specifically in mobile broadband penetration figures. Notwithstanding to this, as in most other countries, digital divide is an important problem in the country to be focused on in several aspects. In fact, too much focus on penetration rates may disguise true extent of digital divide that exists between different segments of the society. For instance, many countries have recently achieved near 100 percent mobile broadband penetration rates but there exist significant differences in the way their citizens are using internet and digital services, i.e., usage levels, access speed and digital literacy considerations.

These arguments are also applicable to this sector in that, the case study market has among the lowest internet usage (amounts) and speed rankings in the OECD countries listing. Here, it should be evident that the country’s policy makers must focus on increasing the quality of internet access, without neglecting digital divide problem in the near future. In the light of these discussions, the study will continue with evaluation of policy papers objectives and relevance of them for the above-mentioned criteria.

5.2 Policy Objectives

In addition to the analysis of the (main) current indicators, evaluation of policy objectives is a useful method to obtain an idea of main topics and market developments. This consideration is also helpful for understanding public policy makers' visions and for seeing the extent of achievements in this regard (in comparison with stated objectives). What is more important for this study is to identify some of the problems encountered in the sector that will be used in the discussions with related (sector) actors.

To begin with, although popularity and (at the same time) significance of the "5 Year Development Plans" have been diminishing in recent years, these documents are still useful for seeing the directions, objectives of the state in various sectors and development process. As in the previous analysis of the sectoral development history from the beginning of the 2000s, the examination of these plans is started with the "Eight Five-Year Development Plan" covering 2001-2005 period giving more emphasis on the recent ones[187].

5.2.1 Eight Five-Year Development Plan (2001-2005)[188]

The importance of internet and ICT in the development policy had been emphasized in this plan.

It is seen that policy makers aimed to increase internet adoption and usage of this medium in various sectors (segments) of the economy and social life.

To begin with, the plan put the achievement of global level telecommunications capability, as one of the main targets of ICT policy. The reason for this is the fact that telecommunications services (previously telephony and internet beginning from 90s) have become an indispensable necessity for raising social welfare throughout the world. In this regard, the policy paper aimed to extend the usage of internet access in every level of education together with the preparation of suitable educational software programs. For the first time, convergence phenomenon and beginning popularity of mobile telecom services were indicated in this plan. High costs and low speed of

[187] It should be mentioned that one can find another policy papers that had/have related to telecommunications policy, e.g., MTI's and TUBITAK's strategic plans and documents. Notwithstanding to this, the papers, which are studied in this part, have covered most of the documents prepared by public organizations.
[188] http://www.bilgitoplumu.gov.tr/wp-content/uploads/2015/01/Sekizinci_Kalkinma_Plani.pdf, (in Turkish)

internet services were cited as problems in the market growth stage. In any case, the number of internet users were planned to reach 15 million in 2005[189]. GSM user numbers were expected to attain 30.5 million whereas the fiber optic cable length had been predicted to be around 103 thousand km by the end of the plan period. It can be seen that these objectives were surpassed in terms of GSM user numbers with above 43 million and nearly achieved with 102 thousand km in terms of fiber network length.

5.2.2 Ninth Five-Year Development Plan (2007-2013)[190]

As a brief summary of the previous plan, Telecommunications Authority[191] was established in 2000 (became operational in 2001) and sector was opened to competition in the beginning of 2004. The Authority completed most of the secondary legislation in line with EU Acquis Communautaire (AC)[192]. Newcomers obtained several telecom service licenses ranging from fixed telephony to infrastructure operating services.

The plan also highlighted the fact that two mobile operators signed concession agreements with the regulatory authority in 2002 and the market has started to expand very rapidly since then.

On the other hand, 'ICT infrastructure indicators table' set some main targets. These were fixed, mobile and broadband penetration rates. Whereas mobile subscriber penetration rate estimated to reach 90%, broadband subscription rate expected to reach 20% percent at the end of the plan period.

Furthermore, policy makers aimed to increase competition in the electronic communications sector with the introduction of alternative services and infrastructures.

Some of the regulations like number portability, provision of virtual mobile network

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[189] Though it is not very important, it should be remarked that the table-24 (of the plan) states number of internet subscriber whereas in the below table, the writing is "…number of internet users…" It is clear that these two wordings have different meanings.
[190] https://www.sbb.gov.tr/wp-content/uploads/2022/07/Dokuzuncu_Kalkinma_Plani-2007-2013.pdf, (in Turkish)
[191] The name of the organization changed to Information and Communications Authority (ICTA) with the Law No.5809 in 2008.
[192] EU legislation term is used interchangeably in the text along with AC abbreviation.

service, broadband wireless access service and terrestrial digital platform services planned to be implemented in this period.

The plan also considered public procurement as a tool for supporting the development of ICT infrastructure. Similarly, policy makers aimed to meet broadband communication needs of the public sector by aggregated purchases. By this way, they intended to achieve cost reductions and contributed to the development of broadband internet networks[193].

Policy makers wanted to support the production of satellite technologies by establishing a research center and enhancement of domestic capabilities in this regard. Apart from this, public procurement issue was stated further in 'the improvement of the business environment[194]' and 'ensuring the transition to high value-added production structure in industry and services[195]' categories.

5.2.3 Tenth Five-Year Development Plan (2014-2018)[196]

As a brief summary of the previous period, it was stated that usage of communication technologies especially broadband internet had been increased in both business and end user segments. In turn, this led to widespread provision of public services and utilization of ICT in the socio-economic life.

In fact, for the first time, a section related to 'e-government services' put in the plan's 'policies and targets' part.

However, the report stated that ICT market[197] did not grow as much as the growth rate in electronic communications sector in the last term. For ICT sector, the plan set the

[193] However, there is no publicly available information regarding the application of this policy proposal in terms of broadband internet infrastructure. For the development of ICT infrastructure including hardware and software, the plan did not give any further details on specific policy proposals. In any case, this issue (public procurement) has been emphasized in subsequent plans and they are discussed further in this study as well.

[194] A suitable, transparent and competitive environment for SMEs in public procurement would be formed with widespread use of e-procurement applications.

[195] Design, engineering and innovation capabilities of the machinery and white goods industry would be supported. Public awareness would be increased to prevent unfair competition in public procurement arising from foreign companies' practices.

[196] https://www.sbb.gov.tr/wp-content/uploads/2022/08/Onuncu_Kalkinma_Plani-2014-2018.pdf, (in Turkish)

[197] The wording in Turkish is 'Bilgi Teknolojileri Pazarı'.

targets shown in the below Table- 31. Starting from this development program, policy papers mostly set broadband adoption (penetration) targets.

More strikingly, an objective related to access costs of internet were stated in this table.

However, it is not clear how to calculate and/or follow the realization of such targets afterwards. Indeed, it can be seen that later policy papers usually have not adopted access cost related objectives.

Table 31- Developments and Objectives in ICT (related segments)

Targets	**2006**	**2012**	**2013**	**2018**
Broadband Subscriber Rate (%)	3,8	26,5	45	70
Broadband Access Cost/Average (per person) GDP	---	2	1,8	1
Internet Usage Rate (%)	30,1	47,4	50	75
ICT Market (Billion USD)	5,1	10,5	11,6	23
ICT Export (Billion USD)	0,1	0,5	0,8	2
E-Trade (Billion TL)	2.4	30.7	40	170
Online Shopping Rate (%)	---	14,3	20	70

Source: 10th Five -Year Development Plan, p. 96

After stating some quantitative targets, policymakers pointed out essential role of efficient ICT usage in the transformation of society into a digital one. The plan further stated necessity of bridging digital divide between different parts of the country. However, there was no definitive or quantitative target set out in this regard. Another development was the establishment of the cyber security council and the acceleration of works in this subject.

For this end, several policies were prescribed in various dimensions. In this context, it was recommended that an information society strategy and action plan would be enacted to determine detailed steps and oversee the implementation. Besides this, policy makers underlined the importance of related actors' participation and ensuring the coordination between these players.

Apart from these, the plan stated some more technical policy objectives. The coverage of broadband networks-especially fiber infrastructure- were planned to be extended together with the provision of accessible costs and quality thresholds. It was also planned that transition process to digital broadcasting over terrestrial transmitters would be completed in this period. The frequency band that unloaded by termination of analog broadcasts would be utilized in more efficient usage areas like mobile communications spectrum allocation.

Policy makers aimed to increase the effectiveness of regulations and competition level in the market, at the same time promote cooperation between related actors in the sector. It may be normal to see these policies formulated in very general terms but in any case, it is not clear what is meant by ‘increasing the effectiveness of regulations’ and ‘increasing competition and cooperation in the sector’. In this heading, a specific objective set out (though the relationship to these more general objectives is not clear to the reader), to make the country international data transmission center.

Another topic related to the regulation of data (in the plan) was the preparation (and enactment) of legal infrastructure and protection of national information security.

The plan declared that ICT purchases in the public projects including ‘Fatih Project’ would be designed to promote domestic sources and to maximize value added from these firms, especially SMEs. Accordingly, incentives and support mechanisms were devised in prioritized areas.

The vertical sector applications (solutions) firstly mentioned in this plan and it was aimed to widen (expand) the usage of these services in areas such as health, transportation, energy, home, water and disaster management.

Besides, the plan aimed to assist development of smart city concept by increasing infrastructure, capacity and skill levels in the field of ICT.

Policy makers intended to bolster the internet economy by devising necessary legal, administrative and technological infrastructures. The plan stated that national internet economy initiatives (ventures) would be supported to enter in foreign country markets, especially in the regional countries.

Additionally, software firms especially games and mobile application developers would be given incentives to generate and commercialize digital content, along with production of more national language content. To assist the achievement of these objectives, the plan envisaged the implementation of educational and occupational programs.

5.2.4 Information Society Strategy and Action Plan[198]

State Planning Organization (SPO)[199] prepared first Information Society Strategy and Action Plan (ISSAP), which was covering 2006-2010, in 2006. The plan aimed to support the process of transformation into an information society by proposing several policies. Briefly, main pillars of the document were 'social transformation', 'penetration of ICT into business world', 'modernization in public administration', 'citizen-centered service transformation', 'globally competitive IT industry, 'competitive, widespread and inexpensive communication infrastructure and services' and 'development of R&D and innovation'[200].

Afterwards, ISSAP (2015-2018) detailed the policies set out in the 10th five-year development plan in ICT related topics. Being a very detailed document, it had eight main pillars consisting of ICT sector, 'broadband infrastructure and sectoral competition', 'qualified human resource and employment', 'diffusion (adoption) of ICT in the society', 'data security and user trust', 'innovative solutions supported by ICT', 'internet entrepreneurship and e-commerce', 'user focus and efficiency in public services'. In turn, there were seventy-two specific actions in total (grouped in these pillars). Since it was a detailed information society plan, all these pillars were related to the (our) study topics whether in one way or another. Notwithstanding to this (and in line with limitation of the scope), 'broadband infrastructure and sectoral competition' category was (our) main point of interest[201]. There were eleven actions

[198] http://www.bilgitoplumu.gov.tr/strateji-ve-eylem-planlari-2/2006-2010-bilgi-toplumu-stratejisi/, http://www.bilgitoplumu.gov.tr/wp-content/uploads/2020/07/2015-2018-Bilgi-Toplumu-Stratejisi-ve-Eylem-Plani.pdf, (in Turkish)

[199] This organization's name was changed to 'Ministry of Development' in 2011. Afterwards, it was reestablished under the name of 'Presidency of Strategy and Budget' in 2018.

[200] The policies set out in each main topic are not stated here, since a relatively more recent one, covering similar topics, had been published by this organization. For this reason, more information about ISSAP (2015-2018) are given in this section.

[201] These actions had very extensive scope covering (nearly) all aspects of digital transformation. Briefly, **ICT sector actions** included several types of software sector supports, preparation of gaming sector strategy plan, cloud program development for SMEs, promoting content production in the Fatih Project and increasing domestic value added in smart devices, among others. **Qualified human resource and employment category** mainly covered preparation (and provision) of educational

stated in this category. Ministry of Transportation and Infrastructure (MTI)[202] and ICTA were the responsible organizations in most of them (10 out of 11), with the remaining one in the responsibility of Ministry of Environment, Urbanization and Climate Change (MEUCC)[203]. One can comment on the outcome (or current situation) of these actions as follows. Transition to a regulatory approach on a regional basis planned to be completed in 2015 but there is no application of this regulatory approach as of this date. Being another problematic area, it was aimed to establish a fiber support program giving incentives to operators to invest in unprofitable areas by using universal service funds. Even though, MTI has implemented universal service projects in some unserved areas, there is also no information related to the establishment of 'fiber access support program' as stated in the plan. Another action was the planned 'revision of regulatory framework'. In this subject, it was stated that an ex-post impact assessment would be made to determine the areas where revisions needed. Furthermore, the plan accepted the fact that competition level in the sector was not sufficient despite several institutions that contributed to the development of the competition like number portability and consumer rights regulation. However, (up to

programs in all levels of schools and for businesses in the form of on-the-job training with additional actions like development of programs for attracting qualified work force from abroad. **Internet entrepreneurship and e-commerce axis** had policies to support the growth of this market such as preparation of e-commerce strategy, completion of e-commerce legislation, development of e-entrepreneurship culture program, establishing an e-Commerce monitoring and evaluation system and creating trust stamp system for e-commerce sites. Development and provision of e-government services, formation of corporate information strategies, increasing capability (and capacity) of public sector in terms of digital services such as cloud computing, sharing public data and establishment of a Public Informatics Competence Center were among the numerous planned actions set out in the **User focus and efficiency in public services category. Innovative solutions supported by information and communication technologies** consisted of wide-ranging implementation areas from smart cities program development, supporting smart applications, integration of e-health records and standardization & accreditation, green informatics program development to big data pilot implementation in the public and ensuring open access to cultural and scientific digital information. **Data security and user trust category** aimed the enactment of cyber security (law) and personal data security law, preparation of a Cyber Crime Strategy and Action Plan, raising awareness in safe internet usage, establishment of specialized cyber-crime courts. **Diffusion (adoption) of ICT in the society** had some mixture of policies covering several areas. These were ranging from preparation of digital divide index, dissemination of special ICT software and hardware for disabled, updating the curriculum for awareness raising on ICT, extending internet access, development of national (Turkish language) digital content and applications to establishment of public informatics centers in local government organizations and improving conditions of internet cafes.

[202] Please note that the Ministry's name previously was "Ministry of Transport, Maritime and Communications". The name has been changed to Ministry of Transportation and Infrastructure (MTI) in June 2018. In the study, current names of the ministries are used to avoid confusion.

[203] At the time of 'action plan' period, the name of the ministry was 'Ministry of Environment and Urbanisation'. It has been changed to 'Ministry of Environment, Urbanization and Climate Change' as of October 21, 2021. In the study, current names of the ministries are used to avoid confusion.

now) there is no such publicly available outcome showing the necessary revisions and/or amendments in the regulatory framework. In other words, people don't see any 'regulatory impact analysis' (both ex ante and ex post) to observe the cost-benefit outcomes of these regulatory works. Unfortunately, policy makers have not preferred to undertake such studies and (even if they have made) they have rarely shared these with the public[204]. Preparation of a national broadband plan was another action item and as detailed below MTI prepared this for the 2017-2020 period. The interesting point here is that most of the above mentioned and other policies were also included in this late strategy plan leading to some sort of duplication and ambiguity in the institutional framework. These policies included supporting of internet exchange-point establishment, making indoor internet infrastructure installation mandatory, allocation of spectrum resources, promotion of domestic 4G electronic communication equipment production and usage. For the remaining action items, ICTA gave 4.5 G mobile technology licenses in 2016 and operators began to give internet services from these networks[205]. Lastly in this category, (it was stated that) 5G related R&D and participation to standard setting works (events, processes etc.) were to be started in the plan period. Although, supporting of domestic production capabilities have begun since the introduction of 3G [206] there is not much information on the efforts (participation) about the standard setting processes of these new technologies. Among the very extensive set of categories (and policies), diffusion of ICT in society is more closely related to the broadband infrastructure topic in that these two can be regarded as two sides of a coin, i.e., supply and demand.

Indeed, it is seen from the national broadband plan that many of the actions were also included in this document like dissemination of special ICT software and hardware for disabled, updating the curriculum for awareness raising on ICT, expansion of internet access, development of content in native language (Turkish) digital content and

[204] The study analyses some possible reasons for this observation. Here, it can be said that lack of transparency and bureaucratic control mechanisms has contributed to this outcome.
[205] The plan stated the intended technology as 4G. However, the regulatory authority (together with the MTI) introduced more advanced version of this technology, which can be called 4.5 G. This upgrade can be seen as an extension of 4G (i.e., LTE and LTE-advanced) that provides faster download/ upload speeds, which in turn enables more efficient IoT connectivity, mission critical public safety and broadcasting over LTE among other advantages, (RF Wireless World, n.d.-b).
[206] Topics related to the hardware production segment has been analysed later, in a separate part.

applications. In this context, preparation of a digital divide index was stated as a policy item to measure ICT access, usage status and skills of individuals more accurately.

This action's responsible organization was Turkish Statistical Institute (TSI) and although this organization prepared several statistics (related to ICT usage), these are not detailed enough to show differentiations in terms of income (lower income groups), disabled and people living in rural areas[207].

Other topics including diffusion (expansion) of special ICT software and hardware for disabled, updating the curriculum for awareness raising on ICT, development of Turkish digital content and applications were also stated in the below mentioned plan (NBSAP) with similar wordings.

Establishment of public informatics centers in local governments were put into responsibility of MTI and Ministry of Family and Social Services (MFSS)[208] took responsibility of improving conditions of internet cafes.

The plan had further aimed expansion of internet access by stimulating demand as an objective in this category. Accordingly, MFSS[209] had given the responsibility of providing internet access to those families that could not afford the cost by using public funds.

Indeed, one article asserted the news that MFSS would start a free internet project (with a fund of 40 million TL) and nearly 300.000 people benefit from this project in 2016, (Dünya Newspaper, n.d.).

However, there is no publicly available information about the implementation details of the project such as starting date, coverage in terms of time (whether it was a

[207] There are six tables in Household Information Technologies (IT) Usage Survey showing the gender differential (and the total amount) in internet usage, internet usage by latest use, e-government service usage rates, e- commerce and internet purchases. Moreover, there are statistics showing regional differences in internet access and (general) internet access in households and internet connection types.

[208] The name of the Ministry was 'Ministry of Family and Social Policies' until 2018, when it was changed to Ministry of Family, Labor and Social Services. Finally, the current name has become Ministry of Family and Social Services in 2021. As a general practice of the study, present names of organizations have been used here.

[209] Together with the National Education Ministry, Ministry of Finance, Ministry of Infrastructure and Transport and ICTA as cooperating organizations.

temporary or continuous project) and usage, i.e., how many people actually benefited from this.

5.2.5 National Broadband Strategy and Action Plan (2017-2020)[210]

Among other policy papers, 'National Broadband Strategy and Action Plan (NBSAP)' is one of the most detailed one due to its focus on broadband internet without expanding the scope to other ICT topics such as software sector development[211]. There are several quantitative targets set out in this plan, (Table-32).

Table 32- Quantitative Objectives in the NBSAP

Indicators (Targets)	2016	2020	2023
Fixed Broadband Penetration Rate (%)	13,2	20	30
Mobile Broadband Penetration Rate (%)	64,8	80	100
Internet Usage Rate (%)	61,2	70	80
Fiber Int. Subscribers (mil.)	1.9	5	10
Accessed residences with (at least) 100 Mbyte/sec. (%)	32	50	100
Accessed residences with (at least) 1 Gbyte/sec. speed (%)	-	-	20

Source: NBSAP, (2017-2020)

The broadband penetration rate targets have been nearly achieved with current rates of 22,2% for fixed (OECD average 34,7% as of June 2022) and 85,7% for mobile (OECD average 128,2% as of June 2022) broadband internet at the end of December 2022. As mentioned, one issue for 2023 objective in the fixed internet category is related to the number of households in the country. According to TSI, there were approximately 24 million households as of May 2020. Excluding other kind of residences (businesses and other organizations), this set a possible maximum level of broadband penetration in the country to around 30% in broad terms.

Another topic with the access indicators is the problem of overlapping. Like fiber length considerations, simply adding up each operators' accessed residences may lead to distorted results. Here, usage of infrastructure inventory system and publication of broadband map can be used in a more accurate identification of these quantitative

210 http://www.sp.gov.tr/tr/temel-belge/s/154/Ulusal+Genisbant+Stratejisi+ve+Eylem+Plani+_2017-2020, (in Turkish)

211 Since it is a long policy paper (116 pages in total), only (quantitative) targets and main policies of this report are evaluated in this study.

objectives. The NBSAP had extensive set of policies in three broad classifications as shown in Table-33. These were 'stimulation of demand', 'stimulation of supply' and 'stimulation of demand & supply simultaneously'[212]. There were 25 policies in total.

Before all else, it is observed that "follow-up of national broadband strategy goals" (last action) has not been made public and for this reason, it is rather difficult to assess the achievement (rate of) of these actions/policies. In fact, anyone that has studied this and other similar papers can comment on the fact that there is rarely a follow-up and/or post-implementation review available for the public, (Box-6). Apart from this main argument, specific points of these policies have been evaluated in the Appendix-F of this study.

Accordingly, some main observations of this paper are briefly stated in the below (Box-6).

Box-6: Observations on NBSAP policy implementations

A financial support model for underserved areas: Although a financial model for expansion of broadband services have been suggested in the plan, there is no outcome related to this policy proposal. In any case, it should be discussed in the context of a universal service policy, which still needs revisions to improve implementation procedures.

Decreasing taxes and other financial liabilities: Sector actors have argued about their tax burdens virtually since the early days of the liberalization process. Nevertheless, these complaints have not been solved with many of the taxes like special communication tax remain in practice. What is more, it can be stated with a confidence that there will be no tax reduction in the sector given macro-economic conditions of the country after recent diseases, natural disasters and conflicts in nearby countries.

Development of cable TV network: The plan emphasised the important role of cable TV network to increase competition and to upgrade capabilities (e.g., speed and latency improvements) of telecom infrastructure.

Accordingly, some policy steps had been proposed to expand this network coverage and upgrade its technology without much success in the end. One can also see this topic in other policy papers, but up to now, there is no significant progress or change apart from some gradual investments of Turksat in a limited coverage area.

Preparation of a mobile broadband spectrum strategy: NBSAP aimed preparation of a specific mobile broadband spectrum strategy in 2017-2020 period. However, it had not been published in this period. Furthermore, ICTA included this topic in the 2020 work plan with a planned completion date of Dec, 2020. In the end, ICTA published a summary of the report after more than two years without mentioning the reasons for this delay and not giving complete report to public.

[212] These are 'Genişbant Arzının Oluşturulması', 'Genişbant Talebinin Oluşturulması' and 'Hem Genişbant Arzının Hem Talebinin Oluşturulması' in Turkish.

Expansion of broadband satellite services: This topic is one of the least discussed items of the plan. There is not much information on related works both in the scope of NBSAP and in other policy papers of public organizations. The number of internet subscribers have reached 16.000 making up very small percentage of total amount.

Establishment of internet exchange points (IEP): As another critical topic in terms of their benefits for improving quality, transmission speeds and reducing operational expenses of service providers, NBSAP aimed establishment of IEPs in the implementation period.

In spite of the fact that, other policy papers have also stated this objective, there is not a satisfactory outcome in this category as well.

Regulation on regional bases: This policy can also be seen in many policy documents especially before recent years. Like many other specific policy proposals, this has not been implemented in practice and it is not wrong to say that sector actors (including public organizations) seem to lose their interests on this issue.

Topics related to market workings: Without going into details, the plan aimed to support infrastructure investments of business firms and development of market competition.

In spite of other action plans that have included similar policy proposals, market actors still complain about obstacles in investment procedures and low level of competition in broadband markets.

Supporting domestic production capabilities: NBSAP also aimed to increase domestic production capabilities and R&D efforts as important parts of a national level broadband strategy. Although some policies and other regulatory mechanisms (other than NBSAP) have been introduced up to now, there exists various problems in implementation process.

Availability and effectiveness of follow-up mechanisms: Having studied important policy papers related to the sectoral development (problems), one can conclude that especially follow-up mechanisms do not work effectively as understood from the lack of sufficient post-implementation reviews available to the public.

It is evident that sharing (disclosing) the outcomes of these plans to the public will increase the benefits of these works since path-dependency is an important phenomenon to consider for a dynamic policy-making process.

Importance of Regulatory Impact Analysis: Closely linked to above mentioned point, it is essential to evaluate possible impacts/outcomes of policy papers and other regulations by both ex-ante and ex-post studies. In addition to making regulatory impact analysis, policy makers should disclose these reports to the public. Another benefit of publicly available ex-post analysis is that, these findings/outcomes can be used as an input for current action/strategy and work plans.

Coordination and implementation problems: Having observed various plans and especially implementation of the NBSAP, it can be said that preparation of more specific policy papers and more clear-cut determination of responsible actors may ease coordination and inspection works in later stages.

In the end, it can be said that NBSAP has been a valuable source for understanding the country’s electronic communications sector, especially the services part including few topics related to production segment of the industry.

Accordingly, the analysis of these policies has been useful to identify the current situation and some of the existing problems of the sector, (Table-33).

Since these are evaluated in a more detailed manner in Appendix- F, some of the main points are summarized in this part. As pointed out, the strategy paper included detailed categorizations ranging from ‘supply side’, ‘demand side’ and ‘demand & supply side’ segments. It is understood that, officials (who prepared this document) preferred this kind of categorization to make it easier to follow each topic.

For instance, facilitating the access of disadvantaged people and decreasing financial burdens of last users can be seen important measures for increasing demand for ICT and especially broadband internet services throughout the country. These measures will also benefit in decreasing digital divide problem among other policies.

Table 33- Strategic Objectives and Actions

	Supply Side	**Responsible Organization**
1	Facilitation of passive infrastructure establishment	MTI
2	A financial support model for regions where broadband infrastructures is difficult to expand commercially	MTI
3	Expansion of cable TV network	TURKSAT
4	Making indoor electronic comm. infrastructure installation mandatory	MEUCC
5	Revision (Update) of rights of way and facility sharing legislation	MTI
6	Facilitation of network investments	MTI
7	Efficient and effective use of spectrum	ICTA
8	Expansion of broadband satellite services	ICTA
	Demand Side	
9	Decreasing tax and financial liabilities	MTF
10	Taking measures regarding OTT services	ICTA
11	Facilitating the access of disadvantaged groups	MTI
12	Determination of areas for the development of Turkish digital content and applications	MNE
13	Increasing user confidence to the internet	ICTA
14	Expanding (Diffusion of) cloud computing	MTI
15	Expanding (Diffusion of) M2M, IoT and IoE services, applications	MTI
	Supply& Demand Side	
16	Revision of wireless license and other related fees	ICTA
17	Data centre supports	MTI
18	Establishment of internet exchange points	MTI

	Supply& Demand Side	
19	Increasing competition in the wholesale broadband market	ICTA
20	Regulation on regional bases	ICTA
21	Domestic production and R&D support in the sector	ICTA
22	R&D and standardization studies related to 5G & beyond technologies	MTI
23	Development of smart cities program	MEUCC
24	Development of smart transportation systems	MTI
25	Follow-up of national broadband strategy goals	MTI

Source: NBSAP, p. 36-37.[213]

Having analysed these policy papers, the study now evaluates the regulatory authority's strategic plans to observe specific sectoral problems and objectives of this organization in a medium-term perspective. It should be mentioned that a new strategic plan will be prepared after 2023, that covers 2024-2029 period.

5.2.6 Strategic Plan of ICTA (2019-2023)[214]

As one of the central public organizations in the telecommunications sector since the beginning of 2000s, analysis of ICTA's publications[215] are helpful for seeing objectives and understanding problematic areas in the sector.

In this regard, the authority has prepared four strategic plans starting from 2010 and the current one's period ends in 2023.

Briefly, it can be observed that although the first plans had objectives, there were not many quantitative targets in each of them.

They had five strategic goals namely, 'protection of consumer rights and interests', 'ensuring and developing a sustainable competitive environment', 'supporting

[213] MTI: Ministry of Transportation and Infrastructure, MEUCC: Ministry of Environment, Urbanisation and Climate Change (present name), MTF: Ministry of Treasury and Finance (present name, at that time Ministry of Finance), MNE: Ministry of National Education, ICTA: Information and Comm. Tech. Authority)

[214] https://www.btk.gov.tr/uploads/pages/yayinlar-stratejik-planlar/bilgi-teknolojileri-ve-iletisim-kurumu-2019-2023-stratejik-plani-published-revised-at-27-05-19.pdf, (in Turkish)

[215] Important ICTA publications include Strategic Plan, Work Plan, Annual Report and Statistical Reports (both quarterly and annual city-based ones) and these provide primary information about telecommunications services.

innovation and R&D activities', 'supporting development of information society' and 'development of organizational structure'.

What is more different in the last two (one of them is still in effect) strategic plans of ICTA is that it has several (more) quantitative targets. Without going into further detail, one can look into strategic plan of 2015-2018 period to observe what kind of performance criteria included in these objective categories. For instance, protection of consumer rights objective had several criteria including 'enabling operators to shorten response/solution times of consumer complaints', 'reducing the number of consumer complaints on a per subscriber bases' and 'increasing various kinds of inspection activities in the sector like quality of service and testing of related telecom equipment'[216]. Some information related to post evaluation of these have been stated in the last strategy paper of the authority. However, there is no information regarding whether these activities have led to some kind of development or whether these targets have been achieved substantially. In this context, the last plan of ICTA has increased number of quantitative (Table-34) targets for 2019-2023 period.

Table 34- Performance Targets

INDICATORS	2019	2020	2021	2022	2023
Expansion of high-capacity fixed, mobile and wireless broadband networks and services and development of fiber infrastructures					
Fiber Length (thousand km)	380	420	460	500	550
H. speed subscribers (million)	4	5	6	8	10
Fixed B. Penetration (%)	18	20	23	26	30
Mobile B. Penetration (%)	77	80	86	93	100
EHABS* (%)	100				
Overseas broadband access capacity (Million Mbyte/sec.)	17	26	39	58	87
Ratio of domestic products in the networks (%)	15	25	45	45	45
Increasing the resources for 5G related R&D activities from ICTA revenues (%)	---	+15	+15	+15	+15

[216] Other categories also comprised of various performance criteria. Some other example criteria can be stated as follows. Ensuring and developing a sustainable competitive environment category included 'reduction of wholesale prices' and 'increasing the use of infrastructure-based services.' Supporting innovation and R&D activities included 'monitoring of ICTA resources (i.e., revenues) allocated to R&D activities' and 'inspection of domestic product purchasing requirement of operators.' Supporting development of information society objective included 'increasing high speed broadband subscriber numbers' and 'dissemination of secure internet service usage'. Development of organizational structure included 'provision of educational services to develop human resource capabilities' and 'increasing employee satisfaction.'

INDICATORS	2019	2020	2021	2022	2023
Increasing the 5g related patent numbers (%)	+5	+5	+5	+5	+5
Preparation of Mobil Broadband Spectrum Str. (%)	100				
Promoting innovative digital technologies and services such as machine-to-machine communications and the Internet of Things					
Organizing an activity for supporting the expansion of Ipv6 usage (event)	1	1	1	1	1
Increasing Cyber Security and user confidence for internet					
Increasing the number of personnel in SOMEs (%)**	+2	+3	+3	+4	+4
Increasing the number of cyber security incident notifications (%)	+6	+7	+8	+9	+10
Increasing the number of disclosed malicious links (%)	+6	+7	+8	+9	+10
Inc. the number of cyber incident response team (%)	+2	+3	+3	+4	+4
Establishment of national and domestic IXP (completion- %100)		60	100		
Regulatory Framework for (supporting) data centers (completion- %100)	100				
Increasing the number of registered e-mails (%)	+1	+1	+1	+1	+1
Ensuring an effective and sustainable competitive environment by encouraging sectoral development and investments					
Pub. of the annual statistical report at provincial level (number)	1	1	1	1	1
Protecting the rights and interests of users					
Market Surveillance Activities and reporting (number)	1	1	1	1	1
Inspection (and reporting) of firms that have measurement certificates (number)	1	1	1	1	1
Equipment testing & reporting (%)	+0,3	+0,5	+0,8	+1	+1,2
Expanding the conscious, safe and effective use of the internet					
Activity on safer use of internet (number)	4	5	5	6	6
Trainings within the scope of awareness raising activities (number)	250	250	250	250	250
Development of internet content (number)	3	3	4	4	4
Increasing number of subscribers using safer internet services (million)	6,5	6,75	7	7,25	7,5

Source: ICTA Strategy Plan (2019-2023), **(*) EHABS:** Electronic Communications Infrastructure Information System, **(**) SOME:** Cyber Incident Response Team

The plan's quantitative targets have six main categories but four of them have more objectives than the other two, namely 'promoting innovative digital technologies' and 'ensuring a sustainable competitive environment'[217].

The other objectives related to cyber security, safer usage of internet and protection of users are undoubtedly important for the development of the sector in various aspects. For the study's main topic, expansion of broadband networks including fiber access category has 10 objectives set until 2023.

The plan has similar quantitative targets (like found in the NBSAP) in terms of internet usage indicators, i.e., fixed, mobile broadband penetration and high-speed internet subscription numbers.

Among others, 'electronic communication infrastructure information system' (EHABS) has been established but there is not much information related to the practical usage of this system. 'Mobile broadband spectrum strategy' paper had not been put into force although the plan stated 2020 as the completion date (a similar and not achieved objective was also stated in the NBSAP).

The summary form of this document has been published in this organization's web page in 2022.

Furthermore, the plan reflects the increasing importance given to national & domestic production capabilities by stating three targets in this category. The Authority has not given any information about the allocated resources (and the increases) for 5G related R&D and the (increase in) number of 5G related patent numbers[218].

The last one is the share of domestic products used in the network investments by mobile operators. Although there is not a public statement about this issue, government

[217] Without going into much detail, it can even be said that although the objective of 'publication of annual provincial statistics' is beneficial for the public (and sector actors), it seems an indirect tool (and not among the main ones) for this main objective. The same thing can also be said for the other category related to promotion of digital technologies (i.e., performing activities for expanding the use of IPV6. In this respect, one can say that there are not enough quantitative targets in these categories and this may reflect the scope (boundaries) of ICTA's jurisdiction.

[218] This patent indicator topic will be examined in the hardware production analysis part. Notwithstanding to this, however, it is not clear in what ways the regulator can affect the patenting activity in this technology.

officials have given figures reaching to 25%-30% range in the total investment expenditures[219,] of operators[220].

5.2.7 Eleventh Five-Year Development Plan[221] (2019-2023)

The current plan covering 2019-2023 (period) has started with the evaluation of socio-economic developments in the previous period. For the ICT (especially internet) usage, it is stated that broadband internet adoption (penetration) rate increased from 42,5% in 2013 to 90,8% in 2018. Fiber infrastructure length reached to 355 thousand km from 227 thousand km in the same time- frame.

It is declared that ICT sector has grown in real terms along with the increase in the sector's export volume.

Besides this, the number of innovative startups operating in the field of e-commerce and digital gaming has expanded in a similar manner.

However, there is no quantitative indicators related to these developments found in the plan.

On the other hand, the plan concluded that although there is intense competition based on infrastructure in mobile services in the electronic communication sector, the same development has not occurred in fixed infrastructure and there is a need for developing infrastructure-based competition in this field.

In addition, there is still a need for qualified employees (work force) in the field of information technologies and (need for) effective policies that would enable companies operating in the field of software to expand into foreign markets by upgrading their scale economies. From this, one can say that the previous plan has not

[219] The Minister of Infrastructure and Transportation stated that "In the 2015-2016 period, the ratio of locally certified hardware and software investments of mobile operators in the total investment was only 0.98 percent. In the fourth investment period, the localization rate in hardware and software exceeded 23 percent. In the fifth period, the investment amount of domestic goods certified product increased to 662 million TL. In other words, we recorded a 44 percent increase in localization compared to the previous period. About 153 different products were obtained from 66 different manufacturers. We will further increase this product range in the upcoming period.", https://www.uab.gov.tr/haberler/bilisim-ve-iletisim-sektorlerinde-yerli-ve-milli-atilim-tum-hiziyla-suruyor

[220] A more detailed analysis is made in the equipment production part.

[221] https://www.sbb.gov.tr/wp-content/uploads/2022/07/On_Birinci_Kalkinma_Plani-2019-2023.pdf, (in Turkish)

been relatively successful in terms of "provision of qualified workforce" and "raising domestic firms' ability of entering into foreign markets" and "achieving competition in the fixed internet market". At this point, it should be mentioned that lack of detailed assessment of the previous plans might be seen as a weakness of these documents.

In other words, there is not a detailed review and only some sentences imply the problems related to the previous objectives. Furthermore, it is not clear how to solve these weaknesses, although one can argue that the development plan has set out macro policies and targets. For instance, the number of firms in the mobile sector are three and by definition, they have to invest in their infrastructures to give telecom services.

In fact, service-based competition in the mobile telecom market (i.e., introduction of virtual mobile network operators) has not been successful due to various reasons. There are also three big operators in the fixed internet services occupying nearly 90 percent of the market. Historical developments (and trends) show that service-based competition has not achieved much success and only after other two operators' entrance in to the market (by making investments in the infrastructure), the picture has started to change gradually. The current plan has prioritized some sectors and electronics is one of them. One can observe that this plan has given more emphasis (than other previous ones) on the enhancement of domestic production capabilities in high tech sectors. In this part, policies related to 5G technologies and usage applications are emphasised in more than one heading, (Box-7).

Box-7: Policies related to 5G in the Electronics Priority Sector[222] (in the 11th Plan)

- Supporting R&D and production activities of domestic electronic communication network and infrastructure components, including 5G and beyond technologies.
- Completion of 5G base station (development works).
- Supporting the production of hardware and software (components) of M2M and IoT ecosystem in vertical sectors with domestic resources.
- Implementation of smart factories, transportation, energy, agriculture, health, environment and disaster management projects and establishment of standards in these areas.

Internet and mobile telecommunications related issues are evaluated in a more detailed

[222] Some others concerning whole electronics sector including increasing competitiveness of firms, transferring defence sector (electronics) capabilities to civil sector uses and patent support mechanisms.

way in the sectoral policies, ‘ICT’ section. What is more different in the current one is the more extensive wording of ICT policy and objectives as opposed to previous plans. Indeed, this section covers nearly six pages of the total volume.

One can divide them into several categories in general terms.

These can be grouped as internet networks and access, cyber security, production capabilities in ICT, 5G technology, internet usage and data privacy regulations, digital transformation, satellite technology, software sector development and broadcasting policies[223].

The plan has a separate chapter for e-government service (applications) objectives and policies.

Expansion of e-government services are undoubtedly essential in digital transformation of the country. Relatedly, the plan aims to increase usage rate of these services from 45,6% (in 2018) to 70% in 2023 with the simultaneous enlargement of (the number of) e-government services from 4.085 to 7.400 at the end of the plan period.

Table 35- ICT Targets (Objectives) in the 11th Plan

Objectives	2018	2023
Mobile broadband penetration rate (%)	74,5	100
Fiber broadband penetration rate (%)	3,4	11,5
The rank of Türkiye in ITU Cyber Security Index	20/175	14/175
Internet Usage in Women (%)	65,5	90

Source: 11. Development Plan, p.118

[223] Although these are all interrelated in various ways, the study mentions only 5G and internet access policies to focus on the topic of interest. If briefly summarised, other measures can be seen in a framework to support ICT production, adoption and effective usage in socio-economic context. Cyber security policies consist of mainly increasing national production and organizational capabilities, establishing a sustainable ecosystem and providing educational programs. Procurement policies and localization requirements in public sector authorizations and other purchases make up the measures related to increasing domestic production capabilities of ICT sector in general. The plan aims to develop national satellite technology capabilities and to produce Turksat 6A with domestic facilities (resources). Continuing from the previous plan, the current one encompasses data regulations (protection of data privacy, safer use of internet), establishment of internet exchange point, transition to terrestrial digital broadcasting, preparation of national policies related to artificial intelligence, supporting of new internet ventures, start-ups and software sector (including establishment of Türkiye’s Open Software Platform) among others.

As seen from the above Table- 35, quantitative targets are related to internet access and usage. Considering the fact that mobile broadband penetration rate reaches to nearly 85%, it may not be difficult to achieve 100% objective at the end of the plan period. For the fiber adoption, the current figure is approximately 6-7%[224] and the target figure is 11.5% in 2023. If we take the average growth rate of last ten years as an indicator (i.e., 18%), the related number will reach to (taking 20% annual growth rate) around 6.6 million subscribers. This corresponds to nearly 8%[225] in 2023 and more than 3 million subscribers needed to reach the Plan's target. In the remaining period, operators need to either accelerate their fiber investments and/or phase out the XDSL access connections without increasing their tariffs much higher than the previous technology. In other words, increasing (the extent of) fiber broadband subscription depends on both demand and supply side developments. Another internet access (target) indicator is related to the women's usage statistics. This category is different from others in that it is collected by Turkish Statistics Institute (TSI) in the context of ICT usage statistics[226]. This rate is predicted to grow from 65,5% in 2018 to 90% in 2023. The current statistics is announced as 80,9% in 2022[227]. Only one indicator is not (directly) in the usage category but it is a cyber- security target. ITU calculates this statistic by collecting all member countries. In fact, Türkiye's position is more advanced (20 out of 177 in 2018 and target position is 14th in 2023) in this indicator than most of the other ICT usage/adoption indicators.

Box-8: Policies related to 5G technology (in the 11th Plan)

- Frequency resources will be allocated in line with technological developments and (in line with) the decisions of international organizations in the transition to 5G and beyond mobile communication technologies.
- Domestic production support will be provided for 5G and beyond technologies, and localization will be compulsory at certain rates in authorizations for these services.

As shown in Box-8, the Plan indicates that the first step will be the allocation of necessary frequencies for the next generation mobile telecom services in line with the

[224] Please note that this figure is the ratio of the number of fiber broadband subscribers to the population, as stated in the footnote of the Table-26, p.111 of this plan. Accordingly, the related ratio is approximately 7% (5.7 million subscribers/ 85 million as a population) at the end of 2022.
[225] Considering nearly 6.6 million fiber subscribers divided by 85.5 million total.
[226] https://data.tuik.gov.tr/Bulten/Index?p=Hanehalki-Bilisim-Teknolojileri-(BT)-Kullanim-Arastirmasi-2022-45587
[227] The related statistic was 73,3% in 2020.

technological developments and the decisions of international organizations, most importantly ITU.

The second policy can be seen as a continuity of the measures adopted in 3G and 4.5G auctions where procurement from (local sources) have been made mandatory in predefined rates.

For widening and raising the adoption of internet technology, the current plan provides very extensive list of measures as shown in Box-9.

Box-9: Policies related to Internet Access and Usage (in the 11th Plan)

- Fixed and mobile broadband infrastructures that provide high-speed and high-quality access will be expanded, and joint use of physical infrastructures will be encouraged.
- Regulations serving to expand broadband networks like fiber, base stations, rights of way and facility sharing will be enacted and it is aimed to increase the efficiency of infrastructure establishment procedures.
- Broadband infrastructures will be installed and operated with government support in regions that are not commercially attractive.
- Digital divide problem is addressed by means of universal service funds and tariff regulations, educational programs. By these measures, it will be targeted to reduce differences in income, region, gender and age groups in terms of internet access and use.
- Regulations in the electronic communications sector (including market analysis) will be revised taking into account the effects of convergence in services and infrastructure, technological developments and regional differences in supply and demand dynamics.
- An infrastructure inventory will be established and kept up-to-date to aid effective implementation of regulations and qualified policy making in the electronic communications sector. In this context, operators will be required to enter their infrastructure information dynamically (up-to-date basis).

Some of these measures can be seen as a continuation from the previous plan. What is more interesting is the emphasis on the ‘joint use’ or cooperation like ‘facility sharing’ in the infrastructure investments (expansion), having observed the recent failures in this regard.

It seems that, policy makers should either oblige the sector actors (previously failed whatever the reason) to cooperate in these projects or should clear all the obstacles in front of operators (as claimed by themselves) in infrastructure investments.

The second set of measures consist of establishing an infrastructure inventory or map to inform operators about the coverage of existing networks. As a technical project, (it is understood that) it was completed in the 2020, but there is not enough information available to public for implementation details. At this point, it can be said that disclosure of this information (network map) to the public may further increase benefits of this system. Several countries have published these maps to inform public but there is not such a mechanism applied in the country yet.

Third set (in this subgroup) is concerning the mechanisms for addressing digital divide issue. The use of universal service funds in this framework has been continued for a long period, but the implementation details are not available to the public. In fact, some actors have criticized non- transparent and off-purpose use of these sources. In other words, they have alleged that these funds have been diverted to other uses and the mechanism is non-transparent. For instance, Ms. Nebil (2020) has stated that the amount of money in this fund has reached to 10-11 billion TL since 2005. It is understood from her calculations that some of this money have not been spent and there is no full transparency in some projects. Similarly, a member of parliament has declared that the MTI did not give a clear answer to his questions regarding to the use of 1.5 billion TL collected in this fund last year, (Lıcalı, 2020). In this context, it can be said that increasing transparency can bring more efficient use of this fund to achieve the policy targets set out in the development plan.

Apart from these topics, it can be observed that the role of public procurement policies[228] has been emphasized as well. In fact, one can see this approach virtually in every strategic plan as (for instance) stated in (the above) chapter 5.2.2 on the subject

[228] In addition to high level development plans, public organizations have prepared (and will obviously continue to prepare) various other papers in this subject. For instance, ‘Technology Development and Domestic Production Program Action Plan through Public Procurement’ had been implemented within 10th Development Plan between 2014-2018. Without going into much detail, the action plan aimed to increase R&D expenditures, domestic firms’ shares in mid and high-level technology sectors and foreign direct investments through public procurements, policies and to support branding process together with increasing number of branded products. It consisted of several policies including ‘long term requirement planning of public organizations’, ‘establishment of public procurement data base’, ‘promoting production based on public procurement guarantees in technology-intensive products’, ‘developing a model for the public to implement an industry participation program in overseas procurement’, ‘developing a model for joint procurement in the public sector’, ‘public procurements that include intellectual property ownership and domesticity rate practices including raw materials’, ‘revision of related legislation to support domestic production, innovation and technology transfer’, ‘making arrangements in favor of SMEs in public procurement practices’, ‘providing advantages to enterprises operating in technological fields through public procurement and increasing number of enterprises’, ‘establishment of a coordination mechanism in this subject and strengthening capacity of public organizations in related topics such as document preparations and standardization practices’ and ‘raising awareness through informing universities, public institutions and private sector’.

of 9th five-year development plan. Here, policy makers aim to develop local production through public procurement and related regulations. The plan has given special attention to authorizations and public procurements to increase value added in ICT sector.

As it is discussed, authorizations (i.e., licenses) are essential tools for the telecommunications sector where main investments (purchases) are made by (authorized) private operators in general terms. One area that is particularly relevant for public procurement is the universal service policies in which domestic products can be purchased by using public funds. On the other hand, software-based telecom products and services including cyber security solutions are gaining more weight in this sector, taking into account the convergence phenomenon.

Furthermore, it is evident that after the introduction of 5G technology, (as shown in case studies) the number and scope of digital applications/services will become more pervasive.

Connectedly, public organizations demand for them (e.g., smart city services etc.) will also increase in the near future.

In sum, policy makers should give even more emphasis on public procurement policies both in policy setting and in practical implementation to support development of domestic sector for economic and security reasons as well.

5.3 Institutional Setting and Public Organizations

As in the service scope determination (discussed above), exact identification of related public organizations and institutional framework is impossible in the world of ever-increasing ICT coverage.

Here, it is sufficient to observe the fact that generation of digital content is related to almost all public organizations in the country.

For instance, while MNE has working on the educational content preparation, Ministry of Health are dealing with digital applications in its area of responsibility.

On the other hand, MTF has influenced any sectoral system's working performance, e.g., tax levels etc. Above all, it is evident that all laws are enacted by the Parliament, applicable to any sectoral system.

In any case, one can state most important (or relevant) public actors by looking into the relations of (electronic communication service) firms in a regulatory setting.

In other words, while firms in the electronic communications sector have interactions with many other public organizations, only a few of them have influenced their ability to work in the form of regulatory relationships like entrance permissions, quality controls and provision of financial resources and incentives.

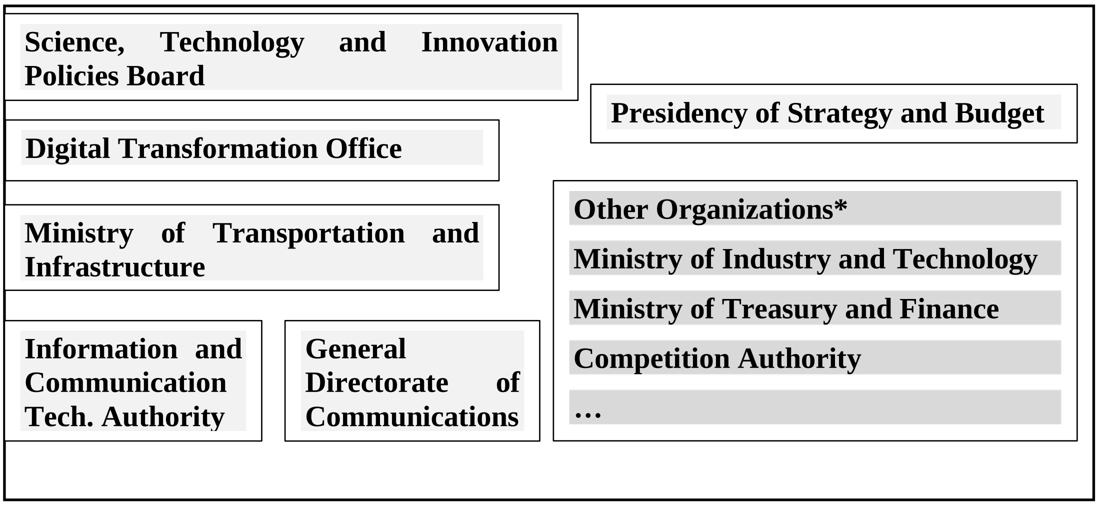

Figure 32- Public Organizations in the IS

Taking a regulatory perspective, one can draw a simple diagram to include important public actors in the IS[229]. Here, it should be stated that the organizations (in dark colored box) are either more related to production part of the IS[230] or have general economic duties like taxation, e.g., Special Communication Tax imposed by MTF, as shown in Figure-32. It is certain that one can add many other organizations that are

[229] This categorization does not mean that these organizations are not important as discussed in the text. In fact, some organizations like other ministries, universities etc. can be included in this category. The author has made this categorization for two reasons. One is that some of them are analysed in a more detailed manner in a separate part and other is for due to space limitations.
[230] Main actors of this part are discussed in a separate part. It can be said that Ministry of Industry and Technology including its related organizations like The Scientific and Technological Research Council of Türkiye (TÜBİTAK), Small and Medium Enterprises Development Organization of Türkiye (KOSGEB) have influenced evolution of this ecosystem. Another organization here is the Competition Authority. This actor has also a role in the development of the sector but its role is more oriented to ex-post competition investigations and the number of these interventions have decreased in recent years, as well.

directly or indirectly affect functioning of system actors, but in this case, the scope can become unmanageable.

Another point for this simple diagram (Figure-32) is that arrows are not used to show direction of relationships between these actors. Although, the vertical direction of the boxes follows a general hierarchical order, there exists multi directional interactions between each organization.

That is to say, (as an example) there may be direct interactions between **Digital Transformation Office** (DTO) and ICTA. Secondly, it can be said that the status of Offices (in this case, DTO) vis-à-vis Ministries are not well established, at least in the views of sector actors.

To start with, after the transition to presidential government system, (high level) policy boards (in certain subjects) [231] have been established to develop recommendations, policy and strategy proposals to the President in July 2018, (Anadolu Agency, 2018). Among them, **Science, Technology and Innovation Policies Board (STIPB)** has starting to work in the areas related to digital transformation. Although, this organization does not have a web page to disclose its workings, there are some news found in the internet sites.

About one year later (in September 2019), the board has announced priority areas as *advanced functional material and energetic material technologies, motor technologies, biotechnological medicine, internet of things, energy storage, robotics and mechatronics, artificial intelligence, big data, information security, broadband technologies, Micro/Nano and optoelectronic technologies*. Furthermore, it is stated that technology roadmaps related to these areas would be prepared in the upcoming period, (Gündoğmuş, 2019). After nearly eight months, it is learned from media sites that the Board started works in the fields of 'food supply security', 'biosecurity", '**cyber security and communication infrastructure** [232] **'**, 'medical device' and

[231] These are 'Science, Technology and Innovation Policies, Education and Training Policies, Economic Policies, Security and Foreign Policies, Legal Policies, Culture and Art Policies, Health and Food Policies, Social Policies and Local Government Policies' Boards.

[232] Most of these study areas are related to digital technologies and can have a role in digital transformation of the country. From these fields, 'cyber security and communication infrastructure' is

‘medicine and vaccine’, (Tosun, 2020). In this context, the president (of the board) has indicated completion of these works until the end of the summer 2020. After some delay, these reports have been prepared as of December 2021, (Figure-33)[233].

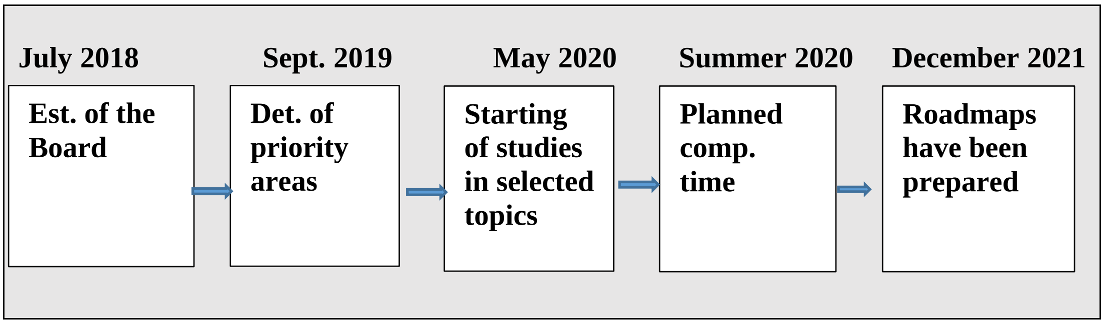

Figure 33- Snapshot of STIPB Work Plan

Apart from more than one year lag, there is not much (if any) information about the usage and/or implementation of these documents. The reason for this is either incompletion or non-disclosure to the public but if this is the case, these works should be shared with the public. In any case, one could not analyze the role and effect of this organization since there is not enough knowledge about its further (and also current) activities. For this reason, it may not be necessary to further examine any possible conflict or overlapping duties (responsibilities) with a similar type of organization[234],

especially relevant to our study topic. Notwithstanding to this, it should be mentioned that the report’s name is ‘cyber security technology roadmap’ without citing communication infrastructure word. Without going into much detail, the roadmap has specified cyber security priority technology objectives as ‘basic network and communication security products’, ‘identification of devices in the network environment and unauthorized access management’, ‘IT systems’ security management in corporate networks’, technologies that can manage traffic and prevent cyber-attacks in networks with IoT devices’, technologies to prevent cyber-attacks against autonomous mobile systems units and administrative interfaces’, technologies for the security of end-user devices’, ‘trusted operating system and new mobile device security solutions used in TEE technologies’, ‘application security technologies’, ‘cloud security technologies’, ‘quantum cryptography and post-quantum cryptography technologies’ and ‘digital forensic analysis technologies’. In the second category, the roadmap has stated cyber security solutions/technology priorities related to sectoral applications. These include ‘indigenous cyber security technologies and products for 5G and beyond communication technologies, IoT protocols and base stations’, ‘Network traffic management in smart production systems, secure communication, cyber-attack prevention technologies’, ‘cybersecurity security products and solutions for Automotive and Transportation sectors’, Cyber-security solutions for energy sector needs’, Cyber security solutions for public (government) usages/needs, Secure cloud technologies and products for public and private sector data, protection of financial service providers against attacks with high-capacity, cloud-based technologies’, products that use secure cryptography technologies in public data encryption, ‘cyber-security and cryptographic solutions for e-commerce and virtual shopping’, ‘cyber security technologies and products for defense, aerospace sectors’.

[233] The publishment date in the internet is not given in the TUBITAK’s web page.

[234] Please note that this word (similarity) is used only for plan and policy papers making category. SBO has various different functions and responsibilities in other areas like annual budget preparations as well.

Presidency of Strategy and Budget Office (SBO). As another new organization, SBO was established in July 2018 after the transition to 'presidential government system'. In fact, this organization has replaced one of the oldest policy making bodies, namely 'State Planning Organization (SPO)'. Relatedly, its main duties are preparation of high-level policy documents such as 'Development Plan', 'Presidency Program', 'Medium-term Program', 'Medium- term Financial Plan', and 'Presidency Annual Program'. Moreover, it is responsible for central government's budget preparation and implementation process. In this context, SBO has an influence on the IS through strategy and policy papers. The study has already evaluated the development plans prepared by this organization (and by State Planning Organization previously). Apart from these medium-term papers, SBO has prepared annual (presidential) programs covering very broad range of topics from macroeconomic policy to democratization and good governance. Sectoral policy's part includes a separate section on ICT. It is evident that although these papers are well prepared and cover extensive topics, one has difficulty in detecting follow up or post implementation analysis of these papers on the internet sites of these public organizations, (Box-10).

Box-10: The situation of (High Level) Strategy Making Organizations

The important point for the strategy and annual programs is that post implementation analyses are not available to the public in many cases. Making them available to the public will certainly raise the benefits of these policy papers in several respects such as increasing self-discipline (control mechanism), transparency and providing inputs to cost-benefit analysis. Here, the relevant question that can be asked is to what extent are these policy papers beneficial (and credible) for sector actors in terms of indicating sectoral developments, policy objectives and long-term planning? Secondly, although the working (outcome) of STIPB is not known by the public, there may be overlapping duties (responsibilities) between this organization and SBO.

However, it can be said that this is not the case at this moment due to the above-cited reasons. In other words, this newly established organization has prepared a policy paper long after its establishment and there is no (at least publicly available) implementation mechanism of this document, at the same time SBO has responsibility of preparing policy documents in the ICT (more specifically electronic communications sector) and done so even in an annual basis. Taking into account the fact that these two organizations have overlapping duties and one of them has not an organizational structure to follow implementation of these roadmaps, one can question the necessity of them in this sectoral setting.

Digital Transformation Office (DTO) is another newly established organization

(Table-36) after the transition to new administrative system[235]. As its name indicates, the office has responsibilities in the digital transformation process of (especially) public sector including preparation of a roadmap, development of strategies for big data, cyber security, artificial intelligence and provision of support for projects in these fields.

Contrary to the SBO (as replaced SPO), this organization has no antecedent (in the form of another previous establishment) and some of their duties had already been performed by other organizations like MTI, ICTA and MEUCC.

Beykoz (2019) has summarized main functions of DTO as coordinating digital transformation of the public sector, devising necessary projects in order to upgrade national technology and raise awareness, big data analysis, leading artificial intelligence applications in priority project areas and developing projects to increase cyber security and information security.

According to him, this organization has given the responsibility of managing public IT projects and operations but it would be more beneficial not to limit these new technologies' part to artificial intelligence and big data, but to look at this issue with a wider perspective, including all new technologies such as augmented reality, internet of things, robots etc.

More importantly, he argues the scope of this organization should be enlarged to include private sector as well. He has also asserted that ICTA's duties and responsibility areas should be revised to avoid (possible) organizational conflicts.

Table 36- Digital Transformation Office (DTO) Structure

Departments	Functions*
Digital Transformation Coordination	Preparation of road maps in related fields, coordination of digital transformation projects, contribution programs to users' digital competence levels
Digital Technologies, Procurement and Resource Management	Assisting to development of a competitive ICT sector, development of alternative technologies for joint usage in public organizations to reduce costs and increase national security, strategy developments for adoption of national technologies. Forming an inventory of domestic companies in the ecosystem in collaboration with related organizations.

[235] Founded in July 2018 with the Presidential Decree No.1.

Departments	Functions*
Digital Expertise, Monitoring and Assessment	Technical support provision to public organizations, monitoring of these organizations' projects, determination of standards (for public organizations), preparation of related statistics and other kind of analyses and studies.
Cyber Security	Preparation of cyber security strategies and national policies, development of cyber security projects, monitoring implementation of these projects and policies. Identification of critical infrastructure and prioritized topics to channelize funds (to these areas), provision of activities to protect essential infrastructure.
Big Data and Artificial Intelligence	Strategy and policy development in these topics, supporting projects, working on big data analytics, coordination of works on national-level open data and activities to make the country a regional centre for data processes like storage, transmission etc.
Others (Support services)	Administrative services, legal consultancy, IT services and international relations.

Source: Compiled from DTO web page. (*****) Only main functions are stated in this table.

The other two organizations, namely **ICTA** and **General Directorate of Communication (GDC)** are relatively older and have involved in the sector regulation since the early period of liberalization process[236].

GDC is one of the general directorates in the organization structure of MTI and ICTA is officially defined as an associated organization to this Ministry.

For the study purposes, i.e., functionality analysis, there is not much difference between these two organizations irrespective of their administrative status.

Hence, the author has only evaluated their functions and interactions in the process of sectoral regulation. GDC's main structure and functions are given in Table-37. These are universal services, electronic communications, and cyber security issues.

In this context, it should be stated that although both of these organizations are shown in the 'organizational structure' of the related ministry (MTI), there are some important differences between them especially in terms of their legal status. While GDC is an organization that is directly included in the MTI, ICTA is shown as an affiliated body to this Ministry. As the study focuses on functions and responsibilities of these organizations, this issue is not evaluated in this context. Furthermore, 'work transfers'

[236] ICTA was founded in 2000. On the other hand, General Directorate of Communication was established in 1995 (previously organized as a department firstly in 1987).

between these organizations have also been analysed in this part.

Table 37- GDC Structure & Functions

Departments	Functions*
Universal Services	Preparation and implementation of universal service strategy, policies and projects in electronic communications and postal services.
Electronic Communications	Ensuring the use of pre-defined standards, (When necessary and to ensure fair competition) determination of price floors and ceilings, determination of principles and procedures regarding rights of way, determination of principles and procedures including tariffs regarding installation of equipment like base stations, antennas etc. Specification of strategy and policies for numbering, satellite positions, internet domain names and electronic communication services that require scarce resources like spectrum allocation, determination of policies, objectives and incentives for the development of sector in a competitive manner and digital transformation process, research activities on determination and implementation of electronic communications policies. Ensuring construction and operation of networks and services in accordance with public benefit and national security purposes, Taking necessary measures for uninterrupted communication services in the event of natural disasters. Contribution to the policies regarding development of electronic communications equipment industry and taking measures to incentivize domestic production. To this end, ensuring (providing) use of ICTA's revenues (up to 20 %) for these types of projects.
Cyber- Security	Determination of strategies, policies and targets for national cyber security, preparation of action plans and coordination of relevant activities, determination of critical infrastructures. Establishment of the necessary intervention centres, conducting and supporting cyber security tools with national capabilities, provision of training and awareness raising activities and preparation of principles and procedures for regulating the workings of the persons (also legal entities) in the sector.
E-Government Services	Determination of policies, strategies and targets for national public integrated data centers, preparation and monitoring of action plans. Establishment of data centers for e-government services and preparation of principles and procedures related to these processes.
Intelligent Trans. Sys. (ITS)	Activities related to ITS**
Support services	IT Services, Administrative Services, Coordination

Source: Compiled from GDC web page, **(*)** There is not a detailed description of each departments' duties in the internet site of the organization. Some of the main functions are summarised in the table. **(**)** There is no information for this department's responsibilities in the organizational duties part.

On the other hand, ICTA has duties in the sector ranging from market authorizations to inspections of these firms in various subjects like service quality and coverage requirements. As shown in Figure-34, starting from a more restricted conventional (electronic communications) sector regulation, the regulatory authority has expanded its scope to other areas like internet content regulation, cyber security and legal activities in the context of interception and monitoring of communications (for purposes of criminal investigation by law enforcement officers).

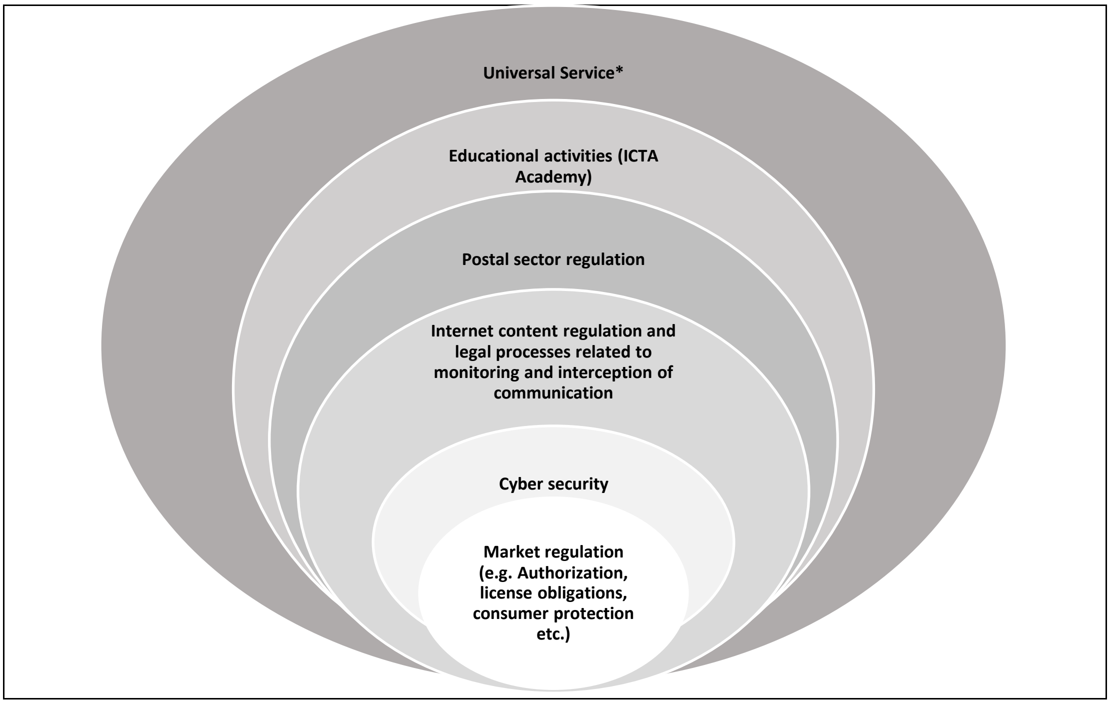

Figure 34- Expansion of ICTA's Area of Responsibility (2001-2021)

*This is the most recent addition to ICTA's responsibility areas. The figure expands in line with historical order in general terms.

The summary of organizational structure is given in the below Table-38. It shows main functions of ICTA and does not necessarily provide exact names of different departments.

For instance, postal service regulation has more recently added to the responsibilities of the authority and there is no department whose name is specifically related to this duty.

It should be noted that human resource department coordinates educational activities of ICTA in collaboration with other departments and sector actors. In fact, the name of this branch is called as 'ICTA Academy'.

This academy has both given educational services from internet (online) and from ICTA main building itself.

Table 38- ICTA Structure & Functions

Departments	Functions*
Regulatory (Economic & Technical) • **Consumer Rights** • **Inspection** • **Sec. Research and Strategy Dev.** • **Spectrum Management** • **Spectrum Monitoring** • **Authorization** • **Technical Regulations** • **Access and Tariffs** • **Sectoral Competition** • **International Relations**	Mainly concerned with market formation and operations of firms. They include market entry (licensing and authorizations, spectrum allocation and management) and operational regulations. These regulations mainly correspond to the names of the related departments, e.g., authorization, access and tariffs, spectrum monitoring, consumer rights and inspection. (Postal sector regulation is under the responsibility of sectoral competition department).
Cyber Security • **Information Technologies**	Operation of the National Cyber Incident Response Centre (USOM), monitoring sectoral and corporate Cyber Incident Response Teams (SOMEs), training activities for the related personnel, developing cyber security programs (e.g., Avcı, Azad and Kasırga programs) and projects.
Internet Content regulation • **Internet**	Activities and administrative measures related to internet content regulation, safe internet centre services.
Monitoring and interception of communication for legal purposes • **Information Systems** • **Law**	Monitoring and interception of the contents of communication for purposes of criminal investigation by law enforcement officers.
Support Services	Administrative, IT, human resources and other logistics.

Source: ICTA Web page, (*) Only main functions are summarized in this table.

Even a general inspection of these three organizations organizational structures indicates overlapping areas of responsibility and duties. For instance, each of them has responsibilities in the cyber security area. Both DGC and GDC has duties in e-government service development. While, ICTA and GDC share responsibilities in electronic communications sector regulation, these are difficult to differentiate for the sector actors. In this context, for instance, both organizations have been involved in regulations related to access network (fiber deployment), rights of way and collocation, among others. As another development recently, people have witnessed a new legislation to enable use of universal service funds by the ICTA. It is understood that these two organizations can both utilize these funds to finance universal service projects with the enactment of this new Law[237].

What is even more important is the fact that, convergence phenomenon, as discussed more than once in this study, is making a precise boundary drawing in the field of ICT difficult, if not impossible. In fact, one can observe this difficulty in strategy & policy papers of public organizations. In many action categories, several organizations involved leading to possible coordination problems and unnecessary delays, (Box-11).

Box-11: Overlapping functions between Organizations

Apart from strategy & policy making organizations, inspection of three organizations' structures reveal several overlapping duties and common regulatory topics that are difficult to differentiate in practice. It is evident that convergence and multidimensional nature of regulatory areas further complicate this phenomenon. For instance, cyber security topics can be found in each organizations' responsibility areas. Similarly, two of these organizations have regulatory functions in telecom sector dealing with firms' operations in the market. Hence, it can be stated that there is not a very efficient work sharing mechanism between the public organizations. This structure has undoubtedly contributed delays and/or implementation problems that are observed in various projects and regulations.

5.3.1 Sectoral Associations

As in many other sectors, market actors have established several associations to make lobbying activities and aim to serve their members interests in this ecosystem as well. In fact, there exist abundance of such organizations due to the large scope of ICT, covering many subsectors ranging from electronic communications to computer technology and software, to name a few of them.

Here, there exists roughly a grouping in terms of service categories of these companies.

Besides this, the number of associations covering more than one segment of ICT sector are more numerous than in the first category, i.e., covering only electronic

[237] Objectives of the Law No: 7297 dated March 20, 2021 can be stated as follows. Firstly, this revision will enable ICTA to use universal service funds by authorizing the Minister for the budgetary transfer process (i.e., transferability of allowances between these two organizations' budgets). The regulation aims to diversify methods for determining the universal service obligation in accordance with international examples and to define the method that will constitute the basis for net cost calculation in cases where the universal service obligation is determined among more than one operator. Besides, the new legislation makes it possible to pay an advance payment of up to 30% of the universal service project costs to universal service obliged parties, and to reduce payment periods, which reached an average of 18 months.

communications sector, (Table-39).

Table 39- Sectoral Associations

Electronic Communications*	ICT (covering Electronic Comm.)
• Turkish Competitive Telco Operators' Association (TELKODER) ** • Mobile Telecom Operators' Association (m-TOD) • Access Providers Association (ESB)	• Telecommunications Satellite & Broadcasting Business People Association (TUYAD) • All Telecommunications Businessmen Association (TUTED) • Informatics Association of Türkiye (TBD) • The Turkish Informatics Foundation (TBV) • Turkish Internet Association (TID) • Telecommunication Internet and Information Technologies Association (TEDER) • Turkish Informatics Industry Association (TUBISAD) • Mobile Communication Devices and Information Technologies Businessmen Association (MOBISAD) • Mobile Service Provider Businessmen's Association (MOBILSIAD) • The Union of Chambers and Commodity Exchanges of Türkiye (TOBB) • Software Industrialists Association (YASAD) • Informatics Industry Association (TUBIDER) • Turkish Electronics Industrialists Association (TESID)

(*) This categorization is mainly included members that have ICTA authorizations to operate in the sector. (**) Abbreviations shown in parentheses is written in (Turkish) original form. Please note that this is not a complete list, the author includes main ones.

In the first category, for instance, mobile telecom operators established a sectoral association to address their problems and needs. Three mobile operators (Turkcell, Turk Telekom and Vodafone) founded **Mobile Telecom Operators' Association (m-TOD)** in 2016. After foundation, General Secretary (Mr. E. Baş) announced their (initial) aims as reducing the tax burden to reasonable levels, to solve the problems encountered with local governments and to enable accelerated continuation of the country's technological advances, (ICT Media, 2017). Unfortunately, there is not any information available about the activities of this organization in its web site, apart from the member list information (profiles of board members). There is only one announcement by the association found (in the internet) and this is about the activities[238] performed by the member operators during the pandemic (Covid-19) in March 2020, (m-TOD, 2020). In any case, one can infer from these observations that this association have been involved in lobbying activities in the form of meetings etc. rather than publishing (more formal methods in a sense) reports or documents.

Among others, **Turkish Competitive Telco Operators' Association (TELKODER)** is one of the most active organizations in terms of various means such as publications, reports, meetings, conferences and press releases[239].

It has been established in 2002, nearly with the beginning of the market liberalization process in the sector. It has currently twenty-four members that operate in the sector with authorizations (e.g., internet service provision, fixed telephony services etc.) obtained from ICTA, (Telkoder, n.d.). The organization declares its current priorities as:

- Rapid and extensive fiber infrastructure deployment (in a competitive environment) throughout the country,
- Ensuring compliance with EU regulatory framework and free competition,
- Increasing domestic and foreign investments,
- Increasing service diversity and quality,
- Ensuring that consumers receive services at affordable prices,
- Ensuring effective implementation of legislation and regulations.

Although it is not directly related to our study (topics), the position of **Access Providers Association (ESB)** is unique among other non-governmental organizations.

The organization is established by Law No: 5651 and its purpose is to implement the access blocking decisions outside the scope of Article 8 of the same Law[240]. As

[238] This announcement emphasized the importance of telecommunications in today's life and pointed out ever-increasing importance during the pandemic. There was no any technical information in this message rather than the operator's commitment to enhancement of their services and social distance precautions for both employees and customers.
[239] Various publications of this organization are also used in this study.
[240] This article states criminal offences including sexual abuse of children, obscenity, encouraging suicide, prostitution, hazardous material provision for health, providing a place and opportunity for gambling, facilitating the use of drugs or stimulants. Judicial organizations with attorney general and judge decisions are responsible for implementing this article.

expected, there are many more non-governmental organizations in the field of ICT (covering also electronic communications sector). Some of them have predominantly members from business firms while some others have (real) person members from different occupations including academia. Most important business members' organization is **The Union of Chambers and Commodity Exchanges of Türkiye (TOBB)** that has over 1.4 million members, (TOBB, 2012, p. 2)[241]. There are fifty-nine sectoral councils including 'Computer and Communication Council[242]' and 'Telecommunications Council', (TOBB, n.d.-a). Unfortunately, the last available report of Telecommunications Council is rather outdated (from 2009). According to the web site of TOBB, the council periodically meet and discuss sectoral problems.

Furthermore, (it is observed that) they have submitted their problems to the Minister of Infrastructure and Transportation (Mr. A. Karaismailoğlu) in May 2020 but there is no publicly available information related to these problems and outcome of this meeting, (TOBB, 2021). In any case, with its countrywide network and strong resources, this organization is in the position to submit its problems and to discuss them with the high-level policy makers. For this reason, it should be noted that sectoral reports, their (identified problems) and the meeting notes are important sources to evaluate sectoral developments for academicians and analysts, if they will be made publicly available.

Other non-governmental organizations have business members in the ICT field ranging from software firms to equipment producers like LCD TVs. For instance, **Mobile Service Provider Businessmen's Association (MOBİLSİAD)** was founded in 2009 with twenty-four members from value added mobile services sector.

The association declares its main objectives as helping the sector to become more efficient (and competitive) and solving their problems by establishing relations between public organizations, (Mobilsiad, n.d.).

Similarly, **Mobile Communication Devices and Information Technologies Businessmen Association (MOBİSAD)**, which is founded in 1998, has nearly four hundred members predominantly from mobile telecom operators, infrastructure and

[241] Though the report is rather outdated, current sources still give total member numbers around 1.5 million, (TOBB, n.d.-b).
[242] 'Bilgisayar ve İletişim Teknolojileri Meclisi' in Turkish.

service providers, mobile device producers- importers and distributors, ICT chain stores and device dealers. The organization aim to work together and participates in projects with public organizations[243] to find solutions to the problems in the sector, as indicated in its internet site[244].

As another example, **Turkish Informatics Industry Association (TUBİSAD)** has a large presence from ICT and new media sectors. Being one of the most active organization, the association helps its members by giving sectoral information, facilitating access to policy makers (i.e., lobbying in a sense) and advisory services in topics like business opportunities, human resources and legal issues. Its reports, especially related to estimations of ICT sector market size[245], provide valuable sources of information for market actors. Apart from business member oriented non-governmental organizations, several other associations are working for public interest in the ICT sector, as well. For instance, **Informatics Association of Türkiye (TBD)** is one of the oldest (founded in 1971) and a leading actor in this category. Due to its extensive academia connections, the association has provided educational, training programs along with the preparation of reports, policy papers and conferences to aid sectoral development in various aspects ranging from human source contribution to technical advice and opinion provision to related actors, among other activities. Lastly, it should be noted that, some of these organizations has no active and/or updated internet sites, which are main sources of information about their activities. This may be due to either from not updating this source and/or inactivity of these organizations in practical terms. There are also other organizations in the field of consumer rights, involving in some of the regulations and issues of the sector related to end user problems,

The associations in the sectoral setting perform various activities ranging from

[243] The organizations cited are Ministry of Infrastructure and Transport, Information and Communication Technologies Authority, Undersecretariat of Foreign Trade, General Directorate of Communication, Vocational Qualifications Authority, TOBB / Türkiye Telecom Sector Councils and Chambers of Commerce, Internet Development Board, the Cyber Security Initiative Working Group.

[244] Among these examples are the participation in the preparation of legislations, establishment process of mobile device registration system etc. (https://mobisad.org/tarihce/)

[245] The publication related to ICT market size has been widely used by both public and private actors of the sector. Although the study is a useful source of information, it has not covered all the firms in ICT sector. The scope has started from 952 firms in 2012 to 5729 firms in 2019. This shows that the precision of market size calculation has been increasing in each year, but it is not certain to what extent these are reflecting the real volumes, taking into account the fact that Turkish Statistics Institute gives 42,805 enterprises in the ICT sector, (https://tuikweb.tuik.gov.tr/PreHaberBultenleri.do?id=33602)

lobbying to provision of advisory services and educational programs. In this respect, it may be useful to discuss the extent of policy contributions of these organizations -in practice- for the solution of sectoral problems (i.e., effectiveness of these organizations).

5.3.2 Institutional Framework Analysis

Since the sector is heavily regulated, it is useful to examine the institutions (in a single heading) under which sector firms are operating and make investment decisions (Figure-35). One can look in to the regulatory framework as in the case of organizational categorizations. In other words, there are (roughly) two kinds of regulations imposed on the sector players, one is the general rules and the other one is more sector specific obligations.

Following the same approach, this analysis concentrates on the sector specific regulatory setting. As shown so far, one can further divide this setting into economic-technical, cyber security and internet content regulations.

Here, in line with the study topic, economic-technical regulations will be discussed, since these are directly influencing performance of firms in the sector.

Figure 35- Type of Regulations imposed on Firms

Before going into specificities of these regulations, one should analyse some of the general topics.

Most importantly, this framework has been (to most extent) transposed from EU regulations. For this reason, there is not much difference between the sector legislation and those of EU legislation. This framework (Figure-36) requires separation of roles and responsibilities between different organizations. That is to say, policy- making, regulation and network operation/service provision responsibilities should be divided between related Ministry, regulatory authority and businesses.

Figure 36- Regulatory Institutional Structure (Theoretical Model)

Source: Adapted from Telecommunications Regulation Handbook, World Bank Publications, p.17, https://openknowledge.worldbank.org/bitstream/handle/10986/13277/74543.pdf?sequence=1
*Independence and impartiality are especially important for the public organizations to avoid regulatory capture and for the establishment of sustainable competition.

In fact, these structural steps have been followed virtually every country that adopted World Bank policies and EU framework. It is also a similar story for the country as seen from historical evolution of the sector, since the structural process takes time to show its effects, history has largely determined the current institutional structure of the IS. To start with, the privatization of Turk Telekom took many years to complete and the resulting outcome is certainly far from what is expected in the end. Although it can be said that the former (monopolistic) operator has influence (i.e., independence issue) on the public organizations (i.e., the Ministry and the regulatory authority) from the beginning of the liberalization process, the current structure is getting more complicated (again) because of the unsuccessful experience of Turk Telekom's privatization and eventual state ownership outcome.

As the below Figure-37 shows, it is very difficult to argue that the resulting structure is compatible with the one prescribed in EU regulatory framework. The former incumbent operator's board of director is at the same time deputy minister (responsible for the regulatory organizations) at the MTI. This fact, alone has raised concerns about the impartiality of these public organizations toward market actors. The second issue is the independence of regulatory authorities vis-à-vis related Ministry. This topic is even more controversial than the first one and there is no clear-cut definition in practice[246]. It looks relatively easy when looking into the written statements like 'policy making is in the responsibility of related ministry and implementing the regulatory framework is in the responsibility of sectoral authority'. However, a question is how to divide the boundary of policy- making and other regulatory undertakings. This is not an easy question and practical implementation has been subject to discussion not only in the country but also in other countries[247]. It is known that World Bank policies and EU regulatory framework has been largely transposed to Turkish sectoral system. However, there seems several problems related to the very structure of the system due to various policy decisions and historical developments, i.e., path dependency. Apart from the independence issue of regulatory authority vis a vis other public organization, relations of public organizations with some firms (especially former incumbent operator) have caused concerns for other sector players and society as a whole.

In this context, it should be stated that 'independence concept' is not an end itself but rather should be seen as a means to increase market efficiency and performance in several aspects. In other words, failure to ensure this in practice has been considered as a source of system problem that can lead to market inefficiency implications. Indeed, there is a vast literature dealing with these problems and market failures. OECD (2016) gives a good summary of these more theoretical arguments. Without going into much detail, lack of competitive neutrality, information asymmetry, capture by bigger firms, externalities and lack of commitment are stated as possible types of market failure in this regard. For instance, powerful companies can manipulate regulatory authority's decision in their favour, at the expense of smaller ones and consumers' interests. As another example, regulatory authority can be influenced by

[246] The independence of regulatory authorities from political organizations do not have a clear-cut definition, even, there exist differences between countries that adopt this kind of framework in practice. However, it can be said that the more important thing is the functional efficiency of these organizations. That is to say, an institutional framework should provide transparency, stability for companies to make long term planning in any sector irrespective of the public organizations' names or their administrative structures.

[247] Apart from organizational arrangements like financial independence etc., there are various board establishment methods, if a relatively independent decision mechanism (not in the sense of complete independence or exemption from any control mechanism) aims to be established. In some country practices, board appointment criteria and methods are well documented and made available to the public, (http://www.oecd.org/regreform/regulatory-policy/49990817.pdf).

other public organizations in its dealing with an incumbent operator, leading to lack of competitive neutrality. This in turn can deter market entry by potential newcomers and brings about underinvestment in the sector.

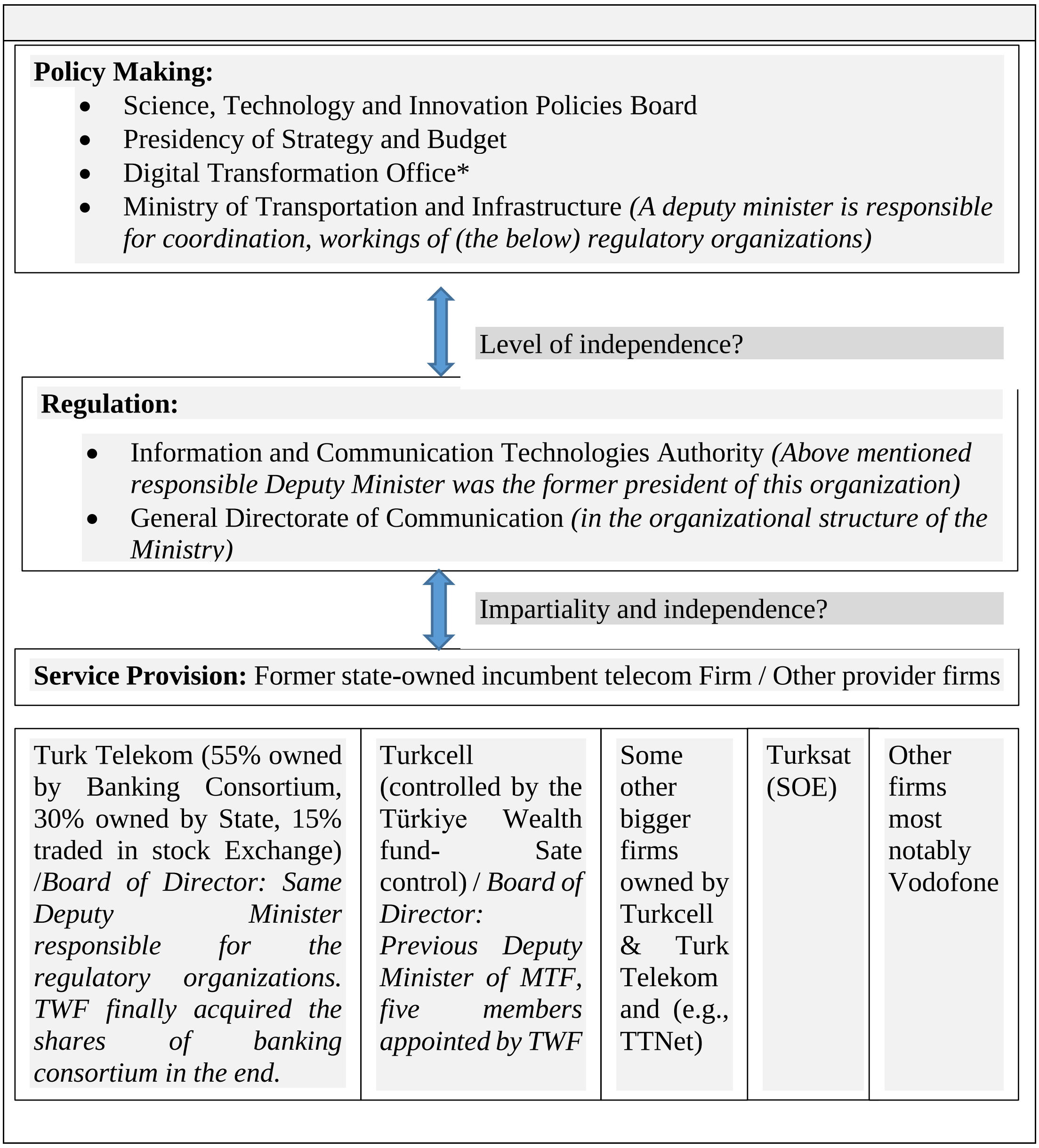

Figure 37- Current Regulatory Institutional Structure of the Turkish IS

*This organization can also be included in the regulatory category as well.

In any case, this seemingly incompatible institutional structure (in practice) with the EU framework does not mean that there is only one mechanism to regulate the sectoral system. In Japan, for instance, there is no regulatory authority and the Ministry of Internal Affairs and Communications (MIAC) undertake these functions. However, once a framework is established, it is normal to expect the adoption of necessary requirements of this system.

5.3.3 Synopsis of Regulatory Framework[248]

This regulatory structure, after establishing required organizations and their roles in general terms**,** requires very detailed legislations to monitor (and at the same time shape) firms' actions in the system[249].

Secondly, the (our case) framework has largely transposed EU legislations as well. In this context, authorization regulations form the central part of this construction.

ICTA[250] defines **Authorization** as registration of firms in order to provide electronic communication network and/or services, under specific rights and obligations. Accordingly, companies can establish & operate electronic communications[251] infrastructure[252] (network) and can provide electronic communications services[253] by only obtaining authorizations from the Authority[254].

There are two types of authorizations, notification and right of use approval. Firms obtained notifications in accordance with the procedures and principles determined by the authority if the type of (electronic communication) services do not require resource allocation of number, frequency, and satellite position etc. Otherwise, the authority gives usage rights to these firms. In this case, there are also two types of authorizations. If the authority decides that there is no need to restrict the number of usage rights, then

[248] This section draws heavily on ICTA's web page.
[249] Regulations and obligations related to internet safety, cyber security and lawful interception of communication issues are not discussed in detail since these are outside of our topic (although they certainly affect firms' operations and consumer welfare in an indirect way).
[250] ICTA, regulatory authority, regulator, (regulatory) organization are used interchangeably in the text.
[251] Transmission, sending and receiving of all kinds of signs, symbols, sounds, images and data that can be converted into electrical signs through cable, wireless, optical, electrical, magnetic, electromagnetic, electrochemical, electromechanical and other transmission systems.
[252] All kinds of network units including switching equipment, hardware and software, terminals and lines through which electronic communication is carried out, their related facilities and their integral parts. Electronic communication infrastructure provision means giving access of this network to other operators for their commercial usage.
[253] Providing some or all of the activities that fall under the definition of electronic communication as a service.
[254] There are two exceptions to this rule. Electronic Communication Service, Network and Infrastructures that are not used for commercial purposes and not available for public do not require authorizations. Similarly, electronic communication service and/or network or infrastructure established by public institutions and organizations in accordance with their special laws are not subject to authorization.

these are granted by the same organization in return. However, in the case of finite resources, the authority restricts the number of usage rights.

In the latter case, which are involving the satellite position and the use of the frequency band, the Ministry decides the authorization policy including (authorization) start date, usage period, number of operators (that can provide these services) and the authority implements these decisions in practice. However, when deemed necessary, the Ministry may directly make tenders for electronic communication services, which necessitate the use of frequency bands for a limited number of operators on a national scale.

The principles and procedures related to authorization applications (in practice) covers detailed steps to finalize including establishment of limited liability or joint-stock (incorporated) company with a written statement of electronic communications services within the scope of the field of activity in the articles of association, paid-in capital specifications and requirements for owners not to be convicted of certain crimes.

Furthermore, these companies (after obtaining authorizations) are required to submit periodic reports, pay administrative and usage right (of satellite position, frequency, numbers etc.) fees and universal service contributions[255], apart from other taxes demanded by the MTF.

Once started operating in the market, companies have several obligations both coming from the authorization conditions and from other type of regulations served to enable market competition and protect consumers in various aspects.

Among the most important ones are access and tariffs, market analysis and resulting obligations, consumer rights, universal service, spectrum management, monitoring and technical regulations including standardization, market surveillance and inspection in terms of devices.

Access and tariff regulations are two components. In general, firms in the sector can determine their tariffs for the end users freely with few exceptions. **The end user tariffs** cover three broad service categories; mobile, fixed telecom and internet services. Among them, only mobile telecom operators have to inform ICTA about their

[255] 1% (one percent) of the annual net sales revenues.

tariff changes prior to seven days before implementation (but they do not need approval) with one condition that these remain below ‘the Mobile Electronic Communication Services Maximum Fee Tariff List[256]’ published by the authority.

On the other hand, operators can set fixed telecom and internet tariffs[257] without any regulatory involvement.

Access regulations mean wholesale provision of electronic communication network, infrastructure and/or services to other operators. They mainly include **interconnection, local network access, data stream access, co-location and facility sharing** to enable market entry for newcomers.

Together with **the market analysis procedure**, they play roles to increase the number of market players and competition by mainly regulating wholesale part of the sector.

Since electronic communications sector still have network economies, owners of these finite number of networks (infrastructures) have advantages over late comers that do not have extensive network rollouts.

For this reason, in addition to access regulations, regulatory authorities undertake regular market analysis[258] to impose several obligations to those network owners, i.e., firms that have significant market power (SMP)[259]. If any firm (or firms) found to have

[256] The list covers all the telecom services provided by the operators ranging from domestic, international voice calls, short message (SMS) to change of number, opening and closing, SIM card change etc. While some of these service tariffs stay below the maximum (cap) like voice calls due to competition between operators, some of them are still important revenue items (like opening and closing of the service) for them.

[257] It should be mentioned that these are retail prices. Internet service providers obtain wholesale internet Access, which are subject to regulatory approval, from Turk Telekom.

[258] The European Commission's Recommendation dated 17 December 2007 (2007/879 / EC) requires market analysis (by regulatory authorities) for the specific (7) markets, which have been determined as susceptible to ex ante regulation. Six of them are in the wholesale part. These are, *“call origination on the public telephone network provided at a fixed location”, “call termination on individual public telephone networks provided at a fixed location”, “wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location”, “wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location”, “wholesale broadband access”, “wholesale terminating segments of leased lines”, irrespective of the technology used to provide leased or dedicated capacity” and “voice call termination on individual mobile networks”.* The other remaining one in the retail part is *“access to the public telephone network at a fixed location for residential and non-residential customers”.*

[259] Electronic Communications Framework Directive (Article 4, Directive 2002/21/EC) defines SMP as *"an undertaking shall be deemed to have significant market power if, either individually or jointly with others, it enjoys a position equivalent to dominance, that is to say a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers."*

SMP, then regulators impose additional obligations such as cost accounting and transparency requirements on them[260].

Regulation of spectrum[261] is essential for mobile telecom operators as another market entry requirement and a prerequisite for continuous service provision. The regulatory authority considers spectrum as an indispensable element of wireless communication and at the same time a natural scarce resource that does not expire with use. In this context, spectrum management covers efficient allocation of spectrum, inspection of spectrum for an uninterrupted (undistorted) communication, preparation and publication of the National Frequency Plan in the light of international regulations. As a closely related topic, spectrum monitoring aims to prevent any interference that causes interruption in communication or impairs its quality. Other technical regulations include market surveillance and inspection of devices to ensure compliance with international standards. In this context, the regulatory authority regularly makes inspections and lab tests to ensure safety of use by preventing the utilization of (technically) unsuitable devices. Regulatory framework has also institutions to protect consumer rights and to increase social welfare by imposing universal service obligations. As in all other network economies, consumers (of these network services) are in a weaker position as compared to bigger companies resulting from information asymmetries and dominant position of these entities. Relatedly, the regulatory authority in the telecom sector are continuously monitoring consumer rights issues and enact legislations to help socially disadvantaged people in the society. Connected to this, universal service regulations are vital for the people who do not have access to telecom services, especially internet in the 21st century. What is more problematic in our case is that, the implementation of this regulation is not transparent enough to inform the public in a detailed manner.

That is to say, there have been projects and works to expand internet access in the rural areas by the Ministry (MTI) but there is not much clarity exist regarding the use of universal service fund which is financed by telecom service provider firms.

[260] Currently in force, ICTA has published six-market analysis, '*Call Termination Market in Fixed Network', 'Call Origination Market in Fixed Network', 'Fixed Telephone Network Access Market', 'Wholesale Fixed Local and Central Access Markets', 'Mobile Call Termination Market' and 'Wholesale and Retail Rental Leased Lines Market'.*

[261] The frequency range of electromagnetic waves, including frequencies of 9 kHz-3000 GHz used for electronic communication, and frequencies above 3000 GHz if internationally regulated.

5.3.4 EU Views on Turkish Regulatory Framework

EU Commission has prepared an annual report for candidate countries progress in accordance with the accession negotiations. In this respect, the view of the Commission is important to see the degree of EU legislative framework alignment with our country case that has an institutional framework largely build on this AC. The document titled 'Türkiye 2020 Report' had a separate chapter (No.10) on 'Information Society and Media' covering electronic communications, e-commerce and audio-visual media services. The chapter pointed out the priority of EU in promoting efficient working of the market (covering above-mentioned services) while safeguarding consumer rights and assisting the enlargement of availability of modern (universal) services. Focusing on (only) electronic communications part, the report stated some developments and problems (in the context of EU framework) in the relevant market segment. To start with, they have mentioned that there is no development between the previous report (dated 2019) and the current one regarding the issues highlighted in this chapter[262]. The previous report had argued that the appointment procedures for the regulatory authority's board members changed by removing specific requirements related to education and sector experience. Although there is no clear finding for the practical implications of this development in both reports, (it is said that) they have concerned with the independence of the organization as a result. The other regulatory topics that need to be aligned with the EU framework are *universal service, authorisation procedures, market access and rights of way*. However, the report has not mentioned any further detailed analysis of mismatches in these regulations. Lastly and more specifically, EC requested *the release of 700 MHz from broadcasting services to mobile broadband* and completion of *the digital switchover process.*

For the market developments, the Commission found inadequate level of competition in fixed voice and broadband internet segments, in addition to high financial costs (including taxes) for both firms and users of these services. Besides this, the report pointed out high fees charged by municipalities for *rights of way and for base station*

[262] In fact, the study has addressed this problem not only in terms of EU accession but also in a more general context in the previous sections. That is to say, although some of the problematic areas and/or projects (to solve them) have been addressed in various public documents, practical implementations have taken either relatively long time or never addressed at all. The author has only pointed out the relatively slow regulatory processes in the IS. Here, another reason may be the fact that public authorities might deliberately choose not to address the EU's recommendations in these topics.

installations as negative practices for increasing these costs.

EC published another report in October 2021, (EC, 2021c). Most of the previous arguments were continuing to be stated in this one as well. With regard to communications sector, the report argued that competition level in broadband market has not increased and there were excessive cost burdens (including taxes) on both companies and users of such services. Furthermore, independence of regulatory authority has not been sufficient according to this document. Here, EC recommended increasing the independence of this organization and its board members but does not give a detailed prescription on how to improve this. In terms of regulations, the report emphasized the need for revisions in *universal service, authorization arrangements, market access and rights of way* in electronic communications to align with the EU legislation[263]. However, in line with previous reports, there is no detailed arguments found how these regulations differ with EU acquis, i.e., whether in wording or in practical implementation. There is not much change in the last development report of EU, which was published in October 2022. Indeed, EU Commission has repeated same criticisms on lack of competition in broadband market and excessive level of tax burden on both operators and consumers.

Apart from these concerns, EU has reiterated the need for alignment in the same points[264] mentioned in above paragraph. At this point, it can be said (by observing recent and past years' reports) that there is not much change in EU arguments related to the telecommunications sector of the country at least in the past years at all.

In sum, as it is evaluated the regulatory framework of the IS has been largely founded on the EU legislation. This framework necessitates a regulatory authority as a main public actor (along with policy- making Ministry and other related actors) that has an independence from business companies and from political interference in practical implementations. Once founded, this authority has responsibility of sectoral regulation ranging from authorization, access arrangements to consumer protection, among

[263] It should be noted that Chapter 10 covers 'Information Society and Media' sectors as a whole. In other words, this part includes telecommunications, media and broadcasting segments. This study does not evaluate media and broadcasting related issues. Besides, comments about internet law are also not discussed here, although it may have an effect on effective usage of internet in social terms.

[264] Universal service, authorization arrangements, market access and rights of way together with independence of the regulatory authority.

others.

The situation is largely the same for our case with more than twenty years of regulatory experience since the foundation of ICTA (in 2001). During this time, it is seen that the legal framework has been aligned with those of EU legislation in this area. However, EU Commission[265] has stated same criticisms related to telecom service sector (excluding comments on internet content, media and audio-visual services) in recent years.

Without repeating these points, what is more important for our purposes is the fact that sector actors also consider them as critical failures and problems of the sector such as inadequate level of competition and nontransparent implementation of universal service regulation in practice[266].

5.3.4.1 Comparisons with EU Objectives and Regulatory Framework

EU set out main priorities in the strategic agenda for a five-year period to guide specific actions and workings of the union in certain areas. The current one is put into force as of June 2019 and covers 2019-2024 period. The priorities are '*protecting citizens and freedoms', 'developing a strong and vibrant economic base', 'building a climate-neutral, green fair and social Europe', 'promoting European interests and values on the global stage'.*

In this context, EU considers having strong capabilities in digital technologies are crucial in achieving success in these priority areas.

Starting from the first priority, EU thinks that they should have more technological capabilities to protect their people from cyber security risks and threats.

Especially in developing economic base priority, EU leaders emphasise the importance of being at the forefront of all segments of digital transformation including

[265] EU Commission, EC and EU are used interchangeably in the text. Please note that although these are not (obviously) same in legal or formal use, they are used in the context of European Union policies and legal framework. In other words, our purpose is to evaluate these policies and regulatory framework without delving into other details.
[266] These topics are discussed with participants of interviews in the next chapter. It should be emphasized that the important thing here (in the context of this study) is not the harmonization process with the EU, but the examination of the effects of these issues on the development of the sector.

infrastructure, connectivity, services, data, regulation and investment. Moreover, they believe social issues like educational inequalities should not be neglected for building fair and social Europe, (EC, 2019d). It is evident that, bridging the digital divide forms an essential part of this undertaking.

Within the umbrella of these priorities, EU policy makers have devised specific action plans to pursue them in several interrelated segments of digital transformation (along with other socio-economic areas). The detailed examination of these plans in wide ranging areas including AI, IoT and advanced robotics (among others) is beyond the scope of this research and the study only focus on broadband and 5G infrastructure objectives correspondingly. In line with these strategic priorities, EC has launched detailed policy documents called 'Gigabit Society by 2025' and more recently 'The Digital Compass', (EC, 2021d), which sets main targets to be achieved by the year 2030. Table-40 gives main broadband coverage targets set out in these plans.

Table 40- EU Main Targets for Broadband Internet Coverage

Gigabit Society- 2025	Digital Compass-2030
Gigabit internet infrastructure for main contributors (e.g., entrepreneurs, clusters etc.) of socio-economic development. Availability of stable 5G connection for all-important locations. At least 100 Mbps internet connection for all residences.	Full Gigabit network connectivity for all residences. Full 5G coverage for all populated areas. Deployment of ten thousand climate neutral highly secure edge nodes. Online provision of all essential public services for people and business sector.

Source: (EC, 2020a)

When these objectives are compared to (our) the case study, one can firstly say that the latter has not currently this kind of long-term plan. In other words, Türkiye has objectives to be reached at the latest by the year 2023. The most recent development plan (i.e., 11th one) sets mobile and fiber broadband penetration rates respectively 100% and 11,5% for 2023. The NBSAP (2017-2020) has a more comparable target of 100 Mbps coverage for all residences for 2023. On the other hand, there is no 5G service availability/ coverage related target in the country's policy papers up to this date. For e-services category, EU policy makers prefer to indicate the objective as online provision of all key public services at the end of the plan period. On the other hand, our latest development plan covering 2019-2023 opt for a more detailed quantitative statement[267].

Being one of the latest policy documents in EU context, Digital Compass has reflected the current experiences of Covid-19 pandemic throughout the world. In this context, EU policy makers have emphasised the growing role of digital platforms and services for the union's future socio-economic development while preparing this document. Accordingly, the paper has two main objectives that are supported by other more specific targets. These two can be summarized as maximising the connectivity and usage of digital services for all the people and increasing the related technological production capability (capacity) of the union.

Apart from increasing the accessibility (coverage) of gigabit connection coupled with 5G technology, EC aims to raise the ICT capabilities of the citizens to get maximum advantage from digitalization. On this matter, policy makers target 20 million employed ICT specialists in the union in addition to objectives set out with regard to basic digital skills in the European Pillar of Social Rights Action Plan[268]. The commission also plan to raise business enterprises' digital capabilities and intend to attain 75% adoption level of cloud computing, big data and AI services for these organizations. Besides this, it is targeted to reach a basic level of digital intensity for more than 90% of the union's SMEs. In this regard, one of the other goals is to double the number of unicorns[269] (established in the union) by the year 2030.

Besides these connectivity (infrastructure and usage related) goals, EC considers the presence of indigenous production capabilities especially in the field of microprocessors and quantum technologies are essential for key value-added vertical applications such as IoT, AI, smart phones, automated transport among other things. In particular, it is aimed to have a market share of 20% (in value) *in the* high-end *semiconductors including processors.* Furthermore, EC plans to have *computer with quantum acceleration by 2025* and aims to be at the forefront of *quantum*

[267] These targets are, increasing 'the percentage of individuals using e-government services to 70% of people between the age of 16-74, e-government services satisfaction rate to 95%, the registered users to 53 million and the number of e-government services to 7.400' by the year 2023.

[268] Main digital skills target (for 2030) in the 'European Pillar of Social Rights Action Plan' include 'at least 80% of those aged 16-74 should have basic digital skills' and 'at least 60% of all adults should participate in training every year'.

[269] Private start-up businesses that have a value of over 1 billion USD, https://www.investopedia.com/terms/u/unicorn.asp

technologies[270] by 2030.

5.3.4.2 Specific 5G Action Plans of EU

In addition to general strategy plans, EU has prepared several other more specific policy documents related to ICT and digitalization processes of member countries. Among them, 5G technology and deployment plans may prove useful to observe the objectives and development process since our IS do not have a detailed and dedicated policy paper (specifying a timetable etc.) in this very subject. In this regard, 5G Action Plan, Electronic Communications Code, Open Internet Legislation and 5G-PPP form the main pillars of supporting policy and legal infrastructure[271]. Apart from these institutions, several member countries have been devising policies including use of joint programs, public funding of vertical applications and even 6G technology development projects.

For instance, German government has allocated nearly 700 million EUR in 6G technology development projects until 2025. Among these initial projects, KOMSENS-6G has been started to support standardization and development activities especially in sensing capabilities of wireless networks, (Nokia, 2022).

5G Action Plan: EU policy makers has emphasised the importance of timely adoption of 5G technology due to its strategic opportunity for the union, (EC, 2016). This opportunity comes from superior features of the new technology being an enabler of new applications in many areas of socio-economic life, as discussed previously. EC has even made quantitative analyses and these studies predicted global 5G revenues in the region of 225 billion Euro in 2025, along with benefits to other main areas such as automotive, health, transport and energy sectors. In the first phase, it set up a Public-Private-Partnership (5G-PPP) with 700 million Euro funding in 2013. Following this, they prepared an action plan (5G for Europe: An Action Plan) to fulfil timely and coordinated utilization of 5G throughout the union countries. This organization has

[270] Both policy makers and leading experts see quantum computing and technologies as a game changer in near future. With their tremendous computing capabilities, they will be used in many applications and sectors ranging from medicine, finance, cyber security, traffic optimization etc. (https://www.lead-innovation.com/english-blog/quantum-computers-state-of-development)

[271] One can include some other institutions since this is a developing and dynamic field. For instance, 5G toolbox is a policy document for member states to deal with risks related to the cybersecurity of 5G networks.

further stated that the document prepared by consultations, events, surveys and this reflects the participatory decision-making process of the union.

Taking lessons from previous failures, EU policy makers do not want to repeat the mistakes experienced in 4G/LTE technology adoption process. For this reason, they have asserted the importance of coordination among the member states (what was not successful in the previous experience) in this new technology development and adoption phase.

Within this framework, EC prepared a common timetable starting with initial 5G service trials[272] by the end of 2018 and provision of commercial services beginning from the end of 2020. Apart from coordination issue, making sufficient radio spectrum available for 5G has formed another cornerstone of the action plan. Indeed, this organization has assumed that continuously increasing (proliferating) 5G usage areas will further raise the demand for additional spectrum bands[273]. In addition to these spectrum needs; it is apparent that an efficient working of 5G network necessitates deployment of both extensive number of small cells (kind of a base station) coupled with fiber connectivity in the backhaul to deal with the enormous data traffic resulting from digital applications and services[274]. Here, similar to our case, the action plan stated that some administrative regulations such as local planning requirements and high rental expenditures have formed barriers to speedier network deployment process.

To this end, policymakers have given utmost significance to reducing network deployment costs by various means including simplification of installation procedures and terms.

Following these prerequisites, the strategic plan has focused on market formation topics. EC has supported member states to be the early & lead users of 5G technology to foster market adoption and technology development in various usage cases ranging from public security to disaster management services. In addition to direct public

[272] These include pre-commercial trials, technological experiments, tests of new equipment and applications including vertical usages.

[273] EC has stated that three group of spectrum bands would be made available for 5G; spectrum below 1 GHz (in particular 700 MHz band), spectrum between 1 GHz and 6 GHz (in particular 3.5 GHz band) and spectrum bands above 6 GHz (especially for meeting future demand).

[274] It is stated in the report that nearly one million devices would be active (connected to the network) per km^2, which is near to one thousand times more than the previous network technologies.

procurements, the organization has initiated incentive and finance mechanisms for start-ups in this area by using European Fund for Strategic Investments (EFSI) and other financial sources.

One can also mention EU's involvement in standard setting process of 5G technology on a global basis. As mentioned previously, this involvement undoubtedly gives several advantages to countries that are active in this process like GSM standard setting by EU countries at the start of mobile telecom development phase. Unfortunately, our IS actors are not very actively involved in such processes historically for the reason that our sector have traditionally been in a follower status by adopting foreign technology.

Table-41 gives some general comparisons of the main topics in 5G-development process between EU and the case study sector. It is already discussed that, unlike EU member countries, Türkiye has not specified a detailed timetable concerning 5G adoption process. Furthermore, there is no publicly available information related to spectrum range that will be allocated specifically to 5G market usage in this regard. Indeed, although policy papers have topics on the subject of spectrum plans, such kind of plans have not been published and/or made publicly available up to now. For standard setting issues, the country has been normally a follower country taking into account scale of resources available to leading countries and their vendor firms, e.g., Huawei and China. Notwithstanding to this, the country's leading operators have participated in various associations and forums working on technology development and standardization issues. Apart from this, public organizations have devised several support mechanisms for development of indigenous technological capability but effectiveness (and sufficiency) of these are another topic that needs to be discussed further.

Table 41- Some Comparisons in 5G Policy

Main Topics	EU	The IS (under study)
Availability of Spectrum	Allocated and opened to use in general terms	Not defined-allocated yet
Commercial Availability	Specific time limits are set for deployment dates. Commercial Launch-Completed as of Jan. 2022 in all members	No detailed timetable is known at this stage. No commercial launch at this stage

Main Topics	EU	The IS (under study)
Coverage	EU level population coverage reached 81%	N/A
Availability of Private Local Networks	Initial phase of implementation, different member country practices	N/A
Cybersecurity	Member countries have begun to implement 5G Toolbox	N/A
Standard Setting Process	Active involvement by sector actors	Inadequate level of involvement by sector actors
Role of governments (in the market formation process)	Public Procurement-Lead User	Not specifically related to 5G, but purchase of domestic products in the context of universal service projects
Support for start-ups	Funding from public sources	Funding from public sources

Source: 5G Observatory Biannual Report, (EC, April 2023) and the author's contributions.

5G Public-Private-Partnership (5G-PPP): EC established Infrastructure Public-Private Partnership (5G-PPP) Project with the main actors of ICT in EU including equipment producers, telecom operators, research organizations and SMEs. After nearly 10 years from the establishment date (i.e., 2013), this partnership is now in its third phase and involved in developing standards and technologies including new applications in vertical usages, (5G-PPP, n.d.-b). The number and type of projects in each phase show the evolution of this technology from local network improvements to different vertical usage applications, mobile virtual services and further improvement of technical components like new radio technologies.

Furthermore, 5G-PPP has organized events and prepared papers to inform related actors and public about developments related to this technology[275].

Electronic Communications Code (ECC): Actors in EU all accepted a need for a new institutional framework to support digitalization efforts of the union starting from 2016.

Accordingly, EC has enacted a new blanket regulatory paper called 'the European Electronic Communications Code (ECC) at the end of 2018 to update previous telecom

[275] Please see Appendix-B.1.1 for a more detailed list of 5G projects undertaken within the scope of 5G-PPP and a summary of recent developments in EU member countries.

legislation[276]. Being a very detailed document, this new legislation has two main objectives according to the press release of EC. These are boosting the rate of 5G and high-capacity network rollouts (i.e., fiber optic) along with giving more protection to consumers in the digital era. ECC instructed all member countries to assign predetermined spectrum by the end of 2020 and the duration of related usage licenses should be minimum 20 years. In the category of high-capacity fixed networks, enterprises can make co-investments more easily thanks to new provisions of the legislation.

Along with the other consumer safeguards, EC has upgraded universal service regulations to enable more affordable provision of internet access to all segments of the population, (EC, 2018c).

5.4 Some Remarks on Peculiarities of the Analysis

Having discussed evolution of telecom services segment, it may be better to summarize some points different than found in sector related reports and policy papers. First of all, it should be mentioned that as a critical sector for the whole country (e.g., from education, finance, to different roles in disaster management etc.), topics and problems related to this industry naturally come to the agenda of academicians, journalists and other interested parties. Accordingly, this study has also benefited from these numerous valuable sources as well.

Notwithstanding to this, the study provides a more integrated perspective to cover all these detailed analyses. In other words, this part has started from the early days of market liberalization and attempted to show main events and regulatory developments in a historical outlook. This section also emphasises the fact that the journey (i.e., market reform) beginning from early 2000s have almost returned to its starting point with the failures of privatizations and market liberalization attempts as shown in (market) statistics indicating competition trends. In this context, the study has pointed out other more specific topics that are not much discussed in other settings.

For instance, the research has noted changing priorities in the statistics category. It is

[276] The final adoption date for the member countries were 21 December 2020.

observed that statistics which shows basic internet data lost their importance considering near full access rates especially in developed countries.

Since, the picture is also similar (especially in mobile telecommunications) in this sector, the study draws attention to the need for changing priorities in data provision.

As an illustration, the findings (of this chapter) indicate the necessity of publishing a broadband access coverage map that shows availability and quality of nationwide telecom network capabilities.

By this way, people can better see available access types (i.e., fiber or xDSL) and average quality of coverage (i.e., 3G or 4.5G) in their locations.

Furthermore, examination of EU objectives, plans in this part demonstrate the need for revision in the country's policy making environment as well. Most importantly, it is examined that EU member countries have implemented 5G action plans that shows milestones and events in the deployment process of this new technology.

Accordingly, the study recommends preparation and implementation of a specific action plan as a starting point of market formation process in the country. More specifically, this 5G action plan should have a time schedule indicating main phases and policy makers should give commitment to implementation of this document, together with related sector actors.

Among other things, the examination of constantly changing roles of main public actors, as shown in institutional setting part, together with observation of related problems in policy papers has more clearly indicated an inefficient organizational structure in the sector. In other words, the chapter put forward these organizations' roles and functions together and then evaluate function transfers between them. To the best of author's knowledge, such a combined perspective has not been adopted in any other policy paper to analyse structural problems of the regulatory framework. This learning, in a sense, has also provided further discussion topics in the next chapter.

5.5 Telecom Hardware Production IS

Having discussed the workings of the services sector, the study will proceed with the evaluation of production part in terms of scope, historical evolution, related actors and policy issues.

5.5.1 Identification of Actors

As mentioned, convergence has erased several clear-cut definitions and categorizations in ICT, including conventional boundaries of telecommunications hardware. Notwithstanding to this trend, one can start with a more general grouping to limit the (study) scope. In this regard, for example National Research Council of USA (2006) has made a broad categorization of these firms in the sector. These comprise communications equipment manufacturers (e.g., Cisco), networking equipment suppliers (e.g., Nokia), semiconductor producers (e.g., Qualcomm), end-user equipment producers (e.g., mobile phones), provider of operating systems and software (e.g., Microsoft) along with service providers (e.g., operators and other type of value-added service suppliers like Zoom).

It should be noted that as previous boundaries have been diminishing, so the separations between firms in these categories. Moreover, many of these firms want to exploit scale and scope economies by diversifying their product portfolios. In fact, some global scale companies (i.e., vendors) have started to produce almost all equipment in ICT field. As an example, Huawei has three main product/service groups in its portfolio. Consumer group include mobile phones, notebooks, LCD TVs etc. Carrier group consists of wireless and fixed network, related service and software solutions, to name a few of them. Enterprise group is composed of different types of network solutions, data storage, digital power, servers, among many other offerings, (Huawei, n.d.).

From the above groupings, the study is especially focused on the equipment/ software that are used in the operators' network operations. This corresponds to communications, network equipment and software solutions in general terms. In this regard, one of the most important products of current times –mobile phones- are excluded from this discussion.

Accordingly, the study focuses on equipment that are found in telecom networks to give service till the end point, i.e., mobile phones, computers or tablets used by consumers and other business entities. Here, only main hardware that have largest cost shares in total network investments are considered as opposed to some others like computers etc. For instance, the government of NSW[277] has made a classification in *"radio communications and link equipment for voice and data services, infrastructure, equipment and services to support radio communications and linking network equipment"* segment. This categorization and supplier list is given in the web page of the government to help buyers and sellers in various ways including online application procedures etc.

Table 42- Categorization of Telecom Network Infrastructure by NSW

Equipment	**Infrastructure**	**Services**
Network (Base stations including related components etc.)	Towers/Poles	Construction
Link (Antennas, Feeders, Switches, Multiplexers and Routers etc.)	Supporting Tower Infrastructure	Design (Site Surveys, Environmental and Structural Assessments etc.)
Power (Batteries, Power Management Systems etc.)	Security & Safety (Alarm Systems etc.)	Project Management
Terminal (Data devices, Modems etc.)	Fibre Infrastructure (Fibre cable, routers, interconnection equipment etc.)	Maintenance
	Communications Buildings (Cabinets, Specialized Vehicles etc.)	Strategic (Strategic, Technical and Commercial Planning etc.)

Source: (NSW, 2021)

Analysis of Table-42 shows that some of the network components do not need high technology like construction and site surveys. Operators can construct and maintain these by using in-house sources or contracting out for completion by a third party, i.e., outsourcing. On the other hand, network equipment investments occupy much bigger share in total expenditures. The cost of these investments can be analysed in three parts. The biggest cost group is the radio access network that covers active infrastructure including base stations, antennas and support units such as power supply

[277] NSW Government stands for The Government of New South Wales, which is the Australian state democratic administrative authority of New South Wales.

and passive infrastructure like towers. More specifically, main expenditure of constructing and operating a mobile network lies in the radio access network (RAN) part. This part makes up to 45-65% of total investment costs, depending on different assumptions like deployment locations and density level of small cells etc., (GSMA, 2019b). 5G necessitates more base stations than previous generations since mmWave bands have limited reach, leading to considerable cost increases. As an example, STL research shows that, installation of 50% more base stations could increase the proportion of network costs absorbed by the RAN from approximately 58% to 67% for a mobile network operator in average terms. This estimation covers other factors such as obtaining land rights and leasing costs, (STL, 2020).

Backhaul part that use fiber and/or wireless hardware like microwave equipment (Ceragon, n.d.), account for between 10-15 % of total expenditures, again depending on various criteria. Energy and (after instalment of necessary equipment) power consumption expenditures are other cost items for operators, (GSMA, 2019). As an evolutionary technology, a 5G network can use several components of LTE (4G) infrastructure to some extent.

However, this network needs Massive MIMO (multiple-input, multiple-output) antennas[278] and much greater number of base stations called 'small cells' along with 'macro cells' that are also used in previous generations. Indeed, small cell stations[279] and RAN towers are among the main components of 5G infrastructure, (Omni sci, n.d.). In this subject, Vice President of China Mobile highlighted this increase by indicating that a 5G network requires three hundred times more base stations and power for the same coverage provided by a 4G network, (Gabriel, 2019).

For this study's interests, the important thing is that base stations, new generation of antennas, backhaul equipment together with supporting devices like batteries, power

[278] MIMO, (multiple-input, multiple-output) is defined as a radio antenna technology that utilize multiple antennas at both the transmitter and receiver to increase the quality, throughput, and capacity of the radio link. Massive MIMO has more antennas to allow 3D beamforming, that enables both horizontal and vertical beams toward customers, increasing data rates (and capacity) for all users. They are particularly useful in urban areas with taller buildings, (Avnet, n.d.).

[279] As one of the principal properties of 5G infrastructure, these stations occupy small areas but necessitates dense instalment in urban areas to enable uninterrupted data transmission between numerous devices in the network. Besides this, they are used to complement whole network that present wide-area availability.

supplies etc. cover much of the infrastructure equipment needs of these firms. Furthermore, virtualized and software-based applications are increasingly become market entry points for new type of infrastructure providers in 5G era. In any case, it is extremely difficult- if not impossible- to specify every firm (even a product/service category) that can be related to the production part of the IS due to increasing role of software and mobile service application developers. Thanks to the convergence in different technologies, many software companies have expanded their operations to digital platform developments and service applications.

Here, it is beneficial to observe the classification made by BT Haber in its ICT 500 list.

Table 43- ICT Market Categories

HARDWARE	SOFTWARE	SERVICES
Servers	Operating System	E-invoice/ E-Ledger/ E-archive
Desktop-Laptop Computers and related/peripheral components (e.g., Monitors)	Human resources software	Call Centre Service
Printing systems	Office Software	Hosting/Management Service
Data Storage	Security Software	Cloud Service
Network Hardware (e.g., Cables, Routers, Switches, Modems)	Archive Management	Internet Service
Information/ Network security hardware	Sectoral Software	Fixed telephone service
POS systems	Geographic Inf. Systems Software	mobile telephone service
Image and audio systems	CRM/ERM/ Other business applications Software	broadcasting service
Telecommunication infrastructure equipment	Mobile Applications (provided over mobile networks)	Value added mobile and internet services
PBX switchboards	Database and data warehouse software	Installation/ maintenance/support services
Mobile phones and accessories	Virtualization	Other outsourcing services
Various hardware (e.g., IoT		
Uninterruptible power supply		
Consumables (e.g., toner, CD)		

Source: BT Haber

Even a brief inspection of the above Table-43 shows that there are many subcategories of products/services that are related to each other in terms of technology and expertise. In other words, one firm can produce many of them by itself or can expand its product portfolio in time. On the other side of the coin, if we look at from the telecom operators' needs, it is obvious that most of these products/services can be included as an inventory list of these firms. For instance, every operator needs servers, computers and several type of software and applications for their infrastructure operations. Notwithstanding to this, attempting any manageable examination of the sector requires a certain limitation of scope. Accordingly, the (firm and product/service) scope is mainly limited with mainly 'Communication Technologies Cluster' since this grouping has more than 100 companies that satisfy main requirements of mobile service operators in building and operating their networks[280]. The cluster firms have capabilities in hardware, software and infrastructure parts of the sector[281].

5.5.2 Public Organizations

Since most of the main public actors has been analysed in the service part of the study, only production related roles of them are examined in this section. Furthermore, it is evident that –like the prior case - one can add numerous other public organizations to the picture however; this will make any comprehensible analysis very difficult, if not impossible. Accordingly, the study proceeds with organizations under the umbrella of MTI.

ICTA: From the preceding argument, it is known that this organization is in the position of market maker, since- before anything else- allocation of limited spectrum licences make possible any kind of network infrastructure establishment and telecom service provision to get revenue for operators.

Accordingly, ICTA has tried to support development of indigenous production capabilities while enabling mobile service operators' market entry, by using service license requirements especially since the introduction of 3G technology in the country[282]. Apart from these policies, the organization has been working on various

[280] As it is indicated, one may add many other hardware items, some of which can be termed as general-purpose hardware like LCDs, computers and peripheral devices to the infrastructure list. However, then the scope will become too complex to analyse in one study.
[281] This cluster is analyzed in the next section and in qualitative analysis part.
[282] These policies are analysed in the next chapter.

aspects of 5G ecosystem before finally making related license auctions in the near future.

In this context, ICTA set up “5G Valley Open Test Site[283]” with a protocol agreement signed by related universities and three operators in 2017. The site aims to provide an environment in the region where universities, research centres and companies can test products, applications and software related to 5G technologies.

Here, five companies finished establishing test network infrastructures at the end of 2018. According to press announcements, Turkcell performed first 5G tests by using Huawei’s system in this site, (Hurriyet, 2018b). The regulatory authority has later announced that firms that want to make tests and trials in these networks can do so by applying to them, starting from 2019, (ICTA, 2018a).

At the same time, the authority also formed “5GTR Forum” to assist in determination of priorities, strategies, targets, roadmaps for the sector and to provide an environment for joint studies and collaborations between stakeholders in the ecosystem, (ICTA, n.d.). This forum has prepared a ‘White Book’ covering strategies and roadmap for 5G deployment process. Although it is not a legally binding document, the report covers almost every area of 5G technology and provides recommendations for technology development and adoption[284].

Like the case of many other strategy papers, one can say that the report has been prepared with a participatory approach; there is no publicly available follow up document related to outcome and/or review of the current situation of this work.

As another policy in this regard, ICTA has initiated a “5G and Beyond Joint Graduate Support Program” with the universities that take part in the 5G test valley project, (Haberler, 2018). Mobile operators are financing this graduate program costs[285]. In

[283] The site covers an area between partner universities’ (METU, Bilkent and Hacettepe) campuses and ICTA headquarters (central building) in Ankara.
[284] Being a very detailed report, it has six main parts. The first part addresses the importance and development of 5G technology and summarizes the activities of 5GTR Forum. Second part examines “5G Core Network’ while third part prioritizes “Physical Network Structure” topics. Fourth part focuses on “5G Vertical Sector Usages”. Remaining two parts deal with “Standardization” and “Funding Mechanisms” with several policy recommendations.
[285] The amount of the scholarship is 15% above the research assistant salary. Students in the program can work full time and are supported without any compensation obligation, (Hacettepe, 2020).

return, thesis topics should be in the field of 5G and Beyond Communication Technologies and should be determined in consultation with operators, (Hacettepe, 2020). From the inception date (October 2018), 38 researchers have been granted scholarships and 21 new research students have been admitted in the Program for 2020-2021 education year, (ICTA, 2020c, p. 96).

The research topics include wide range of topics such as 5G network development, vertical usages and artificial intelligence.

General Directorate of Communications: As discussed, GDC has several responsibilities and objectives actually shared by ICTA in the sector. Among them, the directorate aims to devise policies to encourage domestic production and R&D in the electronic communication industry. In this regard, the directorate has implemented and/or taken part various projects intended to both promote indigenous capabilities and adoption of (domestic and national) technologies. Among them, ULAK project[286] is important for promotion domestic base stations production by enabling their use in the context of universal service deployments. Furthermore, GDC has prepared strategy papers covering many aspects of digital transformation including National Cyber Security (2013-2014 and 2016-2019), National Intelligent Transportation Systems (starting from 2014 to current one covering 2020-2023) and NBSAP (2017-2020) which is discussed in the previous part, with the exception of hardware production related policies, (MTI, n.d.).

Especially, this later plan has topics more directly related to equipment production segment of the sector and ICTA is the main organization responsible for these actions[287].

Transportation, Maritime and Communication Research Centre (UDHAM): The centre has duties in the field of R&D in cooperation with the other organizations belong to the MTI. These duties and responsibilities are ranging from preparing programs to supervising implementation of these (programs) by different

[286] The project has different partners namely MI&TECH and Defence Sector Organizations including Undersecretariat of Defence, ASELSAN and other private companies NETAŞ and ARGELA. These organizations established ULAK Company to produce these base stations. MTI's role is more oriented to promote adoption of them in domestic operators' networks through universal service funds.
[287] These actions and objectives are discussed more specifically in the next section.

organizations such as universities and international research agencies. It is understood from the web page that, there is no direct R&D works of the centre and it has coordination & supervisory roles, (UDHAM, n.d.).

However, there is no information about the activities of this organization both in its web page and in other publicly available source[288].

Apart from MTI organizations, one can indicate the role of **MI&TECH**, its affiliate establishments and defence sector organizations including **Undersecretariat of Defence[289] and ASELSAN**, besides other companies that have connections with these public entities. Defence sector organizations' role is more important in the establishment of ULAK Communications Inc., which is producing domestic base stations[290]. Likewise, affiliate organizations (KOSGEB and TUBİTAK) of MI&TECH have played roles in foundation of electronic communication technologies cluster by providing funding to this entity.

Having summarised the scope of hardware production part (i.e., setting the boundaries of IS), the study proceeds with by looking into evolution of the market and analysing the role of sector actors. In fact, one of main aim of this discussion is to search for an answer to the question that whether our IS firms' can compete with the foreign providers including global vendors, not only in home but also in world markets, at least in some segments.

5.5.3 Historical Evolution of the Hardware Production Part

In line with the previous analysis related to telecom services part, the study will only briefly examine the period before the advent of mobile communications era. Notwithstanding to this limitation due to space reasons, one should not underestimate the historical trends and path dependence in the development of this IS. In fact, current problems and deficiencies have been linked to past mistakes and policy failures.

With this caveat in mind, it is interesting to see that first efforts had begun as early as 1860s with the establishment of a factory to produce Morse telegraph devices, (PTT,

[288] This issue is discussed in the next part in a more detailed manner.
[289] Current name of this organization is 'Presidency of Defense Industries'.
[290] The role of the company in the system is examined in the historical evaluation part of the study.

2007). The reason for this attempt was the difficulties encountered in importing this equipment. Indeed, the factory started production of these devices and had been awarded various certificates of achievement in international exhibitions.

Bezaz argued that these efforts ended with the entry of the telephone into the country and the loss of importance of the telegraph. Furthermore, foreign ownership of telephone companies delayed the factory's transition to this new technology, (Bezaz, 2006). Similarly, Yücel (2016, p. 55) links subsequent failure of the factory as not following the technology, i.e., not acquiring or adopting telephone equipment production capability. However, the next important attempt regarding research and development was made nearly a century later (i.e., in 1965) with the establishment of PTT Research Laboratory (PTT ARLA). Yucel (2016, p.58) also considers establishment of ARLA a significant turning point in the industry. This laboratory then developed necessary technologies related to transmission systems. Notwithstanding to this, the organization encountered several problems in carrying out its activities due to the fact that it did not have a suitable status even though it had undertaken the task of an industrial establishment, and the need to change its structure emerged.

Accordingly, it was restructured as an incorporated company under the name of TELETAŞ in 1983. Afterwards, BELL (Belgian company of ALCATEL) acquired 39% shares of the firm at the end of 1984. In 1988, as the first example of the government's privatization program, Public Partnership Administration (KOI)[291] sold 22% of TELETAŞ shares to domestic and foreign investors.

Finally, Alcatel bought the remaining shares of KOİ to become the majority shareholder with 65 % of total shares in 1994. In a similar manner, Yucel (2015, p. 132) argues that the privatization of TELETAŞ was wrong because it was done prematurely, without taking any precautions and without putting forward the necessary conditions. Foreign partner aimed to provide intermediate goods of the final (Alcatel made) hardware, at inflated prices and to market its own products in the country through TELETAŞ. In fact, after gaining corporate control, Alcatel firstly blocked the small capacity (up to 2000 lines) telephone exchange product called LEVENT. What is more, TELETAŞ cancelled the support agreement made with TTGV in development

[291] Kamu Ortaklığı İdaresi (KOİ) in Turkish.

of this project and even paid a compensation fee. The author (Mr. Yücel) also pointed out that the attempt to establish a facility for production of integrated circuits that were used in digital telephone exchanges failed due to the negative attitude of the foreign partners of TELETAŞ and NETAŞ. Taking all these together, he continues to assert that firms in this sector have been prevented from adapting to the changing technology (due to interventions of foreign companies) leading to capability weaknesses in mobile telecom technology production for all sector actors. In this subject, Serbest (2006) sees TELETAŞ experience an example of preventing a possible competition by foreign (more established) companies.

According to him, when a foreign firm buys another one (in other countries), the strategy is usually dissolving the latter in its own structure and to remove any (possible) competitor in these markets. The fact that, they closed the R&D branch and dismissed related personnel in the so-called restructuring give evidence to this argument.

Apart from these actors, there is another important firm in the history of this sector and it is still active in the IS. **NETAŞ** was established by an international tender with the partnership of Canada's Northern Electric (51%) and PTT (49%) to supply telecommunication infrastructure hardware requirements of domestic operators (at this time mainly PTT then Turk Telekom) in 1967, (Bezaz, 2006, p.122). Since then, the company developed and produced several network equipment successfully. In this regard, Mr. M. Altay (previous CEO of the firm) summarised the milestones as follows. The company achieved 650 thousand digital telephone switchboard production capacity in a nearly ten years' time in which there were also an increase of one hundred thousand to one million available telephone lines in the country. NETAŞ established the country's first private sector telecom R&D facility in 1973 and extended its product range including rural telecom stations, power units, transmission systems and terminal (last user) devices. More significantly, the firm had made technology transfer agreement with the Turkish Republics in Commonwealth of Independent States (CIS)[292] regarding the usage rights of its rural telecom station

[292] Russia and 11 other former Republics (that were part of Soviet Union) formed a free association called CIS in 1991. The association coordinate member country policies in several subjects including economics, foreign relations and defense topics, to name some of them,

technology. In other words, they had succeeded in exporting their own technology products to international markets in 1990s. Furthermore, NETAŞ provided software components of NORTEL's DMS (Digital Multiplexing Switching System) stations and became first exporter of software products (for an amount of 2 million USD) at the beginning of 2000s. The R&D department had reached to 800 engineers in 2015 with a sophisticated digital signal-processing lab, to name only one of these facilities. The company also involved in the development works of 4G base station in the context of ULAK project. Afterwards, NETAŞ participated in "5G Technologies Consortium Cooperation Agreement[293]" with ASELSAN and HAVELSAN under the direction of "Turkish Armed Forces Empowerment Foundation[294]" in 2016. In sum, using the words of Uras (2011), NETAŞ switched from hardware-based technology (e.g., conventional switchboard-stations) to software-based technology starting from the end of 2000s. Currently, the firm's portfolio covers wide-ranging products and services in the field of digitalization including IoT, service management (energy, water meter etc.), cyber security, data centre, mobile broadband solutions to name a few of them. In addition to these technology related developments, more recently, global vendor ZTE bought 48,04% shares of the company for 101.3 million USD in 2017. Regarding this, Mr. M. Altay stated that the aim of ZTE is to make the company a maintenance and repair centre for the Middle East and Africa as a first step and while doing this, it would generate new employment with further investment, (Sabah, 2017).

In retrospect, one cannot help but think about the previous similar experiences in the sector. Notwithstanding to this, for the positive side of this market transaction, it can be said that NETAŞ has surpassed some level of threshold to continue its market presence and the foreign investor does not have majority ownership.

As in other countries, PTT and later Turk Telekom played important roles in the development of hardware sector both in a producer (through partnerships etc.) and in a dominant buyer position. In any case, these efforts helped to form a knowledge base and human resource (i.e., experienced engineers etc.) on which foundations of new ICT firms could be established. Currently, it is seen that these new ICT firms together with the relatively older ones like NETAŞ and state-owned ones like HAVELSAN and

[293] "5G Teknolojileri Konsorsiyumu İş birliği Anlaşması" in Turkish.
[294] "Türk Silahlı Kuvvetleri Güçlendirme Vakfı" (TSKGV) in Turkish.

ASELSAN are working in the sector to develop mobile telecom technology capabilities of the IS with the help of public agencies. In what follows, mobile telecom technology (development) projects are evaluated in a more detailed manner.

5.5.4 Mobile Telecom Hardware Development Policies and Projects

Public organizations have beginning to implement regulations aiming to raise indigenous (mobile telecom related) technological capabilities by 3G license auctions in 2008. Indeed, for the first time, operators that acquired 3G licences obliged to procure infrastructure equipment from vendors that established an R&D department and employed 500 engineers[295] in these units, (Hurriyet, 2008). By this regulation, ICTA has intended to contribute to the development of new employment opportunities and education of qualified human resource in this field.

As another new regulation, 3G service providers had started to acquire at least 10% of their hardware & software needs from domestic SMEs. Here, it is seen that the burden to comply in both requirements has been on the operators. That is to say, operators were held accountable if they had bought infrastructure equipment from a vendor that did not satisfy these R&D related obligations[296,] (Gürsoy, 2009).

One can consider these regulations as important starting point for supporting indigenous technology and production capabilities in mobile telecommunications hardware sector, although achievement levels of these (together with later policies) are open to discussion in varying degrees. To begin with, policy and performance evaluation reports to public in this segment are fewer than those that are related to service provision segment of the sector[297]. In this regard, ICTA has enacted a board decision[298] related to the implementation details of these obligations by the 3G operators in 2009. This regulation requires detailed reporting from operators in the subjects of investment details, list of partner vendors that have R&D and/or technical

[295] The exact requirement is to employ min. 200 (Turkish engineers) in the first year, following with min. 300 in the second year and min. 500 in the third year.
[296] The penalty for non-compliance is an administrative fine up to one percent of the previous year's turnover of operators.
[297] In fact, one of the arguments of this study is the lack of publicly available post evaluation reports made by related organizations in the service segment as well.
[298] ICTA Board Decision on the subject of “Principles and Procedures on the investigation and audit of Hardware and Software Investments to Be Used In Networks Of Imt 2000/Umts Operators”, https://www.resmigazete.gov.tr/eskiler/2009/04/20090424-10.htm

support centre in the country, information about working personnel (ID numbers etc.) and R&D projects, list of partner SMEs in this subject and more detailed specific papers such as invoices, financial tables etc. Within this context, Huawei opened its 15th R&D centre in 2010 in İstanbul. Company officials stated their objectives as advancement of products and services for local and international markets including software design, wireless technologies, billing services and call centre solutions, (BT Haber, 2010). Another vendor that obliged to establish an R&D centre was Ericsson. This company instead preferred to start with buying an already established enterprise called **'Bizitek'** in 2009, (Haberturk, 2009).

There are several evaluation parameters of this regulation. One is relatively easier to inspect, that is employment of required personnel in these centres. The other one is determination of whether they have been working in R&D projects. This is undoubtedly not a straightforward inspection topic and some actors (in the sector) have pointed out TUBITAK would be in a better position to make this kind of controls, (Turk internet, 2010). Apart from these, examination of procurement obligations from SMEs makes up other inspection topics.

In any case, ICTA started these inspections beginning from 2011 as indicated in annual activity reports of this organization. Activity reports of 2011, 2012 and 2013 state that ICTA performed related inspections, but there is no detailed information available in these papers. ICTA eventually published its decision related to these obligations in April 2013.

The decision indicated that although there were some errors and shortcomings (e.g., false reporting in some invoice amounts, personnel information etc.), these did not warrant an administrative penalty and operators warned to comply with implementation procedures, (Vatan, 2013).

5.5.4.1 Developments after 4.5 G Auctions

As stated previously, operators launched 4.5G services (after obtaining necessary licences) starting from April 2016 (until April 2029). Continuing from 3G experience, policy makers have imposed detailed obligations on license holders.

Immediately after the auctions, ICTA president of this period (Mr. Sayan) held a meeting with stakeholders to emphasize the importance of R&D and usage of domestic products obligations brought by the IMT authorizations for the realization of the country's goals. Mr. Sayan declared that ICTA would closely monitor the implementation of these obligations and expected utmost cooperation from all related actors. Moreover, he said that they would complete necessary (secondary) regulations in a short time period, (Dinçer, 2016).

In the context of changes in 4.5G licence conditions, it is observed that the level of mandatory domestic (local) product usage has been increased in a progressive manner. These requirements are at least 30, 40 and 45% of total investments in the first, second and third years respectively. One journalist (Oğuz, 2017) points out the abuse (manipulation) of the previous SME regulation among the reasons for this regulation. He indicated by referring the previous president of ICTA that operators fulfilled SMEs purchase requirements by fraudulent methods in the previous period. In more detail, these companies imported some equipment via SMEs and received necessary invoices from these enterprises. Here, more interesting topic to note is the fact that (as noted above) ICTA found no evidence of material non-compliance with regard to the implementation of these regulations in the previous period.

Hence, one can find this situation as contradictory in that some violations of the regulation have been detected but there is no (publicly available) information about the previous decision, i.e., whether changed or not.

Apart from this, the local production objectives have not been meet as stated by Mr. Sayan in this interview dated June 2017. Here, he said that these requirements actually reveal a vision and they do not want to harm the sector by giving harsh penalties for non-compliance immediately. Instead, he continued by indicating it would be more accurate to look at the average of 3-4 years for evaluation, (Oğuz, 2017).

This method takes into account four-year averages of 30, 40 and 45% respectively in the first, second and third (four-year) period, (HTK, 2017).

At the point reached, there is not much information about the developments related to this topic, except some statements about realized levels in ICTA activity reports and public officials' interviews. According to these sources, the local (domestic) content ratio was 0, 98% in 2016 and near 2% in 2017 later increased to about 23% and latest publicly available figure has become approximately 22% in 2021, (Yeni Şafak, 2021). Though the increase is remarkable in this period, the figures have not reached to target levels. Secondly, some of the increase might be due to what Mr. Sayan stated in the above-mentioned interview. Referring to this again, the inclusion of software expenditures and TOBB's categorisation of such products with 'domestic certificate' might be among the reasons for the increase. This does not necessarily mean a misapplication but at the same time, there is not any further information about the details of this inclusion and development of expenditures in the total investments of operators (e.g., share of these software costs, share of foreign & locally produced base station costs and dynamic changes between these cost categories etc.). At the least, it might imply a ceiling above which is difficult to surpass. If these items are already existed (i.e., they were considered as foreign product before), then their inclusion in calculations (after this definitional change) could increase this ratio immediately.

Apart from this issue, policy makers have increased their efforts to support indigenous production capabilities in mobile telecom technologies by also forming new commercial equipment manufacturer, devising projects and establishing clusters in recent years. It should be mentioned that these projects have contributed to the increase in domestic production ratio lately, but as already stated there is not much information related to specific contributions of each item and/or activity.

Having said that, the study proceeds with detailed evaluation of these undertakings.

5.5.4.2 ULAK, MİLAT and ÇINAR Projects

The need for reducing foreign technology dependence in mobile telecommunications had become apparent in 2G (GSM) era due to the reason that operators nearly imported all essential components including advanced base stations. In order to address this problem, ASELSAN (main contractor), NETAŞ and ARGELA established a consortium called ULAK project under the coordination of Undersecretariat of Defence Industry (SSM)[299] together with MTI[300] in February 2013, (MTI, 2020a). Within this context, a second project called MİLAT launched under the responsibility of ARGELA in 2015 to develop national network technologies including 'Software

[299] Savunma Sanayi Müsteşarlığı (SSM) in Turkish.
[300] The name was "Ministry of Transport, Maritime and Communications" in this period.

Defined Networks' (SDN) and 'Network Functions Virtualization' (NFV) that are in the centre of 5G. According to Mr. Balcı, the project has aimed to advance Wide Area Network, Campus Networks and Data Centre systems that will use SDN and NFV technologies along with centralized management of network infrastructures, especially mission-critical communication networks, and the implementation of cyber security policies with our national means, (Hurriyet, 2020a). After these initial steps, ULAK project has reached another level in the form of establishing a separate company to commercialize these outcomes (e.g., patent activities, product development and marketing steps). SSTEK Defence Industry Technologies (owned by SSM) founded ULAK Communications (Inc.) company[301] in April 2017. ULAK's activity area starts from R&D and encompasses nearly all segments of value chain including production and commercialization of mobile and broadband communication systems to provision of support services in the form of maintenance, training etc. (ULAK, n.d.).

After the establishment of ULAK Communications, a third programme called ÇINAR (SDN/NFV Based 5G Core Network Development Project) was launched to complement previous two in 2017. Owing to these activities, the market has beginning to see final products for use in mobile telecom networks. 4.5 G Base stations firstly deployed in operators' networks starting from 2018 in the context of universal service projects carried out by MTI. The Ministry announced that ULAK base stations have been installed in 729 universal service areas that cover 976 settlements as of May 2020, (MTI, 2020).

In addition to this, Mr. Balcı had given commercially delivered base station number as 1600 (of which 1000 were active) as of January 2020.

He added that they have concluded a four-year Framework Agreement, which is a significant achievement for the sustainability of the company, with Turkcell for the supply of 2,650 base stations in 2019. Here, he has attached great importance to this firm's request of product improvements that lead to (positive) challenges for the company. In addition to this, he emphasised that usage of ULAK base stations in some public organizations' premises including the Presidency Office has supported establishment of confidence in their products. As discussed, although all three methods

[301] Ownership structure is 51% Aselsan and 49% SSTEK.

(i.e., public procurements as early buyer role, symbolic usage in prominent locations and user-producer relations to enhance equipment features) have been instrumental in the early market formation, they may not be enough for sustainable (long-term) market presence and share. At this point, Mr. Balcı also draw attention to the marketing strategies of global vendors on the eve of 5G transition of the country. In fact, in line with international developments, global (scale) vendors have used all their powers (with the help of their governments in most cases) to capture foreign country markets at the expense of smaller domestic actors. For instance, they are offering to construct whole 5G networks with the addition of after sale maintenance and upgrade services. In most of the cases, these end-to-end solutions are more economical and thus preferable for operators, which naturally prioritize cost minimizations throughout the world. Here, Mr. Balcı warns against the temptation of attractive offers by these firms because of possible negative impacts on national (domestic) production efforts. Instead, it is essential to proceed with continuously increasing commercial orders from domestic operators and at the same time obtaining some sort of financial support to offer suitable price offers in this process until reaching sufficient order quantities, i.e., scale economies, (Hürriyet, 2020a).

As it is seen from the previous discussions, being able to produce some hardware (especially if it is a standardized product) is not a very difficult process in ICT era where software plays central role in many components. However, it is evident that cost and quality considerations together determine the success in today's competitive global economy. Even, developed countries (in terms of mobile telecom technologies) do not easily reduce their dependence especially on Chinese firms (e.g., ZTE, Huawei) with their cost advantages. Nevertheless, several countries have increased their efforts to diversify their network suppliers. At the same time, governments have been devising policies to enhance their (domestic) sectors' performance and production capabilities in this field. Turning to the case study, even though the above-mentioned policies are important by themselves, they may not be sufficient to achieve necessary scale economies even in domestic market let alone in global arena. Notwithstanding to this, starting from 4.5G and especially in 5G demand for base stations will certainly increase even more rapidly. Here, current stock of base station numbers, which are among the main cost items in networks, can show volume of domestic market. Although this figure is not publicly available regularly, one newspaper article referring from Parliamentary Petition Commission mention a number of nearly two hundred thousand (197,000 exact) as of January 2020 without giving details in terms of technology, e.g., 3G or 4.5G, (Milliyet, 2021).

5.5.4.3 Communication Technologies Cluster[302]

Another main project in this regard is the establishment of Communication Technologies Cluster (CTC) in 2017. OSTIM[303] set up CTC by bringing together different stakeholders in the sector with the support of ICTA. The cluster has several but interrelated objectives ranging from development of products to meet the requirements of the sector in a cooperative way to commercialization of knowledge that universities have developed on this subject and facilitation of companies to compete in international markets, to name some of them, (HTK, n.d.).

At the point reached, CTC with over 150 member companies and more than 8000 employees in these firms, have been working to reduce foreign hardware dependence of the sector in several respects. To accomplish its main aim, cluster members initiated a proposal called "End-to-End Domestic and National 5G Communication Network Project" and public finance in the amount of 253 million TL obtained from the Scientific and Technological Council of Türkiye (TUBITAK- TEYDEB 1501 Program) in the same year (i.e., 2018). The project members initially consisted of 16 firms, 3 operators, 6 techno-parks, 10 universities, OSTIM organized industrial zone under the coordination of MI&TECH and ICTA. In the opening ceremony of this project, former Minister Mr. Özlü has announced that they would adopt a proprietary R&D model in the workings of the cluster.

Here, the model requires collaborative working in different stages. Shareholders determine priority R&D areas (i.e., type of products) in the first stage. Later, they perform test stage in these operators' networks.

The last stage is concerning the operational usage of them by operators. In addition to this, an example from a speech by Mr. Özlü may also be useful for showing the future

[302] Haberleşme Teknolojileri Kümelenmesi- HTK, in Turkish. Both HTK and CTC are used interchangeably in the text.
[303] OSTIM is an organized industrial region, which has 6,200 companies with nearly 60,000 working personnel in 17 sectors and 139 different businesses, located in Ankara, (OSTIM, n.d.).

investment levels of operators in the home market. According to him, the project would contribute to the fulfilment of the domestic commitment of approximately 7 billion TL until 2026 under the 4.5 G auctions, (HTK, 2018). At this point, it should be noted here that there are few different figures available (mostly from interviews and conference keynotes) to see the potential domestic market volume. Deputy Minister of MTI, (Sayan, 2019) assert the annual 4.5G hardware & software investments of operators as around 1.5 billion TL whereas Vice President of ICTA gives the annual figure around 2 billion TL, (Hurriyet, 2020b). TBD[304] , (2019, p. 29) gives a more detailed volume prediction as 6.4 billion TL until 2020 and as 9.6 billion TL in 2020-2029 period. Furthermore, they state a magnitude around 18 billion TL for 5G until 2029 citing ICTA data[305]. The upshot of these figures- apart from the precision level of these amounts- is that the market trends will undoubtedly present opportunities for domestic firms if they can provide necessary products to operators in this period. From a more technical perspective, the project scope covers all the essential components of a mobile telecom network as indicated in the project name (i.e., end-to-end). Accordingly, there are three general categories in the whole project and each category is composed of several hardware items that add up to a network infrastructure as shown in Table-44.

Table 44- CTC Project Scope

Categories	Components
Software	Core Network Software/ NFV & SDN/ Business Support Systems/ Network Operational Support Systems/ Geographic Information Systems/ Security and Tracking Software/ IoT Software/ Cyber Security
Hardware	Base Station Equipment/ Massive MiMo/ Small Cell & Radio Integrated Antenna/ Radio Link/ Repeater/ Antennas/ IoT hardware/ Switch-Modem-Router-Gateway-Server/ Test Equipment & Services
Infrastructure	environmental auxiliary equipment/ Base Station Field Design and Installation Services/ Consultancy and Engineering Services/ Data & Signal and Energy Wires/ Power-Electric-Energy Equipment and Parts/ Air Conditioning Systems/ Mechanic Construction Systems/ RF-Optic Cable Connector Equipment and Accessories/ Other Infrastructure related Hardware& Software

Source: (HTK, 2020)

[304] Türkiye Bilişim Derneği in Turkish, (Türkiye IT Association).
[305] It should be noted that, the author could not find such figures in ICTA sources. It is possible that they make some calculations for this total but do not give the details in the report.

As a more recent development, ten firms of CTC established a joint venture named GTENT (Global Telecom and Integrated Technologies Inc.) in 2020. The establishment of the company coincided with the last period of the three-year (2017-2020) TUBITAK project. Here one can ask the reason of founding a new company within this cluster by some firms. Indeed, CTC president (Mr. Bağören) and GTENT chairman of the board (COB, Mr. Kayaduman) give some answers to this question. At the start, they have indicated that many of cluster members are SMEs that lack adequate proficiency (capability) in sales, marketing and mass production.

For this reason, they argue that one bigger firm can be in a better position to address these marketing issues and mobile operators prefer to deal with a single company. For the present situation and objectives, the COB of the company singles out GTENT as the only active firm in main product groups of 5G including New Radio (Antenna), BBU, Core Network and Radio Link. In this context, they aim to reduce foreign dependence and want to end security concerns with their products. As a quantitative object, they intend to achieve 60% market share in domestic (mobile telecom network equipment) market in the near future[306]. What is more striking is the statement of COB saying *"There's no reason why we wouldn't be Türkiye's Samsung",* (Baş, 2021).

Having observed historical evolution of the IS and with these ambitious goals in mind, this study would try to highlight some of the issues and to discuss some points related to these developments in the next heading.

5.5.5 Policy Papers Revisited

Since a very detailed analysis of policy papers have been made in the previous part, here emphasis will be given to production related objectives of current documents. Here, the same order is followed (as the previous analysis), starting from macro papers and proceed with a few sectoral ones.

The 11th Development Plan (2019-2023) gives special emphasis on increasing indigenous production capabilities in different segments of ICT.

The plan puts increasing competitive production and exports based on R&D as a main

[306] https://www.milliyet.com.tr/ekonomi/kuresel-lig-icin-5g-milli-takimi-6478084

objective in the electronics industry. In this direction, there are several policies and measures related to mobile telecom technologies (5G and beyond), along with other vertical sector usages like smart factories, transport, energy, agriculture and disaster management etc.

These measures begin with supporting R&D and production activities of domestic electronic communication network and infrastructure components, including 5G and beyond technologies. Specific targets and measures can be summarized as follows:

- Completion of 5G base station development works.
- Support of domestic production and R&D activities within the scope of new generation mobile communication technologies and M2M & IoT hardware & software. Here, certain amount of locality requirement will be introduced in authorizations for 5G services.
- Provision of incentives for the transfer of capabilities acquired in defence electronics to the civilian sphere and for commercialization in this field.
- Establishment of special support programs to increase production and to assist sectoral transformation.
- Assistance for patent purchases, on the condition that a more advanced patent is developed within a certain period.

It is seen that, several (lower level) policy papers included similar targets and measures reflecting these objectives (stated in the development plan) to most extent. In this context, **Information Society Strategy and Action Plan** (ISSAP- 2015-2018) and **National Broadband Strategy and Action Plan** (NBSAP-2017-2020) had some corresponding objectives in their scope.

Preceding the above-mentioned plan, **ISSAP** had very extensive coverage of ICT ranging from competition to adoption policies. Two of the policies specifically targeted improvement of R&D and production capabilities of telecom hardware policies.

- Promotion of Domestic 4G Electronic Communication Equipment: The action steps included determination of a necessary (required) list of hardware for 4G networks, preparation of a comprehensive study related to domestic production of those hardware requirements and lastly provision of (financial) supports for production of the related products on a call-based basis from the R&D fund of MTI (previously Ministry of Transport, Maritime Affairs and Communications).

- Commencing of 5G R&D and Standardization Works: The policy steps started with monitoring, participation of 5G related R&D works in international arena (especially EU) and support for domestic manufacturers to join this type of projects. Second policy covered preparation of a road map by evaluating the effect of incentives (provided to) for the 4G related production of electronic communication equipment. Other one included planning of R&D studies that support the production of 5G electronic communication equipment by the domestic industry with the participation of the relevant parties and allocation of the needed resources. Following and monitoring of the standardization (standards determination) process by participating in international activities represented last policy in this regard.

NBSAP (2017-2020) had also two similar policies namely, *supporting domestic production and R&D activities in the electronic communication sector* and *carrying out R&D and standardisation works related to 5G & beyond technologies.*

- Supporting domestic production and R&D activities: This policy has mainly concerned with monitoring of domestic hardware usage requirements of operators in the sector. Furthermore, the same type of obligations (with increasing domestic content rates) would be used in new authorizations. This category also included promotion of R&D and technological capabilities of domestic firms. Here, another step aimed effective implementation of the criteria and principles for obtaining the software domestic product certificate to increase the usage rates of this type of hardware.
- R&D and standardisation works related to 5G & beyond technologies: This policy has included similar actions to the above stated *commencing 5G R&D and standardization works.* It included preparation of 5G roadmap, following of international R&D projects and participation in some of them, allocation of necessary funds for R&D works. Apart from these, there were some other actions such as following and participation in spectrum & standardization determination works, more active use of 5GTR Forum to coordinate 5G works and establishment of 5G test networks for the use of operators and application developers.

Being one of the leading public actors in the ecosystem, **ICTA's strategic plan (2019-2023)** has put 'Transition to Domestic and National 5G Mobile Communication Technology and Promotion of Domestic Production' as one of the major objectives of the institution.

In this regard, the plan has stated following performance criteria.

- Raising resources allocated to R&D activities within the scope of 5G,
- Increasing the rate of certified domestic products in the investments of operators that are providing 5G services,
- Expanding the number of 5G supported patents and other copyrights developed by universities and private sector organizations,
- Raising the number of 5G compatible domestically made base stations used by the operators,
- Increasing the number of 5G compatible domestic hand terminals used by consumers,
- Conducting regulatory studies that encourage domestic production and producers,
- Publishing mobile broadband spectrum strategy report.

Within this background, some has quantitative targets stated in the annex of the plan as shown in Table-45.

Table 45- 5G related Quantitative Targets (in the ICTA Strategic Plan)

Objectives	2019	2020	2021	2022	2023
Increasing the Rate of Domestic Goods Certified Products Used in Networks to 45%	%15	%25	%45	%45	%45
Increasing Resources Allocated to R&D Activities within the Scope of 5G	---	+%15	+%15	+%15	+%15
Following Preparations of Operators for 5G and Increasing the Number of Applications and Patents on 5G	+%5	+%5	+%5	+%5	+%5
Publication of Mobile Broadband Spectrum Strategy Report	%100				

Source: ICTA Strategic Plan, p,102-103.

In this plan, it can be seen that apart from general objective statements, there are several quantitative targets that are relatively easier to follow (on an annual bases) annually. In the first category, the authority intends to reach 45% of domestic content starting from 2021. It is known that current realization is fluctuating between 20 to 23% rates according to different sources. For this reason, it will be a big step (achievement) to achieve nearly hundred percent increase (i.e., from 20-23% range to 45%) at the end of this year. Next one is related to raising the monetary allocation to the R&D fund. The plan set 15% increase each year to the allocated fund amount. More specifically, ICTA has transferred (to this fund) 966 million TL in 2020 as opposed to 877 million TL in 2019 nearly 10% (9% exact) increase on an annual basis. It is relatively easy to achieve and monitor the implementation of this action but –as discussed below- the real problem lies in the use of the fund. Indeed, the fund has not been used for this object at all. Third action has two parts, one is the following operators' preparations and the other one is related to patent number trends[307]. Last item in this category (that has quantitative targets) is the publication of spectrum strategy[308] to help relevant actors in their (future) decisions with regard to market entry and investment plans etc.

This is a one-step target and achieved after the publication of the report. Although, the completion of the report is relatively easy to accomplish (since one organization is responsible for the preparation of this document and there are no other mechanisms like funding etc.), as mentioned, a summary of the plan has been published after a considerable delay in 2022.

Apart from these papers (and action plans), **TUBITAK** selected ICT as one of the priority sectors[309] for R&D and innovation in 2020-2021 period. Specific topics (of ICT) cover wide-ranging areas. These are 'big data and data analytics', 'IoT (including mobile communication technologies)', 'data security (including cyber security)', 'cloud computing (including virtualization)', 'modelling, simulation and gaming

[307] Putting them in one category seems awkward for the reason that one of them is a general statement and the other one is a more specific subject. It may be argued that companies' preparation levels can be deducted from patent numbers but some other actors (e.g., academicians etc.) may also obtain patents.
[308] This is a one-step target and achieved after the publication of the report. Although, the completion of the report is relatively easy to accomplish (since one organization is responsible for the preparation of this document and there are no other mechanisms like funding etc. As mentioned, a summary of the plan has been published after a considerable delay in 2022.
[309] The other priority sectors are energy, health, automotive, agriculture, food and machine manufacturing.

technologies', 'robotic and mechatronic systems', 'embedded systems (sensors, automotive and machine related applications)'. Furthermore, TUBITAK determines 'micro/ nano/ opto electronics and semiconductor technologies', 'artificial intelligence', 'broadband technologies (including wired and wireless communication and IP technologies), 'photonic technologies', 'quantum technologies', 'software technologies' and 'display technologies' as other priority topics for technology support programs.

In the first place, it can be said that many of the above technologies are related to each other in terms of scope economies. That is to say, one company that work on cloud computing can diversify to data security and data management technologies. Notwithstanding to this and keeping in mind that nearly all these technologies can be used by telco operators, some of them stand out with particular reference to 5G. Here, Broadband technologies category targets development of next generation wireless data networks. TUBITAK also gives examples of project topics that can be eligible for supports as multiple input-multiple output (MIMO) and MIMO technologies compatible with big data, advanced antenna technologies, spectrum access architectures, internet architectures of the future, and resource management for wireless networks suitable for big data. Furthermore, supports for development of user-oriented applications for various sectoral needs (e.g., autonomous vehicles) and innovative mobile apps that are compatible with 5G and later communication technologies are stated in this category. Likewise, software technologies category aims to support works on compatibility of current applications with 5G & beyond communication technologies and advanced application software suitable for real-time data exchange, among others.

5.5.6 Considerations on R&D Expenditures and Public Funding

As mentioned, public organizations together with other stakeholders (e.g., firms, entrepreneurs, academicians etc.) have been continuously trying to establish some degree of indigenous production capability since the fixed telecom era of 1960s.

These efforts initially had been hampered by several factors including privatization of companies (e.g., TELETAŞ) and blocking technology development works of these organizations (i.e., direct procurement of required hardware from international vendors). Due to this discontinuity in technological capability build-up, firms almost completely imported network equipment used in mobile telecommunications infrastructure deployment and operations. Here, it can be argued that there are many factors behind this other than unavailability of domestic products such as cost considerations.

In any case, looking at some other country experiences like Sweden's Ericsson, the importance of having long established telecom technology firms is evident in this segment where accumulated knowledge and technological capabilities give advantages to these firms.

Within this background, public organizations have started with the requirement of R&D centre establishments in the country by global vendors. It is observed in this setting that although these vendors have set up these centres, there is not a publicly available detailed report related to outcomes of these activities up to this date. At the least, one can point out to the contribution of these organizations to human source development in the domestic sector.

After that, procurement obligations from domestic SMEs have formed second step to increase domestic content of network equipment. Here, some of the companies have not fulfilled these obligations in reality as stated previously. What is more complex is the fact that related public organization did not penalize firms for these actions. Finally, requirement of domestic product use in certain levels have constituted third step in this regard. However, the implementation of this regulation is also contradictory, to say the least. Here again, in spite of low achievement rates, it is not known that the regulatory authority has taken any administrative action towards the operators until this date.

In this subject, a journalist (Mr. Şimşek) has strongly criticized the public organizations for not imposing sanctions on operators that failed to comply with the domestic product criteria within the framework of 4.5G tender specifications.

Second point of his critique is focused on the underuse of ULAK Base Stations by these firms, (Şimşek, 2021a). In any case, one can use these allegations to support the regulatory capture arguments mentioned in the part of service sector analysis. Apart from institutional problems, another problematic current issue is the presence of two similar companies that are established by directly public organizations and by indirect public support in the sector. It is evident that the essence of the argument is the use of state funds in an optimal manner. At the start, it can be said that establishment of two companies would reduce the limited sources and may block achievement of scale economies (to reduce unit costs in the long run) from an economic point of view. In fact, GTENT COB (Mr. Kayaduman) actually is in the opinion that ULAK's inclusion in CTC "End-to-End Domestic National 5G Project"[310] (UUYM5G) in the last year of the project led to work sharing instead of cooperation and collaborative work between member firms. What is more, he thinks development efforts of similar products have caused inefficiencies in terms of workforce and time. Moreover, The COB points out the experience of ULAK in the development of 4.5G base stations and add that cooperation opportunities will increase if this firm continues its activities as a private sector company. According to him, countries do not favour state partnerships in telecom manufacturing companies, especially with defence industry relations. For this reason, he asserts that it is very difficult for a company with both state and defence industry connections to export its products to civil telecommunications sector in the world, (Şimşek, 2021a).

At the point reached, it is declared that CTC has developed four basic products including 5G new radio (hardware part of base station), radio access network (software part of base station), 5G core network (communication system management) and radio-links (connections between different components) along with virtualization and management systems. However, it is not known exactly at which stage are these products.

At least, they have performed some product (prototypes) demonstrations in June 2021 related to interoperability of 5G base stations with the existing 4.5 networks and (foreign-based) base stations together with usage of 5G controlled drones and robots in emergency- situations, (Vatan, 2021).

Here, the problematic issue in terms of our purposes is that there is not much

[310] Uçtan Uca Yerli ve Milli 5G Projesi (UUYM5G) in Turkish.

information about the current production levels and capabilities of the company. As stated before, almost single publicly available quantitative indicator (for showing the level of domestic equipment) has been the number of base stations since the foundation of ULAK and we do not have such kind of information for GTENT. On the other hand, the COB asserts that they are starting to make bids in 5G tenders abroad. When talking about product commercialization and foreign trade (i.e., exporting), another essential tool that comes to mind is patent activities of technology companies. As discussed in foreign country cases, telecom hardware companies (in essence, ICT firms taking into account different branches of them like Samsung consumer electronics, telecom and computer components etc.) compete in various dimensions starting from R&D and innovation. One of the most crucial outcomes of these works are undoubtedly the extent of patent activities. For this reason, any firm that obtains more patents than its rivals gain competitive advantage in the sector[311]. According to Pohlmann (2019), companies that have extensive number of patents will become prospective technology and market leaders in the sector. Additionally, firms with standard essential patents can demand royalty fees from beneficiary enterprises, further increasing their market revenues, owing to the central role (crucial) of patents, it is paradoxical to observe that there is not much patent activity found (in fact not exist) in our recently founded 5G hardware companies.

Notwithstanding to this, the COB (of GTENT) argues that there are other ways to protect intellectual property rights including open-source code development and academic articles.

Nevertheless, it is understood that they have been preparing some patent applications but he also states the fact that a patent application process might take 3-4 years to finalize in the end.

All these discussions lead to another indispensable element of the IS, i.e., R&D

[311] The role of patents in the sector have been discussed previously, so here it is sufficient to re-emphasise by giving few quantitative examples from 5G technology race. Though there are different patent types and classifications, it is sufficient to look number of declared 5G patent families to see the extent of global vendors' dominance in the field. In this category Huawei (3.325), Samsung (2.846), LG (2.463), Nokia (2.308), ZTE (2.204), Ericsson (1.423), Qualcomm (1.330) have more than 1.000 patents and occupy the first position, (IPlytics Platform, Nov., 2019).

intensity requirements of the industry. Again, we have seen that global vendors have allocated considerable amount of their budgets (revenues) to R&D and innovation activities[312]. On top of that, these companies' governments have supported their efforts by various means, e.g., Chinese government extensive range of policies and EU's support policies along with publicly funded 5G projects etc. On the other hand, our sector firms' R&D levels and public funds are low as compared to the above-mentioned country examples.

R&D Expenditures of the Actors: It is known that Türkiye as a developing country aims to increase her technological capabilities by raising R&D expenditures almost in every sector. Within this perspective, although there has been increase in R&D efforts, these achievements are not uniform or equally satisfactory in each sectoral setting. Without going into macro figures, it can be stated that the bulk of these amounts belong to a few sectors. In parallel with the ascending status of defence industry due to both its strategic and foreign trade (in terms of exporting) roles, R&D levels of this industry has surpassed other sectors of the country, in recent years. Indeed, defense sector companies made up nearly 66% of the total R&D investments of the first 50 companies in 2021, increasing from approximately 61% in 2020.

It is remarkable that second largest sector in terms of R&D spending is Automotive and its supplier industry with 12,5% share in the top 50.

Afterwards, white goods and electronics companies have 5.5 %, and pharmaceutical companies comes with 1.6% shares in the total. It should be stated that telecommunications and software has nearly 10% (9% exact) share in this list, as well, (Turkishtime, 2021).[313]

Within the context of software and telecom sector, it is seen that R&D expenditures have been increasing owing to accelerating impact of digitalization in every sector,

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312 Since these topics are evaluated previously, only some R&D spending examples can be given here to indicate the magnitude of these expenditures. According to NASDAQ, Huawei has spent 22.04 billion USD on R&D, which is 15.9 % percent of its total revenue in 2020. Similarly, Samsung has allocated 18.75 billion to R&D, which is 9 percent of its sales in 2020, (Bajpai, 2021).

313 This percentage is calculated by choosing firms that have telecom and/or software words in their titles. These are, Turkcell, Turk Telekom, Huawei, Logo, Netaş, ARD, Netrd, Karel and Global. It should be noted that other firms like Aselsan have considerable amount of software related works/projects, but they are categorized in defense sector.

starting from ICT itself.

What is more interesting is the fact that telecom service providers' R&D investments are increasing as compared to previous years. Although these developments can be considered as positive trends, they are certainly not enough in terms of international comparisons and on a relative basis. In fact, Özözer (2021) has pointed out negative real growth of R&D spending in private sector, if defence industry R&D spending is excluded from the overall picture[314]. Here, it should be mentioned (again) that difference between various segments of ICT is getting more and more blurred due to convergence.

For this reason, it is very difficult to identify which firms' R&D belong in which part of ICT in some cases.

In any case, Table- 46 below gives the spending details of main companies with the information about their R&D activities mainly in telecom sector[315].

Table 46- Telecom Firms (in the 250 most R&D spending list of 2021)

Rank	Name	R&D Exp. (000 TL)	R&D Personnel	Brief Summary
4	Turkcell Technology R&D Inc.	680.910	1216	Business Intelligence (e.g., Big Data), Customer Relations (e.g., Call Centre applications), infrastructure and digital services (messaging services like BIP, payment systems), 5G related applications.
14	Turk Telekom	273.817	NA	Big data, data visualization, data mining, Next Generation Communication Services (e.g., 5G, M2M, Cloud, SDN)
15	HUAWEI	270.011	708	Software development for 5G terminal equipment and mobile service applications etc.
21	NETAŞ	141.421	626	Telecom hardware, IoT, mobile applications (e.g., energy management

[314] In essence, most of the R&D spending came from five companies that are owned by Turkish Armed Forces Foundation. Apart from the considerable weight of these firms (and this sector) in total picture, there are other problems in this context like need for more emphasis on strategic thinking etc, some of which are discussed in the next chapter.

[315] The scope covers selected firms if they have 'telecom' word in their titles or if they have directly telecom related software R&D. It should be noted that even a cyber-security software can be included in this category, but it is assumed that these are not directly related to our topic of interest. In any case, larger R&D spending companies have broad categories both related to telecommunications and other areas of ICT.

Rank	Name	R&D Exp. (000 TL)	R&D Personnel	Brief Summary
				and water management, meter reading)
36	KAREL	66.464	220	PBX, Routers and mobile service applications, IP products etc.
42	GLOBAL	53.316	222	Digital platform and services (e.g., artificial intelligence and robotic process automation-based business models)

Source: Turkish Time ARGE 250

As one of the central actors in mobile telecommunications sector (in terms of both service provider and buyer of hardware), Turkcell is further expanding its position by diversifying into related areas of ICT and increasing R&D spending in recent years[316]. Turk Telekom is the second most R&D spending company in telecom sector, which also attained 14th position in the corresponding list.

It is known that the company founded the country's first mobile operator R&D centre (TT Mobil R&D Centre) in 2010.

After the merger of Türk Telekom, TT Mobil and TTNet brands, all R&D activities in these companies were combined under the umbrella of Turk Telekom R&D Center, as of May 2016[317]. The third telecom company in the list (15th position) is -hundred

[316] The company has participated in several EU funded R&D projects and programs including Horizon 2020, Eureka, CELTIC and ITEA, all of which are focusing on topics such as telecommunications, new media, future internet and related software applications. Turkcell also collaborates with SMEs, Start-ups and research centres in the domestic market to develop new services/products. Apart from these activities, the firm has been supporting PhD projects with partner universities since 2014. These efforts lead to increase in patent activities and the company climbs to the first position with 114 (177 in 2020) patent ownerships in top 50 according to the number of patents received in the R&D centre list (2021). These numbers also reveal the company's determination to protect the achievement of its R&D outputs as well. Turkcell group has another company, 'Turkcell Global Bilgi' that enters top R&D spending companies list. Additionally, the company occupied 29th position in the number of undergraduate and postgraduate employees at the R&D center category with 43 employees in 2021.This firm has mainly concentrated on call centre services[316]. Due to its development activities, Turkcell Global Bilgi expands service areas ranging from artificial intelligence and robotic process-based automation, cloud-based switchboard infrastructure, digital assistant and self-service information technologies technical services, along with research, social media and customer experience management, (Turkcell Teknoloji, n.d.).

[317] The centre has carried out 19 EU and 16 TUBITAK projects ranging from big data to new generation communication services in the last 5 years. In the last year, it published 25 scientific papers and made 116 patent applications resulting from projects carried out in cooperation with other R&D centres, SMEs and universities. Like the leading operator (in this field), Turk Telekom has also participated in several international projects, coordinated by EU like Eureka and H2020 programs. Apart from multinational R&D and university R&D collaborations, the company established an incubation centre to provide technical and commercial mentorship to entrepreneurs in 2011. As an example of outcome, it is stated

percent- foreign owned Huawei with nearly 270 billion TL in 2021. It is known that the vendor commenced its operations as early as in 2002.

Huawei R&D centre director (Hai, 2020) state that they have invested 665 million TL and over 1.500 engineers have worked since the establishment of the centre. If we take into account the fact that there are over 600 people working there, it can be said that the company- at the minimum- has contributed to the human source enhancement of the sector[318]. On the other side of the coin, this establishment and organizational activity is a part of global strategy of the company. Huawei[319] has a presence in all parts of the world with 17 R&D centres and through acquisitions of local ICT companies in several countries. Here, Chen et al. (2011) have classified R&D internalization strategy of Huawei (also applicable to other global Chinese firms) into three stages. The first stage covered establishment of technological alliances with the leading foreign ICT firms like Motorola and Lucent.

Second stage is more about identification of innovation resources and foundation of R&D units in different countries. The third stage has focused on market expansion of the company on a global scale. Accordingly, the company has started to increase overseas presence in the countries that have business relations. In other words, Huawei aims to be in a better position to respond different country demands and market conditions with overseas presences.

Netaş, as one of the most important and oldest actors in the history of sector, has attained fourth place among the most R&D spending telecom firms in 2021.

In parallel with its history, the company has a broad range of research and development topics including broadband communication technologies, cyber security, defence

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that three firms that graduated became the suppliers of Türk Telekom Group. In addition, cooperation/projects with six out of eight companies and three partnered TEYDEB projects have been completed as a result of incubation activities, (Türk Telekom, n.d.).

[318] In more detail, the firm has three separate divisions including R&D, Training (Academy) and Customer Solutions Innovation & Integration Experience Centres. The R&D centre mainly works on software solutions for ICT. According to Mr. Hai, outcome of these projects has been used in other country markets (i.e., 40 corporate customers in more than 30 countries) bringing 280 million USD foreign exchange inflow to Türkiye. Main R&D areas cover advancement of software, e.g., software for 5G terminal equipment and mobile service applications.

[319] It should be reminded the company has 105.000 R&D employees and (R&D) expenditure of 141.893 million KNY which is near 22 billion USD in 2020. (https://www.huawei.com/en/corporate-information/research-development)

communication technologies, cloud computing, multimedia, big data analytics, internet of things (IoT), virtualization, optical ethernet and voice over IP (VoIP) systems[320].

Apart from these achievements, (what is more interesting for our topic is that) some of the developments concerning the company might have different implications for the sector. As indicated in the previous part, one of the largest telecom hardware producers, ZTE has acquired 48,04% of the company. Furthermore, as a more recent event, Orion Innovation (a USA firm) bought subsidiary company of Netaş called NetRD for 9.2 million USD in 2021. In this subject, CEO of the Netaş (Mr. A.E. Eren) commented that they had two R&D companies and sold one of them and would continue to develop solutions and products for information and communication technologies both at home and abroad in the other one. He added that they would also accelerate their localization efforts, from which they have saved 4 billion dollars for Türkiye by producing the technology in the country, (Haber Turk, 2021). In fact, the annual report of the company puts equipping Türkiye's ICT infrastructure with domestic products as one of its main missions[321].

Notwithstanding to these developments, one may have some doubts about the foreign based acquisition of these domestic companies by looking into history of the sector (e.g., TELETAŞ case and recent experience of Turk Telekom's privatization).

In this respect, Mr. Şimşek criticizes the sale of Netaş to ZTE and argues that government should not have approved the sale of the company. Relatedly, he asks the

[320] In general terms, the company has similarly participated in many national and multinational research projects and it has a member of ULAK consortium. Netaş's patent applications since 2012 has become 506 and its registered patents reached 117. Having made nine trademark applications in 2020, Netaş has made 134 trademark applications since 1984 and its registered trademark increased to 59, (Netaş, 2020).

[321] For this end, the report continues by emphasising that NETAŞ has performed several important projects related to localization from telephone exchanges to the first domestic 4.5G base stations, positively affecting the foreign trade balance of the sector. As a more recent development, Netaş have started to adopt ZTE's (main shareholder) technologies beginning from 2019. In this context, the company obtained a 'domestic product' certificate from Istanbul Chamber of Industry for the FTTx fiber infrastructure systems[321] produced in its (Istanbul Orhanlı) production facility. Netaş is currently continuing localization efforts with ZTE's VDSL Modem, Fiber Modem (Home Gateway), Rack Type Server (for virtualization and big data applications) equipment, (Netaş, 2020). ZTE equipment is produced locally to provide fiber-speed internet to both residences and businesses. X is variable and farthest from end user FttC (Fiber to the Cabinet) equipment positioned provides the least bandwidth and FttH (Fiber to the Home) can give the highest bandwidth. The bandwidth that can be provided to the FTTx end user is continuing to increase due to advances in these network infrastructure technology components.

question that *“Why should Chinese who bought the Netaş support the ULAK who is in a rival position?”* Instead, he continues by saying that (relevant) public authorities could have made it possible for a Turkish company to buy this firm, (Şimşek, 2021b).

Starting from the fifth position (of Table- 46), the R&D budgets of telecom companies has begun to reduce below 50-60 billion TL range as opposed to 150 billion range of the fourth position. Here, Karel has allocated nearly 66 billion TL to R&D in the last year, (Turkish Time, 2021). Being one of the oldest domestic telecom company, Karel has developed various telecom equipment mainly PBX exchanges, telephone sets and GSM routers since 1986. In parallel with convergence, the company has begun to produce IP hardware (IP phones etc.) and diversified into telecom services like vehicle tracking systems and cloud solutions.

The company puts greater emphasis on R&D since they believe competitiveness (of the firm) depends on capabilities of developing new technologies and adopting them to marketable products/services. Indeed, they set apart 10% of their turnover to R&D with 187 people working in this department. What is more, the firm does not have any license or knowledge dependency (on foreign companies) and stresses the importance of this fact in its web site, (Karel, n.d.).

Further proceeding to outside first 50 companies (in terms of R&D intensity), related expenditures of these firms range between roughly 7 and 30 billion TL. Their R&D areas are mainly in software related ICT topics such as geographic information systems (e.g., Başarsoft), digital platforms including B2B procurement and human resource management systems (e.g., Sabancı Digital), hotel management systems (e.g., Protel), hospital management systems (e.g., Akgün), to name a few of them. Many of these firms have broad range of interest in mainly software part of ICT.

In fact, they are diversifying their operational areas in the vast array of digital services (e.g., cyber security, digital platform development, AI solutions etc.) thanks to continuing convergence in ICT. Apart from this, it seems that hardware related R&D activities of these firms are very few compared to software part.

Among the very few exceptions, Prysmian Group stands out with its focus on many types of cable products such as fibre, copper and antenna, among others. It is worth noting that the company in the country belongs to foreign group that has presence in 50 countries with 7.5 billion Euro sales volume, (Prysmian , n.d.). Lastly, the case of Alcatel- Lucent that bought TELETAŞ is striking for the fact that the company is only in the 89th position with 27.1 billion TL.

Without going further into each of these (relatively smaller) firm R&D details, it may be useful to summarize some points. First of all, it is evident that although sector players have put increasing importance for R&D, the level of these expenditures are obviously very low compared to international players that aim to dominate mobile telecom infrastructure markets globally. Secondly, and in parallel to the first one, patent numbers of the sector are also very low against the global vendors that are competing with each other for technology leadership and dominance in this area. Thirdly, some experts point out the structure of R&D expenditures and indicate dominance of product development activities (PD) as opposed to basic research and technology development efforts.

Although PD activities are beneficial and bring positive economic contributions along with business model innovations', it is evident that these activities cannot carry this sector to the forefront of technology race in the long- run. As a further downside of the argument,

Özözer (2020, p. 224) emphasise that domestic companies are integrating existing foreign technologies into their products and at the same time put these expenses in R&D category to benefit from (state) incentives like tax exemptions etc.

On the other hand, this practice also benefits state figures related to R&D expenditures and gives more positive picture in this regard.

Fourthly, most of the firms' R&D areas cover software developments in various segments of ICT, not necessarily limited to telecommunications. Fifthly, foreign companies have entered in the sector either buying already present domestic firms or establishing their own local R&D organizations.

As it is seen, some of the privatizations have still been criticised for negative consequences in terms of curbing indigenous technological capabilities among other problems. On the other hand, it can be argued that foreign investment has several benefits to the economy such as contribution to the human capital and to the balance of payments etc.

Without going into details, taking into account the fact that foreign investments are both inevitable and needed, one can emphasise the role of institutional structure in controlling these activities. In other words, an institutional structure should be transparent and conducive for foreign investment but at the same time should provide safeguards for possible abuses of market power and mismanagements, e.g., Turk Telekom's privatization process and resulting situation.

Funding and Incentive Mechanisms: As seen in the historical evolution of the sector, state organizations have begun to see 5G as a specific area that needs to be supported by various incentive mechanisms, starting from the establishment of ULAK project (and Company) and the foundation of CTC cluster. Apart from this, it can be said that each firm can benefit from several supports within the incentive framework of the country.

In other words, any firm that produce equipment and/or develop (and sell) ICT services may apply for different type of incentives while those companies in the specific cluster also obtained funds given by TUBİTAK with the cooperation of ICTA (for a specified time period).

In this context, it should be mentioned the country's incentive system has many organizations and institutional settings in various categories. Even, it is difficult to specify each organization that has a role in this framework.

One can group them mainly into investment, export and R&D categories [322]. Investment incentive system has four main pillars namely regional incentives, promotion of priority investments, strategic investment incentives and general type of incentives.

Here, VAT exemptions, VAT returns, custom tax exemptions, tax reductions, interest support, provision of investment location (area), income tax withholding, insurance

[322] Although one can add specific headings like environment and energy, employment supports, these are the main categorizations and, in most cases, include specific incentives like energy supports and reimbursements.

premium support and insurance “premium employer share support” are the mechanisms used depending on incentive categories.

In addition to these, relatively new programs ‘Attraction Centre’ and ‘Breakthrough Programs’[323] have been implemented in this category to support specific projects. These programs include above incentive mechanisms as well as capital, energy and qualified personnel support, public procurement guarantee, R&D and hardware related expenditure reimbursements.

For instance, ‘call centres’ and ‘data centres’ benefit from attraction centre programs by obtaining energy support, VAT exemptions, corporate tax reductions (deductions), insurance “premium employer share support”, provision of investment location, interest reductions and other type of tax exemptions such as stamp duty and building tax exemptions, construction fees, (MIT, n.d.).

As another main incentive category, export supports cover all segments of this activity. Relatedly, it starts with preparation (for export) stage and includes P&D supports.

Marketing stage has a number of support mechanisms such as market research, foreign market entrance related supports (e.g., provision of overseas units and promotional activities), participation in domestic & overseas fairs and export credit insurance supports.

Being the last one, branding phase consists of design support and brand-Turquality programs that provides reimbursement of several operational and marketing expenses, among other benefits, (ISO, 2018).

R&D supports have similar components like tax deductions/exemptions and financial aids (grants). In the same way, there are more than one responsible organization in this field. To start with, main source of funding for R&D expenditures is TUBITAK (Scientific and Technological Research Council of Türkiye) in the country. If companies’ projects are approved by this organization, they become entitled to grants and reimbursement of their expenditures of their projects. In fact, there exists an extensive array of supports under the name of ‘TEYDEB- R&D and Innovation

[323] “Hamle Programı” in Turkish.

Support Programs'. These programs target all levels of firms from start-ups, SMEs and to large- scale companies.

They have names like 'venture capital support program', patent support', 'SME R&D', 'Industry R&D', 'Priority areas R&D' and 'International Industry R&D', to name some of them. As it is seen, CTC cluster obtained 253 million TL 'Industry R&D' support from this program involving reimbursement of personnel, hardware, software and R&D expenses up to sixty percent of the total amount.

KOSGEB also implements R&D and innovation (support) and industrial application programs encompassing rent, personnel expense, seed capital support and project development supports, e.g., advisory, educational, promotional activities, participation in fairs etc. These are in the form of reimbursement of these costs between 75 and (up to) 90% of the expenditures depending on the availability of domestic product certificate, (ISO, 2018), (TUBITAK, n.d.). In addition to these[324], MIT[325] has devised 'techno investment program', 'R&D and design centre support', 'cluster support', 'technology development zones support', 'pre-competitive phase cooperation support'. R&D centre supports are becoming increasingly important for telecom firms in recent years along with call and data centres.

Nearly all major telecom players have already established this type of centres and receiving tax deductions/exemptions depending on the category, e.g., up to 100% for R&D taxes, stamp and custom duties.

On the other hand, MTI's R&D funds are different from the above-mentioned ones in that this fund is supposed to be used in related areas of this Ministry. In this context, Decree Law No: 655 (Article 40) specifies the sources and uses of this support mechanism.

Accordingly, ICTA makes revenue transfers to this fund four times in a year (quarterly). For instance, ICTA has transferred 966 million TL in 2020. At the same time, the Authority is required to submit its opinion related to primary subjects (in the

[324] There are several other organizations to mention in these (R&D and investment) categories like Development Agencies that provide financial (interest, interest free loan support, direct financial support) and technical support programs. https://www.ankaraka.org.tr/tr/teknik-destekler_38.html
[325] Ministry of Industry and Technology

electronic communications sector) that needs to be supported in the form of annual reports.

This article also enables use of this source for aviation and space technologies R&D projects. However, there is no information related to use of this fund for electronic communications sector, up to now.

In this respect, CTC board member (Mr. Bağören) has also drawn attention to this potential source for financing, in which 3 billion USD accumulated (according to him[326]) but not used for years, (Kaya, 2019). In fact, one can find some uses of this fund for aviation and space sectors as indicated in the annual reports of the Ministry.

This report states that close to 5% of the total amount has been transferred to Space Agency's budget and 0,02% (of the total) has been allocated to expenses of personnel who attended Turksat 6A project meetings, (MTI, 2020b, p. 76). Hence, it is evident that one of the important sources of finance has not been used for electronic communication sector R&D purposes, in spite of the fact that mobile telecom technologies necessitate more supports than currently available levels.

5.5.7 Concluding Remarks & Assertions

This chapter has attempted to analyse historical developments and important actors in various perspectives. Without making much repetition, it can be said that sectoral liberalization process that started with high expectations, has not brought in relatively successful outcomes. Starting with problems in the early period of mobile telecom operators (Telsim and later Aria), privatization of Turk Telekom failed to bring intended outcomes. What is worse, the company again transferred to public ownership with some financial losses encountered due to foreign holders' previous operations. In addition to that, the biggest company in mobile sector (i.e., Turkcell) encountered ownership struggles for a sometime, before falling into state control (i.e., the Wealth Fund) until recently.

At the point reached, sectoral competition in different service segments have not been developed as compared to other country (especially EU member countries) levels. As shown in this chapter, alternative ISPs market shares (excluding dominant actors) has

[326] Please note that this is not an official figure.

not increased above 15% in broadband internet services segment. In mobile telecom services segment, three operators have shared the market and alternative services such as MVNOs has not been implemented at all.

As another internet access method cable TV segment could not be opened to competition and has also not achieved widespread coverage during this period. Apart from competition concerns, technology composition of broadband networks constitutes another problematic area of the sector.

That is to say, fiber access coverage of the country has remained below developed country levels and more crucially, it is regarded as an inhibiting factor on the eve of 5G transition of the country.

It is widely discussed also in this study that, mere access to basic internet is not adequate for successful digital transformation of any country at this stage. In this context, there exists various problems as well. It is also indicated that the bulk of subscribers are still in moderate internet speed categories and international comparisons in terms of speed etc. show relatively backward position of the country.

Analysis of regulatory attempts to increase production capabilities of the sector constitutes another part of this chapter.

It is known that policy makers have been talking about achieving ‘point to point domestic and national mobile telecom network’ production capabilities before passing to 5G technology.

Nonetheless, it seems that the sector is far from achieving this objective in the near future, without speaking the economic feasibility of 100% domestic production rate.

At this point, especially recent regulations have been evaluated to focus on current problems of the sector.

Owing to the importance of the sector, there are many strategy and policy papers and the chapter has examined them to observe objectives and priorities of the public organizations. According to this analysis, several main topics has come to the forefront, which is also the subject of the next chapter. In other words, it is seen that many of the priorities and sectoral targets, which can be found in these papers, have not been solved and/or reached yet and these are still in the agenda of sector actors. In essence, main findings of this chapter have been summarised in the form of, what can be termed as, assertions that are shown in Table- 47.

Table 47-Assertions of the Study

A-1: Although the sector reform model has been largely adopted from EU legislation, the resulting outcome is not satisfactory as compared to this framework. In the current institutional setting, there exists conflict of interest problem and redundancy of organizations that lead to inefficiency and unnecessary time delays. **A-1.1:** There exists overlapping functions between organizations causing some problems like time delays in solving market problems. Accordingly, organizational framework should be revised to establish a more simple and efficient structure. **A-1.2:** The regulatory structure of the sector should be revised to ensure regulatory independence.
A-2: Existence of multiple policy papers that share similar topics lead to follow-up problems. Furthermore, unavailability of post evaluations (follow-ups) has further reduced the effectiveness of such documents.
A-3: The number and coverage of publicly available regulatory impact analysis should be increased to evaluate costs & benefits of related regulations.
A-4: The interactions between public agencies and sectoral associations, non-governmental organizations should be increased to establish a more participatory institutional framework.
A-5: Location based regulations should be implemented to better address market problems given the fact that there exist differences across regions in terms of competition and availability of infrastructure etc.
A-6: The usage of universal service fund should be more transparent and made available for public on regular bases.
A-7: Underutilization of Cable- TV network is one the important reasons for a market failure in terms of competition and access coverage.
A-8: Insufficient fiber coverage (infrastructure) is presenting another market failure and is inhibiting the performance of communications services in terms of speed, latency and user experience. The problem will be more severe after the start of 5G if there is not any progress made until launch date.
A-9: There will be three operators in the 5G auctions and the market will continue to be dominated by these operators (irrespective of their ownership structures) in the near future. **A-9.1:** Although not a completely new market, 5G can provide opportunities for future market developments.
A-10: 5G auctions should be used for increasing domestic production capabilities of the system. **A-10.1:** These mechanisms should be more transparent and implementation process should be followed by public.
A-11: Instead of aiming domestic production of all components of 5G networks, the sector should prioritize specific segments and production of related hardware and software equipment.
A-12: Public procurement and adoption of usage cases developed by domestic firms should be prioritized to increase indigenous production capabilities.
A-13: Co existence of similar organizations, some of which are owned by operators and one of them is a public company, result in inefficient use of scarce resources.

These assertions have been derived from the observation of the historical development, examination of policy papers and analysis of market development trends.

The numbering of these assertions generally follows this chapter order. Notwithstanding to this, the findings indicate the fact that one can consider failures in the working of regulatory framework as the fundamental reason for the current outcome of the sector.

The chapter has found numerous factors that lead to inefficient working of this structure, as well. It is seen that although some kind of appointment mechanism had been established in the early days of regulatory authority, this was not complied with in practice.

At the point reached, there is no specific criteria left other than general civil servants appointment specifications. It is obvious that, this situation is not compatible with one of the essential tenets of the regulatory framework, i.e., independence of regulatory authorities.

What is more striking, many of the executive officials of the two biggest companies, one of them has still owns the backbone of the fixed internet network, currently comes from public organizations.

Indeed, one official currently represent both related ministry (i.e., deputy minister) and this company (i.e., chairman of the board of directors) at the same time.

Other than conflict of interest problems, examination of policy papers and other sources indicate inadequate levels of adherence to, what can be called, good governance principles, such as transparency, accountability and efficiency, among others. Passing to other assertions, many of them are related to (or caused by) this deficiency, in a sense. As will be seen in the next chapter, most of the participants also think that other problems stem from this setting. It is observed more than one place in this chapter that most of the topics, project and problematic areas have already been identified by sector actors and also in policy papers. These are all covered by assertions in several areas ranging from lack of regulatory impact and follow up analysis to non-participatory decision-making process and inadequate, non-transparent implementation, inspection mechanisms. Briefly (and without making much repetition since these are well covered in this chapter), the study has found that various projects, topics had been included in successive policy papers and while some of them were completed, there were considerable time delays in comparison with planned (completion) dates.

It appears that costs in terms of ‘time delays’ have not been taken into account by policy makers in spite of assertive statements like telecommunications sector is a dynamic one and requires quick decision making and implementation. In fact, some of these are stated in assertions like showing underutilization of Cable TV as one of the reasons for market failures, in terms of competition levels. Here, starting from privatization of Turk Telekom, there has been many attempts and policy proposals to more effective usage of this network but the current situation is far from satisfactory. It is important to notice that, sector actors seem to lose their interests in this topic due to these long-time delays after all.

Similar arguments have also been made (in this chapter) in the availability of fiber coverage topic that is even more critical for 5G transition as discussed in this part. It is shown that, in spite of the importance (at least in policy papers, speeches etc.) given to this issue, several projects and attempts have also not achieved intended results so far. In fact, these unsuccessful attempts (especially failure to establish a joint infrastructure company) along with the privatization failure (resulting situation of Turk Telekom with financial losses) can be seen among the most important problems in recent history of the sector.

Although some factors that played roles in unsuccessful attempts of establishing a joint company has been discussed with the interviewees, a more detailed analysis of these issues would fall within the field of political economy and beyond the scope of the study for this reason. In other words, it can be said that although the research has reached some findings regarding these, it does not explain why these failures occurred and they can be regarded as research gaps of the study. On the other hand, the research shows the essential role of licence policy in the transition of a new technology. Together with the assertion that 5G can provide new opportunities, the study has examined how some tools can increase sector performance and market competition.

As an example, while new types of licences can bring more innovative usage opportunities to the market, ensuring MVNO entry (in the market) can increase (market) competition in this period. At the end, all these findings indicate a need for a well-planned preparation period before introduction of 5G technology in the sector.

These assertions and related discussions (in the next chapter) also answer the reasons for not choosing an immediate market introduction (i.e., why) and put forward some mechanisms and policy tools to prepare (i.e., how) for this technology, market transition.

In sum, this chapter has provided main discussion points for the interviews, which are made by various sector actors in the next chapter. Coupled with analysis by using policy papers, journal articles and statistics, it is aimed to further shed light on these assertions by taking experts views and considerations in the next chapter.

Afterwards, the study provides several policy recommendations from all these analysis in the end, as well.

CHAPTER 6

6. EVALUATION OF SECTORAL PROBLEMS & ASSERTIONS

6.1 Introduction

Before starting to discuss the assertions and problems in the context of main sectoral functions, it should be mentioned that topics such as sectoral boundaries, main actors, historical developments etc. are not repeated as they are dealt with in the previous section. Notwithstanding to this, some of them are revisited and analysed in a more detailed manner whenever they are deemed necessary. In line with the approach taken, the analysis proceeds with service provision and equipment production segments of the telecom sector separately. This does not mean that there are no relations between these segments. Among other relations, firms have producer-user interactions to continuously monitor and upgrade their products/services in a common regulatory environment, (Figure- 38). Besides, main functions of market workings are evaluated along with the findings derived from historical and literature analyses.

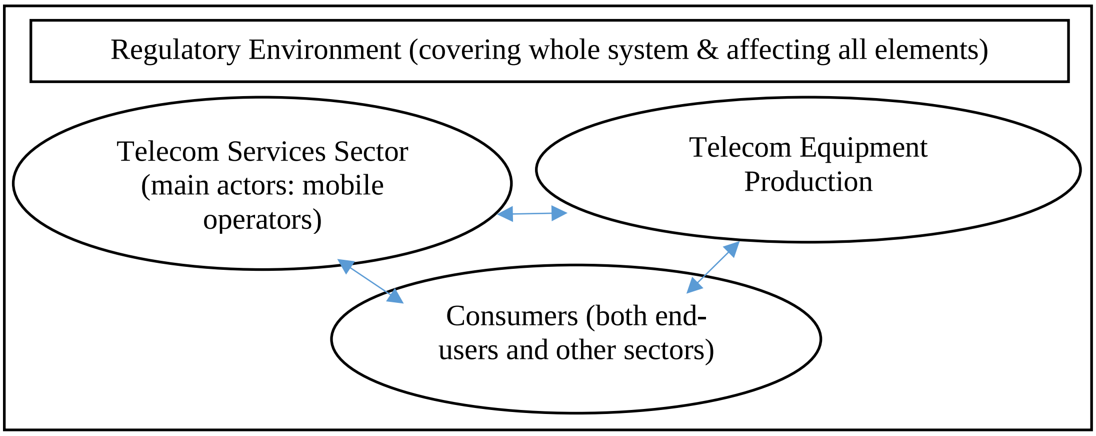

Figure 38- Interactions between Actors

It should be noted that services sector can be regarded as a leading market in this case, as well as in other countries (even including several developed ones). As can be observed from the case studies that are mentioned in the study, although most countries established telecom networks that have more or less nationwide coverage, few of them have managed to use their domestic sector products in construction of their infrastructures. By now, it should be evident that use of domestic products has a general meaning since a telecom network consists of wide variety of components ranging from more critical parts (e.g., advanced 5G base stations) to maintenance equipment like batteries, accumulators and even simple construction items. At the minimum, whether it is constructed by domestic means or not, importance of having and maintaining a widespread and efficient telecom network is further increasing due to recent developments like Covid pandemic and other natural disasters. In fact, major earthquake that occurred in the southern part of the country showed vital role of resilient communication infrastructures in emergency situations.

In this context, the study proceeds with the analysis of telecom services sector with particular emphasis on the observed problems and derived assertions in the previous part.

6.2 Telecom Services Part

The evaluation has followed main market functions as stated in TIS framework. It should be noted that different market structures have different problems depending on their characteristics and development levels. Moreover, some topics can be analyzed in more than one functional category.

As an example, availability and use of public funding mechanisms might be examined in entrepreneurial experimentation for supporting market entry, guidance of search for indicating public organizations’ objectives and resource mobilization categories for observing priority level and allocation of resources to particular sector, as well.

6.2.1 Market Structure and Formation

As in most other countries, mobile communication services and various forms of internet access (e.g., cable, fiber etc.) have permeated almost all segments of socio-economic life in Türkiye.

The most recent statistics show that mobile telecom penetration rate (PR) has nearly reached to nearly 115%, meaning there are more subscriptions than the whole population of the country. On the other hand, fixed (broadband) internet PR has increased 22% according to latest figures. More specifically, being a more prestigious international statistic, fiber (internet) penetration rate has approached to 7% levels. These indicators alone show the prevalence of these services in the country but there are still problems in terms of (what can be called) more effective provision of them.

Table 48-Comparison of 11th Development Plan vs Current Levels

Rates (%)	2022**-Realized	2023 Targets	OECD Av.***
Mobile Broadband PR	85	100	128,2
Fiber PR	6,7	11,5	35,88
Internet Usage (Women)	80,9	90	NA

Source: 11th Development Plan, ICTA Quarterly Reports and OECD Broadband Portal
(*) Excludes UN Cyber Security Index Ranking Target, (**) As of 3rd quarter, 2022, (***) As of June 2022.

From the above Table-48 and corresponding statistics (mentioned in the previous section), it can be said that fiber connection rate of the country remains far below the OECD average and there is high probability that the current plan's target will be difficult to achieve in the remaining one-year time.

Apart from mere access indicators, it is clear that more refined statistics such as broadband internet speeds and affordability issues have coming to the fore among countries that aim to fully utilize digitalization in their economies.

As it is discussed average internet speeds (of the users) in the market is far below international figures, though there is no available OECD statistics in this category.

Indeed, several statistics related to this category all show the unsuccessful (negative) performance of the sector.

For instance, Speedtest Global Index[327] ranks Türkiye as 70th in the mobile broadband category of 137 countries (with 30,28 Mbps) and ranks her as 107th in the mobile broadband category of 180 countries (with 32,65 Mbps). Similarly, Wisevoter puts her in 91st position among 176 countries with 64,52 Mbps average internet speeds[328]. On

[327] https://www.speedtest.net/global-index
[328] https://wisevoter.com/country-rankings/internet-speeds-by-country/

the other hand, average costs of internet access are even more difficult to compare due to numerous tariff packages in different countries. At least, one comprehensive survey puts the country in 18th position among 219 states[329]. However, this site calculates these costs by taking exchange rates and not adjusting purchasing power parities and (if taken into account) this may change the relative position of the country.

From user's perspective, mobile telecom and internet provision related quality of service and coverage issues make up the categories with the most complaints in ICTA's quarterly reports. Related to this topic, several interviewees[330] (e.g., Int.3-4) argue that mobile operators' coverage rates (related to 3 & 4.5G services) are not satisfactory and criticize the regulatory authority for not giving official coverage rates of these services given by mobile operators. In fact, and not only related to this topic as well, general consensus among the participants (observed during discussions) is the need for more comprehensive data provision by ICTA.

Coupled with the analysis in the previous section, it is evident that there exists a huge market and demand for both forms of internet access and mobile telecom services, on the eve of 5G services introduction in the market. Nonetheless, there are various problems related to access and availability. Firstly, internet access speeds are low compared to other developed countries and people criticize these along with higher costs of upper-level internet access categories.

Secondly, coverage rates are not available and people complain about inadequate quality of service.

These issues, in turn, point out the need for network investments if sector actors want to achieve better coverage and quality of service targets in the medium term. In addition to existing investment requirements, operators that will be in the market with 5G offerings have to undertake considerable amounts of infrastructure expenditures after obtaining necessary licenses, without even mentioning potential 5G auction fees. This, in turn, leads one to look into supply side of the existing market structure. Indeed, some participants (e.g., Int.3) complain about low ARPU levels of the market as one

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[329] https://www.cable.co.uk/broadband/pricing/worldwide-comparison/

[330] Int ( ) abbreviation is used for the remainder of the text. Besides this, interviewee, respondent, participant and expert words are used interchangeably in the text.

of the most crucial problems for their sustainability in the future. This point is another common argument especially made by private sector representatives and one can easily observe **“low ARPU levels”** as one of the most commonly used phrases from these actors. According to ICTA, average mobile ARPU is 3,50 Euro as opposed to EU average of 17,51 Euro and the next lowest one becoming Portugal market with 10,18 Euro. One can criticize this by not taking into account purchasing power parities, but in any case, it remains the lowest one across EU countries. As a more controversial topic from both consumer and policy maker perspectives, respondents state that price increases in telecom sector have remained far below other sectors, limiting firms’ ability to earn profits and make network upgrades. In more detailed terms, they[331] have compared other network sectors and indicated price increase differentials of nearly six times between telecom and others such as electricity between 2003 and 2022.

Closely related to ARPU concerns of commercial actors (of the sector), participants agree on decreasing growth rates and total revenues in real terms. One contributor (Int. 11) has given detailed figures for this situation. While total sector revenue was nearly 15 billion TL in 2003, it became nearly 13.5 billion TL in 2021, in real terms[332]. Accordingly, one can say that total revenue has returned to 2003 levels in recent years. Furthermore, same participant underlines decreasing share of this total in GDP of the country, i.e., while the figure was close to 2,5% in 2005, it decreased to nearly 1,3% in 2021. Although, some experts (Int. 17 & 18) point out deteriorating macroeconomic conditions and real exchange rates for this outcome, the decreasing trend in total share is definitely showing underperformance of the sector relative to others as well.

Whatever the validity of these arguments, it can be said that demand for 5G licenses will show the final valuation[333] of bidders in the near future. In this context, license conditions are certainly going to influence market formation by shaping (existing and/or potential) market entrants’ investment decisions. From these discussions, one can see an inherent conflict between commercial and public actors regarding future market developments. On the one hand, there exists firms’ (private actors) arguments

[331] Please note that instead of using ‘he/she’ words, ‘they’ pronoun is preferred to use gender neutral language. This usage also disguises gender of the participant.
[332] In nominal terms these figures are 14.98 billion Tl in 2003 and 92.37 billion TL in 2021.
[333] It should be mentioned that valuation is used as a general word that includes market conditions, demand predictions and value of spectrums etc.

about low levels of revenue (implicitly meaning additional investments are difficult to undertake) streams and on the other hand there exists further and considerable investment expenditures that are necessary to upgrade existing infrastructures, without even mentioning potential 5G investments[334]. Here, one question comes to the forefront, 'How can policy makers revise existing regulations and introduce new methods, provisions etc. in the forthcoming 5G spectrum auctions to reconcile this conflict of interest?' However, one respondent (Int. 19) argues that as long as there is a demand from market players to new 5G spectrums, there is no need to worry about investment obligations of these firms. Similar to above mentioned valuation argument, participants assert that potential bidders will enter these auctions, knowing their obligations beforehand. Having discussed some of the financial considerations, one can ask possible reasons for this outcome.

In this respect, path dependencies should be briefly discussed to shed more light on the current situation.

Role of path dependencies: Among many events (occurrences) that have an influence on the development and current structure of market, one can separate some of them. Briefly, privatization procedure of the incumbent has undoubtedly affected both fixed and mobile parts of the sector development. As a result of privatization choice, cable TV, satellite and maritime communication service parts had been separated from privatized company. Remaining company owned fixed telecom network to give both internet and telephony services along with a mobile telecom operation. What is more problematic is the fact that, this company has begun to provide internet services in both wholesale and retail level. Although, a separate legal entity began to provide retail level services due to Competition Authority decision[335], this (legal) separation has not achieved desired objectives of market competition according to both market statistics and respondents' point of view, that will be discussed below. Secondly, mobile market could not sustain four operator and three operators remain afterwards. This outcome has undoubtedly affected market competition and contributed to oligopolistic market structure. Thirdly, failures and/or mismanagements in Telsim (private firm failure), Turk Telekom (privatization failure) and Turkcell (ownership struggles etc.) has

[334] On the condition that related auctions are made.
[335] https://www.rekabet.gov.tr/Karar?kararId=56e0691e-8814-4e7f-aaf4-3e7762657441

resulted in increasing state ownership in the market. The line between state organizations and these firms has also become blurred, causing some regulatory problems as a result.

This, in turn has contributed current inadequate market competition levels as compared to EU averages and in the views of sector actors, as well.

Competitiveness of the Market: As reviewed, previously distinct sub sectoral boundaries of mobile telecom and fixed internet services are becoming increasingly blurred, mainly due to convergence, merger and acquisitions. In the market, there are three mobile operators and all have fixed internet service provider firms, which dominate the services sector as well, (e.g., Table- 30). This number (in mobile telecom part) is similar to many EU countries most notably with exceptions of larger (and more populous) countries including UK, France and Poland having four operators and Italy having six operators. In Türkiye's case[336], respondents (from private and public sector as well) see little probability (if any) of a new (fourth one) mobile operator in 5G era of the market. They mainly give already existing and oligopolistic market structure with three operators as a reason for these statements.

Having seen their comments, considering inevitable path dependencies and sunk costs (in the sector), it can be said with some level of confidence that there will be no additional (nationwide) mobile operator in this era, *i.e., three operators will be in the market after 5G introduction.* Apart from having one less network operator (from above mentioned ones), this sector (case) differs from most of other EU countries in mobile virtual network services (MVNS) category. Being a part of mobile telecommunications (service) environment, MVN operators (MVNOs) can increase market competition by offering innovative and cost-effective services. For instance, MVNOs has a market share of 6,7% in France in the 2nd quarter of 2022[337] and this figure already reached to nearly 8% (7,8% exact) in Italy by 2021[338].

Without going into much detail (in terms of other international comparisons), it is

[336] "The case" or "this sector" words are used to avoid repetition.
[337] https://www.telecompaper.com/news/french-mvno-segment-shrinks-further-in-q2-after-latest-ma--1433425
[338] https://www.statista.com/statistics/549242/market-share-of-mobile-virtual-network-operators-in-italy/

sufficient to note that although there are 50 firms that have MVNO licenses, such a service does not exist in practice. Omission of statistics for this category by ICTA is a further indicator that no firm actually gives MVNO services even they have permissions to operate in this segment. Indeed, along with **competition problems,** this issue is mentioned more than once (e.g., Int. 3, 4 and 19) during meetings. For instance, Int. (4) argues that although MVNO[339] licenses have been given, an operational environment has not been established (and supported) by regulatory authority. In this regard, another respondent (Int. 15) claims that lack of market development (in this area) has brought about economic costs and market inefficiencies such as fewer alternatives for customers and lower competition, i.e., higher market consolidation for mobile operators. Continuing on, they further point out the need for state support (mainly regulatory authority's) to improve market development in this category.

The situation is not much different in internet services market in terms of market structure and competition levels. Starting from early periods of liberalization, alternative (late-comers) internet service providers (ISPs) had not achieved much market share at the expense of incumbent operator (i.e., TTNet). Only after the entrance of other two mobile operators, the incumbent's share has been reduced to approximately 60% level with other two company (i.e., Superonline and Vodafone Net) has nearly 15% and 8% percent market shares respectively. Remaining ISPs has nearly 15% market share in terms of subscription numbers with the exclusion of Turksat's cable TV services, which is another story.

Most of the interviewees, especially from smaller companies have criticized regulatory authority for this outcome. They (Int.1 to 5) argue that one of the principal missions of ICTA is to establish and support competition in the sector but measures taken by this organization has been inadequate for achieving this aim so far. Here, Int. (4) has made a reference to EU average of nearly 60% market share as opposed to nearly 15% market share of alternative ISPs in the country.

They point out the need for more effective regulations such as preparation and

[339] MVNOs also have different levels of development starting from branded reseller, light MVNOs that also gives customer and billing services, medium MVNOs that additionally provide value added services and full MVNOs that operates core network & switching centers, (http://mvnoeurope.eu/).

implementation of an ‘ordinance on market competition’ and a ‘procedures and principles regarding competition violations, whose works were started many years ago. Apart from this, internet service provision over cable TV network can be considered another problematic area of the market. From its beginning dates (i.e., service introduction by Turk Telekom in 1997 and afterwards by Turksat since 2005), this network has not been expanded widely and coverage rates remain limited vis a vis fixed and mobile networks, due to low level of investments in those years. As a more recent development (nearly after 14 years from Turksat’s cable TV service inception), ICTA has given permission for sharing cable TV network with other ISPs in 2019. So far, it is known that only two firms (bigger ones) have made agreements with Turksat and there is not much available information about the actual implementation.

More importantly, some sector experts have recommended privatization of (cable TV branch) of the company to better utilize potential of this network. In fact, official opinion could be considered same as the above argument, taking into account ‘ISAP 2014-2018’. The plan stated privatization of this network (11^{th} heading) and even pointed out preference of transferring infrastructure on a provincial base. Unfortunately, there is no information related to reasons of not implementing this provision, like many others in different plans as discussed previously. In any case, it seems that there is not much consensus among the participants on this issue, at this time. Some (e.g., Int. 6-7) have made reference to the privatization process and resulting situation of Turk Telekom and have taken a cautious approach while others (Int. 4-5) have pointed out still underutilized cable TV network and recommended a well-planned privatization procedure as a better way to improve the performance of this segment.

Since, this issue will not be dealt with in other sections, it may be better to sum up ***Assertion-7*** which states underutilization of cable TV network as one of the reasons for lower adoption rates and less competition in the market. From the above discussions (participant opinions), market development trends (usage and coverage rates) and policy paper statements (e.g., ‘ISAP 2014-2018’, NBSAP 2017-2020), it is evident that problems in cable TV network have affected the current structure of the market in terms of less competition and fewer consumer choices. Apart from this obvious conclusion, there seems no general consensus on the privatization of this network operation. On the other hand, network sharing agreements with other two service providers can be considered as positive development to increase effective use of this infrastructure. However, market actors (e.g., Int. 1-3) have not been affected by this new institution which seems to have rather limited scope of implementation.

In any case, one may ask the reason of implementing such a deal after nearly fifteen years of market presence and stated policies in official reports. It can be argued that this represents a significant time delay for a sector which is considered essential for the country. Taking into account the decreasing probability (or declining attention for) of privatization, it is evident that investment policies (and budgetary allocations) of Turksat will decide development levels of the network. Besides removing obstacles in infrastructure investment activities in general terms, more crucial issue is obviously to increase investment expenditures for this service to achieve widespread coverage rate in the future. Accordingly, one expert (Int. 2) emphasizes that rights of way, facility sharing problems should be solved to decrease investment costs and recommends use of public funds to support infrastructure development in commercially unfeasible areas.

As a last point in this subject, another respondent (Int.1) demands access to cable TV network for all other service providers on an equal basis.

The above discussion deals with some observations related to market formation and structure. Here, the author intends to highlight these topics. First of all, it is agreed by participants that liberalization process of the sector has not been successful in terms of various criteria.

In this context, **'competition problems (or inadequate levels of competition)'** is one of the most cited keywords in those discussions. The participants base their arguments on oligopolistic market structure and inadequate market shares of alternative operators in internet service provision market. The criticisms are even worse for (as it is seen) **MVNO services in which there is no real market** at all. Moreover, Int. 3 draws attention to current state presence in commercial part of the sector, resembling early period of liberalization process. In a similar manner, participants point out state control in bigger firms with the exception of one provider that is owned by a global corporation. Lastly, the sector has not grown in terms of revenues and interviewees considers structural and competition problems as principal reasons for this outcome. In the light of these observations and market data, it is a fairly obvious conclusion that sector as a whole has not faced with a successful liberalization experience on the eve of 5G introduction period, *(partly related to **Assertion- 1**).*

Closely linked to their past experiences, participants do not expect satisfactory market growth rates in the near future given regulatory framework (more precisely application of it) and deteriorating macro-economic conditions of the country. Moreover, similar to above discussion, they think that alternative service providers will still have difficulty in entering new segments and increasing their market shares in existing ones, again within existing conditions. Lastly, and in a secondary consideration level, participants do not seem to give much emphasis to businesses/household segmentation and they have not made any comments on this topic. Notwithstanding to this observation, it is known that especially bigger firms are starting to provide what can be called bundled services to firms and the importance of them will obviously increase with the introduction of more capable network technologies (i.e., transition to 4.5G and later to 5G).

Having mainly discussed current market formation, structure and competition issues, the study will focus on more detailed regulatory topics that have affected growth rates and market performance.

6.2.2 Guidance of Search

As emphasized in the study, public organizations have influenced development and structure of the sector by means of regulations in numerous fields ranging from market entry to market exit procedures.

At the same time, these organizations have prepared various policy papers to inform and guide both sector players and other interested parties (e.g., researchers, citizens etc.) about their plans and objectives related to further market growth.

In this context, this section evaluates participants' opinions not only about these documents but also about organizations that prepare them.

It is already observed that the number of these plans are numerous and their scope are also wide ranging. To start with, there exists somehow different views about redundancy levels of these documents. One contributor (Int. 8) accepts a problem here but mainly criticizes public organizations for not following and implementing these plans' provisions rather than excessive numbers of them. They further give an example of 'NBSAP 2017-2020[340]', which was prepared by nearly all stakeholders and took months to prepare (in his words). In the end, most of its provisions had not been implemented according to this participant. Similar answers are found when the availability of post evaluations have been asked to respondents. One of them has even given a short answer, "*Rarely, or never…*". On the other hand, Int.4 recommends more cooperation between high level and other organizations in both preparation and implementation stages of those plans. Furthermore, it is observed that the situation becomes more problematic if one organization is responsible for an action item where there are more various other organizations have responsibilities. For instance, 'tax reduction in the sector' is one of the most repeated actions in these papers. As an example, one can see responsible organization as MTF, while MTI, ICTA and other related public organizations (writing is exactly like this) as cooperative actors in NBSAP**.** At this point, another respondent (Int. 16) told their experience related to tax reduction subject. They witnessed a conversation between a minister (MTI) and a bureaucrat (in MTF) in this subject. Accordingly, the minister indicated need for tax reductions in their talk but this conversation led to no positive conclusion (outcome) in the end. Similarly, Int. 15 has pointed out another action item (related to native language digital content) in which MNE (Ministry of National Education) as responsible organization and more than ten organizations (including ministries, TRT, SPO etc.) as well as universities that were included as related actors. Anyone, who are familiar with bureaucratic workings of the country, can easily see the difficulties of working in such an environment where a policy paper prepared by one organization and responsibility is given to other organization (i.e., MTI as owner and implementer of the whole document, MNE as responsible for a specific action) with numerous others in assisting (collaborative) positions.

Similarly, participants also complain about lack of vision and forward-looking steps in related organizations' plans. On this topic, Int. 5 has given an example from ICTA annual work plans. According to them, a topic related to 'Internet Exchange Points'

[340] Please see Appendix-F for a more detailed analysis of this plan.

was included in this organization's work plans starting from 2020 and 2021. More specifically, these papers aimed to complete works on the establishment of IEPs in the country. Afterwards, preparation of regulation on installation of IEPs and fulfillment of physical establishment objective were stated in Presidency Annual Program of 2022. However, they have not seen any regulation on this up to now, after more than two years' delay. They think that these statements also answer the question of whether the sector has credible and attainable objectives or not.

Looking from this perspective, it seems that main problems lie in coordination and follow up activities, rather than number of such documents. Indeed, **inadequate implementation, limited follow-ups and lack of post evaluations** are the main words encountered in interviews. Having obtained these opinions, one can slightly modify ***Assertion- 2*** and state that in general terms once policy papers have been prepared, responsible organizations have a decreasing tendency (whatever the reason is) to follow, coordinate and make outcome analysis. The fact that some topics are found in successive plans also means **unnecessary and costly delays** for the sector and for the whole socio-economic structure[341] as well. During the conversations with experts, they often complain about **same issues that are constantly on the agenda for long periods of time**. Without going into repetition, it is sufficient to mention internet exchange point, cable TV (i.e., privatization, access to this network etc.) and fiber internet network expansion policies (i.e., establishment of joint infrastructure company) that are not successfully completed, among other projects and objectives.

In this respect, a closely related subject is the availability of regulatory impact analysis to see costs and benefits of these institutions, i.e., laws, ordinances etc. As examined in the previous chapter, the author could not find much impact analysis made by public organizations in his own research. When asked about the availability and necessity of such evaluations, two participants (Int 4 & 5) reply that they wrote and told many times about this issue to the regulatory authority but their opinions were not taken into account. Others (e.g., Int. 15 & 16) have emphasized the fact that, both ex-ante and ex-post impact analysis are necessary for increasing effectiveness of regulations,

[341] For instance, efficiency and productivity losses in other sectors, inadequate internet access in some areas leading to difficulties in online learning etc. One can include many other possible negative outcomes due to delays and failures in telecom sector as a whole.

institutions. Notwithstanding to this, majority of respondents think that since impact analysis are time consuming and costly activities, they should be made when they may affect certain number of people or sizable financial effects, (above some threshold). In any case, the general consensus is that, it would be beneficial to evaluate the effects of regulations (i.e., ex-post and ex ante also before implementation) and, if necessary, to make necessary changes in line with these evaluations. Same participants also recommend a written procedure (e.g., internal directive) to ensure consistency (i.e., when and how to make) in implementation[342]. To sum up, the necessity of having publicly available impact analyses is shared ***(Assertion- 3)*** by all experts in discussions.

In other words, participants find the number of impact analysis totally insufficient and consider these institutions as necessary tools for increasing performance and efficiency of regulations, at the same time.

What is more, it can be concluded that uniformity and observability (i.e., principles, procedures and application procedures) are prerequisite conditions for sector actors in these analyses.

Above discussions lead to another controversial topic in the sector. Starting from early days of market liberalization process, regulatory independence and conflict of interest issues have been encountered in the sector.

As addressed in detail (both above and in the previous chapter), the situation has become more complicated recently with the overwhelming state ownership in dominant firms of the sector.

When asked the question of whether the regulatory organization (including other public organizations) is independent from former incumbent and other (state controlled) firms, the overwhelming answer of participants is negative. This is because, they all give a basic reply that chairman of the board (of Turk Telekom) is at the same time deputy minister of MTI and majority of board members are also government officers. Secondly, the situation is similar in the other dominant company

[342] This can be seen as an internal and more specific recommendation especially for the regulatory authority.

(Turkcell) for the reason that it is currently under control of (Türkiye's) Wealth Fund and majority of board members are appointed likewise.

Accordingly, they argue that there exists **a conflict-of-interest problem**[343], which undermines independence and impartiality of the regulatory authority (including other public organizations) against other private firms. Some even (Int. 2 to 8) consider this as one of the significant reasons that lead to competition and growth underperformances (failures) of the sector. Thus, it can be said that the actual implementation (presence) of the regulatory framework is not compatible with the theoretical model, in which a starting point is the independence of regulatory organizations from commercial actors, in essence. Here it should be stressed that what is more important for the sector (and for the whole country) is not whether EU's legislation is fully adopted or not, but the resulting outcome of this structure, which is clearly not satisfactory in terms of various criteria, i.e., competition level, consumer satisfaction and service quality etc., ***(Assertion- 1.2).***

In addition to independence from sector players (private ones), there is one more independence concept that is also controversial and less clear-cut to define, which is independence of regulatory authorities from higher level public organizations, e.g., related ministry, government etc. Unlike the former one, implementation and meaning of this can be different in each country, to some degree.

Without going into much detail, a common responsibility sharing structure (in countries adopted regulation by independent authority model) is as follows. In this context, related ministries have responsibility in policy design while regulatory authorities are given operational duties under this broad picture. Of course, this does not exclude parliament and/or presidential involvement in the framework through various means. In other words, there is a wide spectrum in the distribution of duties and responsibilities of these organizations in each country. Furthermore, these settings

[343] There are many definitions of this concept and also numerous reports on how to deal with related problems. For instance, (UKRI, n.d.) *defines it as a situation in which an individual's ability to exercise judgement or act in one role is, could be, or is seen to be impaired or otherwise influenced by their involvement in another role or relationship.* The important thing from this definition is that it can arise not only from financial interests but also from competing loyalties between different organizations occupied by same person. Among other research organizations, OECD (2003) also considers conflict of interest phenomena as a major concern in both private and public sectors.

are not static and some disputes can occur depending on the nature of regulatory topic.

As reviewed in Chapter 5.3, OECD (2016b) gives several cases, in which some sort of dispute occurred between public organizations in several countries such as UK and France[344].

This does not mean that there are no set mechanisms to minimize these problems at the same time.

Among these, one can see that presence of transparency and public consultations (in important decision-making processes) are essential for the functioning of a system in every organizational structure.

Returning to (our) the case study, participants agree on **lack of transparency and open public consultations** between responsible organizations related to sectoral policy making. In this respect, selection and appointment of board members (including head of a board/ organization) are part of these procedures that require transparency and considered essential for maintaining independence (as discussed not in an absolute sense, it should be interpreted as maintaining impartiality against sector players and not favoring some parties due to political or lobbying pressures) of regulatory organizations.

Respondents (e.g., Int. 15, 20 & 21) state that there is no transparency in appointment of board members in the country.

Int. (19) has mentioned the previous procedure which was stated in repealed article 7 of Law no. 2813. This article[345] specified the composition of the board by requesting candidates from different organizations, as shown in Table- 49.

With this provision, policy makers probably aimed to achieve some degree of plurality in composition of the board. However, as anyone familiar with many legislative practices, what is written in the laws may not be implemented fully in the country

[344] For instance, a dispute occurred between energy regulator and related ministry on the deployment of electricity smart meters at no cost for users in France. Here, the regulator made a public statement announcing the ministry had no duty and/or responsibility in this topic, (OECD, 2016b).

[345] The article states other personal rights, responsibilities and other terms of appointment (e.g., education etc.) in addition to this procedure.

(same as the situation of policy papers as discussed previously). In fact, contributors (Int. 19, 20) talked about some kind of manipulation in the implementation of this article. Accordingly, sector and consumer representative candidate names were given (by related public organization) to nominating organizations beforehand. Even this example clearly shows that implementation of legislation is what matters and transparency, accountability can help in achieving intended results of (written) papers and documents.

Table 49-Previous Board Nomination Procedure

Nomination by Ministry of Transport	Nomination by Firms from Sector	Nomination by Ministry of Industry & Comm. Un. of Chambers & Comm. Exch.
1-Head of the Board (one from two candidates) 2-Telecommunications Services representative (one from two candidates) 3- Wireless Services representative (one from two candidates)	1-Sectoral representative (One from candidates given by companies that have 10 % market share in telecom sector)	1-Consumer representative (one from four candidates- two from each organization)

Source: Law No.2813
(*) Please note that there were five board members (including head of the board) in the early period of the organization.

In any case, amendments to that law have repealed this procedure (Law no 5809 dated 2008) and currently board members are appointed by the President according to decree law 703 dated 2018.

That is to say, other than some requirements stated in the general law no 657 on Civil Servants, there is no other appointment criteria exist for minimization of those concerns, at the present.

The total number of board members have reached to 27 (23 of them were civil servants- of which 3 from academia- only 4 of them from private sector) since its establishment date in 2000.

In terms of educational backgrounds, 15 of them have engineering (most of them electric-electronic) while 12 of them have social science related (4 of them have law, others include economics, management and public administration) degrees. Lastly, 12 of them had previously held executive positions in the organization. It seems that being occupied an official position (in the ICTA) has increased the probability of appointment as a board member in the same organization[346].

One other thing closely related to above discussion is the roles of different public organizations in the ecosystem. Indeed, looking from functional perspective, it can be seen that not only ICTA but also some other organizations[347] affect (regulate) market players' decisions and actions. During the conversations, participants mostly name main public actors as 'GDC (in MTI organizational structure)', 'ICTA (associated organization with MTI)', 'DTO', 'MI&TECH', 'Ministry of Trade (MT)', 'SBO', 'CA', 'KVKK' and 'RTUK'[348]. Although, MTF is important for financial operations for the companies, they do not regard it as specific to this sector. Anyhow, almost all experts see sector related taxes as negative factors for market growth, but here also companies (seem to) make complaints about this issue (in a sense indirectly) to the ICTA and related ministry (MTI), most of the time.

Notwithstanding to this, (without repeating each organizations roles etc.), the focus will be on the more problematic parts the system. First of all, it can be said that there are three organizations that have similar functions in the regulatory environment. As studied before, a transfer of duties can be observed time to time between ICTA and GDC. For instance, implementation of universal services duty has been transferred from GDC to ICTA more recently.

One can add other topics such as cyber security in both of these organizations' area of responsibility as well. Here, several respondents (e.g., Int. 4, 7 & 8) attributed **delays in implementation of some regulations** to this factor, as well. Among them, 'rights of way and facility sharing' and 'facilitation of electronic communication infrastructure establishments' has become most mentioned topics. They also argue that there exist unclear areas of responsibility and this has generated some degree of confusion for the sector actors. According to Int. 19, more recent additions of two higher level organizations has further complicated the picture. At this point, several

[346] Please note that, there may be minor omissions due to the fact that the author has compiled these from separate annual reports of ICTA, of which some years are not available.
[347] As mentioned, more organizations and institutions like can be added to this list, but this time the size of the analysis will become unmanageable.
[348] Most of these organizations' roles are discussed in Chapter 5, (mainly in 5.1.1, 5.3 and 5.4.1 and 5.4.2).

respondents have asked the effectiveness of having a science and technology policies board in practice. Continuing the topic, Int. 20 said "…*on the one hand, we have rarely seen works of this board and on the other hand there is no clear procedure for implementation of reports, plans etc.*". For the position of DTO, several interviewees (e.g., Int. 7, 8, 17, 18) think it has **incorporated some of the issues that ICTA had previously considered as a formal or de facto field of study.** On the other hand, some of them (Int. 4, 5, 6) point out another issue as the main problem in this subject. Accordingly, they emphasize the need for effective communication between these organizations to minimize possible conflicts and/or delays in regulatory works. In any case, majority of participants see the current structure as unsatisfactory for supporting market actors in several respects.

These encompass provision of market guidance (especially) related to priorities & objectives in short- and long-term perspectives. In this context, **overlapping duties, confusion of responsibilities and resulting delays** are among the most emphasized words that are encountered during meetings. At the same time, some experts (e.g., Int. 4, 5 & 7) advocate simplification of this structure by consolidating these organizations. That is to say, board and digital office roles can be incorporated in a newly established **'Information and Communication Ministry'**.

By this way, this new ministry will be more able to concentrate on this field (already covering a very large scope from telecommunications to digitalization topics) unlike the present one where telecom regulation is just a one part of whole organization, which comprise many other responsibilities such as overseeing construction of transportation infrastructure related parts, e.g., railways and highways etc.

In this respect some of them suggest (e.g., Int. 15, 16 & 22) establishing a more direct connection with **MI&TECH**, taking into account increasing relations between telecom and several other industries, as given in **Appendix- C** with some examples, ***(Assertions- 1.1 & 1.2)***

During the interviews, the current status and role of regulatory authority has been further put forward by the author. More specifically, it is mentioned that some other regulatory structures such as Japan and China have no separate telecom authorities apart from related ministries (Ministry of Internal Affairs and Ministry of Industry and Information Technology respectively) and asked whether this setting is more effective solution for our sector as well[349]. However, the participants did not support this proposal, (Int. 15 to 21). They have argued that a more transparent structure with well-defined roles would increase efficiency of the system.

Apart from the need for regulatory restructuring, some respondents have pointed out several overlapping duties between related organizations. It appears that task sharing problems, occurred between the CA and ICTA in the past are not observed by the respondents, currently. On the other hand, one inter-organizational problem (in a specific level) can be deducted from participants' words. According to them, some regulations of ICTA and MT (General Directorate of Consumer Rights in the organizational structure of Ministry of Trade) have addressed same issues sometimes contradicting with each other. What is more, they state some cases in which both organizations have fined companies for the same topics. In the words of Int. (1) "*Along with increasing the workload of the operators, the incompatibility of the legislation brings unnecessary regulations and imposes excessive obligations on the operators. Two different public institutions can fine the operator for the same violation…".*

Although this can be considered as a micro level problem, it should be definitely evaluated if a new administrative restructuring will be made in a near future. In sum and in general terms, participants do not think that the sector has a clear vision for future developments and objectives that are well defined and attainable either in short and in long term. Moreover, the lack of such guidance has constituted an obstacle for the progress of IS, according to their opinions, as well.

All of these factors have also obviously affecting both existing and potential players' decisions related to investments in the market. This, in turn, leads one to look into entrepreneurial market entry and their operations in the sector[350].

6.2.3 Entrepreneurial Activity

After seeing some problems due to overlapping responsibilities of public organizations, this section focuses on more specific costs incurred by firms that want

[349] It can be said that regulatory authorities are part of EU legislation and candidate countries also have to adopt this framework. Notwithstanding to this, the study focus on how well the system functions and which organizational structures are well suited to this purpose.
[350] Please note that mainly entrepreneurial entry/exit and current firms' operational situations are discussed in the heading of 'entrepreneurial experimentation and production'.

to enter and/or are already operating in the market. It is already observed that one can divide firms (in this IS) roughly in two categories, in terms of investment capabilities and requirements, i.e., mobile service providers and others. Irrespective of this, first of all, firms are certainly affected by macro-economic conditions of the country. The study has already mentioned the participants' complaints about decreasing value of local currency and increasing inflation levels, which are raising their expenditures and also limiting their revenues (i.e., lower ARPU levels). In this respect, most emphasized words that are witnessed as **deteriorating economic conditions**, **negative reflections of this to the sector and inability to increase their service prices in line with inflation rates** occurred in the country. For this reason, along with other regulatory problems, participants have pessimistic views of market entry prospects. One interviewee (Int. 2) shared his thoughts as "*Since the beginning of liberalization in 2002, domestic and foreign capital groups had made investments in areas such as internet service provider, fixed phone service and virtual mobile network operation. However, due to the lack of a fair competition environment and economic conditions, they stopped their investments and withdrew from the sector. For example, Sabancı Group (Sabancı Telecom), Koç Group (Koçnet), Doğuş Group (İxir), Ülker Group (Global Communications), Swedish Tele2 and USA Verizon all left the market".* On this occasion, another one (Int.1) made a reference to ICTAs recent figures and pointed out nearly 335 revoked licenses in recent period to emphasize this trend. Along with macro-economic conditions, Int.1 and Int.2 have reiterated alternative service providers' criticisms related to ICTA's decision to increase paid-in capital requirements to one million TL and said that "*it is both difficult to enter the market and difficult to hold on, now."*

On the contrary (and specific to this statement), Int. (18, 19) have argued that some kind of market entrance requirements are necessary to control market entry and deter nonserious entrants. Though some truth exists in this argument, above examples of respondents (about market exits) indicate the negative trends and perceptions of market entry prospects.

For the other three dominant players, general picture is not much different as can be seen from their outlooks. The situation for two of them is even more complex, considering their position of state control in the wealth fund. In fact, this can be regarded as among the most fundamental issues for the market development (including entrepreneurial activity in the meaning of possible new market entry) in the near future, along with forthcoming 5G license auctions. Participants overwhelmingly agree on **the need for sale of wealth fund's shares** (re-privatization in a sense) to return market liberalization path, in a sense. Of course, they all aware of the previous experience and emphasize **establishment of other indispensable institutions such as independence, accountability and transparency** in practice.

Besides this topic, market actors are looking forward to 5G license auctions and it is probable that sale of two companies' shares may coincide with these auctions[351].

All participants (i.e., from large to small companies etc.) have expectations (from 5G introduction) for future market development. Large companies (as expected) want to pay less license fees in return for higher infrastructure investment obligations and better quality of service targets. Here, they presented examples from other countries such as Germany where rural coverage supports were given to mobile operators, China where deployment of base stations was subsidized and South Korea where 5G use cases in vertical industries were given some tax exemptions[352].

In any case, it is certain that there will be investment (coverage) and service quality requirements in these licenses as in the past. Accordingly, the author assumes that operators do not want to expend relatively higher amounts than their estimates. In more detailed terms, they might prefer more innovative (from their own perspective) approaches from public organizations. For instance, one respondent (Int. 21) thinks location based (regionally limited) and/or industrial usage related licenses can be given in 5G era. As it is discerned from usage cases, some entrepreneurs have begun to construct private networks for many industries (e.g., Mercedes car factory in Germany) and transferring full operation to these companies but this demand can be met with mobile operators establishing and servicing these limited networks by their own licenses, as well. The preference by the public authorities whether this limited 5G

[351] Of course, it depends on the decision and timing of related organizations. At this time, nothing can be said exact date of these processes but in any case, 5G auctions will probably be made between 1-5 years' time period and one can said that the resale of other ones is inevitable due to various reasons such as obtaining revenues. Lastly, one can ask a question like that, 'How can 5G licenses be sold, if these firms will be owned by the wealth fund for a long period of time?'

[352] Please see Appendix-B for specific country examples in 5G deployment.

licenses will be given or not, may also affect the total amount of auction fees, on the other hand. In sum, bigger market players (both potential and existing) clearly want from policy makers **not to aim maximizing revenues** from these auctions and instead **focus on infrastructure investments** coupled with more innovative approaches like more specific license types and spectrum sharing possibilities.

Apart from these license fee considerations, sector experts want to see some developments in other market entry opportunities and reductions in (possible) operational costs. As usual, all participants (e.g., Int.1 to Int. 8) are uniformly complaining about higher sector specific taxes and some (Int. 15 & 16) have also pointed out lack of tax exemptions and support mechanisms especially related to rural areas.

Secondly, commercial players (irrespective of their sizes) indicate ‘rights of way and facility sharing’ issues as critical barriers for entrepreneurial activities in terms of network expansion and entry in new market areas. In the words of one correspondent (Int. 3), *“…we have still faced with arbitrary rights of way fees, in spite of being on the regulatory agenda for several years. Furthermore, facility sharing fees should be reduced by 50% to make investments more feasible...”*. In this context, there are various other vital topics to be considered before introduction of 5G services to the country.

Indeed, respondents emphasize the need for facilitation of infrastructure investments and promotion of joint infrastructure installations since without a widespread fiber network, expected benefits of 5G technology cannot be achieved in terms of service quality, i.e., high-speed internet access with minimum latency levels.

These considerations also give rise to one of the fundamental statements of this study ***(Assertion- 8)***, related to insufficient coverage (availability) of fiber infrastructure of the sector. As perceived in the previous chapter, this is one of the most important reasons for relatively lower average internet-speed rates observed in the country. Moreover, participants see this type (of network) as a prerequisite for the fulfillment of 5G capabilities. In fact, at the same time, there should be enough base stations present and these should be connected to core network via fiber technology. Here, without repeating fiber coverage statistics, it may be useful to emphasize the situation by referring one of the participant's words as "*Since 2008, it is seen that the fiber network in kilometers has approached to five hundred thousand km. In Sweden, which is one of the countries that has successfully expanded its fiber infrastructure in the world, the fiber infrastructure network of the city of Stockholm is currently 1.9 million km long and over 100 operators are giving services by using this network. That is to say, fiber infrastructure of this city alone is about four times the length of Türkiye's total fiber infrastructure. From this only one example it is possible to say that fiber network infrastructure in Türkiye still has not reached sufficient levels"*. Indeed, all the participants (Int. 1 to Int. 8, Int. 15 to Int. 23), which are asked the relevant questions, more than accept the inadequacy of this network and what is more consider it as one of the most important barriers on digitalization process of the country including any sector, that are using this network.

When asked about the reasons for this outcome, one response (Int. 4) is that "…*the incumbent operator has been reluctant to share its infrastructure. Furthermore, regulatory authority and the related ministry also do not show a clear will to solve the problem."* In fact, same experts link failure of joint infrastructure company, which had been established with high expectations, to nonparticipation of the incumbent operator in this undertaking.One interviewee (Int. 21), referring to some public statements made in this period, reiterated their disappointment from the incumbent player's non-involvement, which is also a main player that operates internet backbone of the country and it has a license till 2026. This date is important for other reasons and deserved some further discussion as well. It is observed both in this section and in previous ones (e.g., market formation and structure) that license conditions (including duration periods) are the most fundamental determinants of market entry/presence of business actors. As a recent development, it is known that ICTA has extended two operators' 2G licenses (expiry date) to the end of April 2029. On this, Ms. Nebil (2023b) has mentioned that ICTA has extended Turkcell's 2G license terms for 120 million EUR (excluding VAT) and assumed the same procedure for Vodafone is valid[353]. In this subject, some respondents (Int. 1, 2, 4) consider asymmetry in license terms (i.e., 2G, 3G and 4.5G license periods) as a problem on the eve of 5G transition. In any case, it

[353] Since Vodafone is not publicly traded in Istanbul Stock Exchange, the company has not made any information disclosure in this matter. Ms. Nebil has continued by making a reference to undisclosed source that *Turk Telekom did not make any request since its' license period will end in 2026 and the company has considered making any application at this time.*

can be said that the regulatory authority (and MTI) should deal with this issue before initiating new licenses in the near future.

Returning to the topic (fiber issue), what is clear from data (e.g., Fig.-23), international comparisons (e.g., Fig.-27), policy paper objectives and above-mentioned discussions is that, both coverage and growth rate of fiber network has not been satisfactory and several attempts to increase this rate has not been very successful so far. Here, one can also observe **regulatory delays** and this project is on the sector's agenda for nearly eight years now (if one starts from establishment date of the company 2016, without even taking an earlier date for the start of these discussions, requirements). Anyhow, interviewees still recommend establishment of such a venture to increase network roll out. Moreover, they prefer service competition instead of network competition, especially in commercially difficult locations. One respondent (Int. 15) has made an analogy by giving examples from roads between certain points. *"...there is one main road, let's say between Ankara and Eskisehir. You can upgrade it but, normally, you would not think about constructing an additional one. This is the same for network construction, you do not need many at least for some regions."*

In sum, it is perceived that **establishment of a joint infrastructure company, facilitation of infrastructure sharing, reduction of tax levels, facilitation of base station installations and provision of support mechanisms** are most emphasized words by participants to improve entrepreneurial activity (for both market entry and improving working conditions of existing firms) and help 5G transition as well. These policies have already been used in various countries**.** As a matter of fact, it is sufficient to note that all these countries including China, Japan, USA and Germany have already well-developed network infrastructures (compared to the study case) but they are using these policies to be at the forefront of digital transformation race.

Furthermore, it is understood from both participants and from sector actor's [354] statements that, market actors expect more innovative approaches from forthcoming 5G auctions like local licenses. Secondly, it appears that they want from public authorities not to put revenue maximization as the main priority. Instead, policy

[354] In one of the interviews with journalists, Turkcell CEO (Mr. M.Erkan) has emphasized that local and industry specific licenses should be given by ICTA in forthcoming 5G license auctions, (Yeniova, 2023)

makers should request more ambitious network expansion and quality of service targets, according to their opinions. More recent and very unfortunate events (i.e., Covid and unfortunately very devastating earthquake in the southern part of the country in February 2023) clearly show the vital importance of having a resilient network to enable communication even in emergency situations. As stated above, this does not mean that there were no targets and requirements from network operators in the previous licenses but on the eve of 5G transition and experiences gained from this great disaster, it is normal to expect different approaches from policy makers to minimize possible risks.

New Market Opportunities (expected after 5G): Although it is not completely new technology by itself (as noted in Chapter 3, it is an incremental- but important- change from 4G and a bridge to passage for 6G in a sense), both participants (to this study) and market actors (in general) expect new market opportunities with 5G introduction in the country. Indeed, there are some potential benefits and opportunities for market actors with the introduction of 5G technology in the near future, as shown by some examples in Chapter 3.3 and in Appendix- C. Apart from vertical usages, smaller actors expect some opportunities for market entrance in mobile services segment, as well. Before discussing this, it should be stressed that **respondents almost uniformly think** that there will be no change in the number of mobile operators after transition to new technology, i.e., 5G. However, it is normal to expect that, depending on the government (especially MTF and the Wealth Fund) decision on the sale of existing two mobile operators shares, there may be ownership structure changes. Together with participants' considerations, the study put forward several supporting statements (in the previous chapter) for this assumption. Since they are already discussed, some of them are briefly mentioned here. First of all, nearly all respondents (e.g., Int. 1 to Int. 8, Int. 15 to Int. 22) does not expect additional nationwide operating mobile operator (fourth one) after new auctions, ***(Assertion- 9)***. Sunk costs, network economies and brand images established in consumer perceptions for many years all make it very difficult, if not impossible, for a new (nationwide) market entry.

It is sufficient to note that establishing a large scale (covering towns, rural areas etc.) retail channel will take considerable amount of time, without mentioning necessary infrastructure investments to provide services nationwide. Lastly, as a historical experience and path dependence phenomenon, fourth mobile operator could not sustain its' operations even in the relatively early days of mobile telecommunications services, mainly due to late entrance relative to other operators and difficulties in making roaming agreements with these operators. There is no need to repeat the fact that, in a hypothetical situation, late entrant has to undertake huge infrastructure investments to reach a considerable coverage throughout the country. Even this is not sufficient and one should take into consideration how long it will take to complete a moderate level of network coverage, i.e., time costs and further time delays.

Returning to above arguments again, aside from (new) nationwide market entry (un)availability, respondents consider several opportunities for market entrants in more specific segments. Industry specific and/or local licenses can influence development of vertical usages in many sectors. On the other hand**,** mobile operators have already diversified their operational areas (Chapter 5.1.1) and started giving these services to businesses in different sectors with the introduction of 4G technology. It is clear that this scope will expand further after the passage to 5G. At the same time, they are establishing several branches to develop value added digital applications like OTT services.

These opportunities will certainly help operators to increase their revenues and also raise their valuations of new licenses as well. Here, regulatory policies should be reconsidered to make room for alternative operators in new service segments.

Moreover, respondents consider introduction of 5G (in the market) as a revitalization opportunity for MVNO services, which has not developed properly and not gained a market share in the sector. In this subject, one interviewee (Int. 6) has commented *"... only difference of 5G from other generations is not just higher speeds. Another advantage is network slicing technology. Network slicing allows provision of multiple virtual networks on top of a shared physical infrastructure. Thanks to 5G, MVNOs will be able to operate small networks for their customers in certain sectors with the network slicing method."*

Accordingly, the general consensus is that regulatory authority should include some provisions in licenses to enable MVNO access to 5G networks. In addition to this, participants request other regulations, after market formation, that can enable market growth in this segment, as well.

In the light of above deliberations, it can be concluded with a fair amount of confidence that, there will be no change in the number of mobile operators (irrespective of ownership changes) in a forthcoming 5G era, ***(Assertion- 9).*** Apart from this, in line with new capabilities of 5G technology and developments in other countries that are already adopted 5G, participants expect new opportunities from introduction of this new technology, ***(Assertion- 9.1)***. However, more crucially, they request (expect) more effective involvement, policy design from public organizations to realize these opportunities in implementation phase.

6.2.4 Legitimation and Counteract Resistance to Change

People's resistance to change mainly comes from introduction of a new technology. In more detailed terms, avoidance of a new technology stems from various factors such as fear, mistrust, health and privacy concerns. It is known that people all over the world worry about possible health problems due to booming presence and use of mobile telecom technologies but at the same time most of them are increasingly use these technologies in all aspects of their lives. Indeed, this prevalence is so dominant that opposing ideas or voices are hardly heard in the wider public opinion. At the opposite, it is certain to expect this trend (i.e., expansion of telecom networks) to continue in the background of many problems like traffic congestions, pollutions and diseases and natural disasters[355].

Notwithstanding to this inescapable expansion, complaints about base stations located in various places of urban centers are encountered in media sources. At this point, public organizations and commercial actors' notifications and information activities help reduce these concerns to some extent[356]. In spite of this, some participants (Int. 22, 23) comment on the fact that as 5G networks start spreading in densely populated areas, people will face with much higher number of base stations (including small cells). In this context, they recommend increasing public awareness activities by using

[355] A shown by some examples in Appendix-C, digital technologies are increasingly considered for helping to solve many of these worldwide problems.
[356] This does not mean that there is absolutely no negative health effect and/or presently unknown ones of using these technologies. Indeed, side effects of many other technologies have been found after using them for many years like DDT etc. In this respect, a more rational thing would be continuing to investigate possible side effects and to try to take measures against them.

various media channels. By this way, wider public segments can be reached about safety precautions used in base station installations, confirming these are constructed in accordance with international standards. Here, one research (Kaynar & Özmen, 2019) supports this recommendation. According to this, people (participating in that research) have limited information about base stations and they similarly advocate informing public about base stations (possible effects, safety rules etc.), especially by making use of media power.

Second concern comes from privacy and security worries. In essence, digital transformation is all about data transmission, processing and as it is debated digitalization means that nearly all aspects of people's lives are becoming parts of this process. For this reason, enabling user confidence in the protection of this sensitive data has increasingly becoming vital part of a sustainable ecosystem growth.

Although it is not directly focus of the study, it should be emphasized that **privacy and cyber-security topics** is at the forefront of the political agenda as well. Participants have also highlighted critical roles of these topics both for enabling user confidence and for sustainable sector growth[357].

According to their views, apart from economic considerations, ensuring privacy is undoubtedly a part of human rights and should be protected in various ways. In this regard, one of the most emphasized topics is **the need for increasing education to improve people's awareness and knowledge** related to new technologies.

Certainly, many organizations emphasize the necessity of raising peoples' awareness on these topics.

More specifically, one report prepared by European Parliamentary Research Service (2022) state the necessity of providing education on 5G and other digitalization issues in the form of lifelong learning and in school programs to ensure access to relevant knowledge and critical thinking about every aspect of digitalization[358]. Some

[357] In fact, participants point out (relatively) well developed domestic market related to cyber-security business and many opportunities for domestic firms. Since these issues are not included in the scope of the study, they will not be elaborated further.

[358] There are many other topics analyzed in the report including, promoting accountability & reliability of 5G ecosystem actors, developing indicators to analyze social impacts of 5G, establishing an ethical framework for 5G as well as other more technical issues such as acceleration of cybersecurity standards and ensuring full anonymization of subscriber identity etc.

participants (Int. 22, 23) of the study have also highlighted increasing importance of information provision and educational support about these topics in this (our) context, as well. Furthermore, participants agree on updated and transparent regulatory framework to prevent misuse of sensitive data (protection from data theft, regulation of surveillance etc.) that will continue to increase after introduction of 5G technology.

In any case, the study has not obtained much impression about the effects of these concerns in the form of (formal) resistance to mobile technologies in the approval, establishment procedures like base station installations. Operators do complain about problems and difficulties encountered in installation and infrastructure building processes, but these are not mainly related to factors that are mentioned here, but more often stem form bureaucratic reasons, some of which are examined in the next section.

Apart from these, national security concerns are being used to increase use of national or what can be called allied national hardware/ software products in 5G networks. This topic is discussed in the analysis of telecom equipment production part (Chapter-6.3).

6.2.5 Resource Mobilization

Since various topics related to this subject have been analyzed before, some issues will be summarized here along with participants' views[359]. When asked the sufficiency of incentive mechanisms (e.g., subsidies, tax reliefs etc.), participants (Int. 1 to Int. 8) responded in a negative way.

They especially emphasized that no incentives are given to infrastructure investments in the telecom sector and -what is more- nearly half of fiber investment expenditure is in the form of 'rights of way' costs. Moreover, although policy makers seem to give priority for development of this market, it is seen that many of them (targets, projects, regulations etc.) have not been achieved in reality and/or completed up to now even after relatively long-time delays, according to them. In accordance with this observation, respondents claim that **allocated resources have not been enough** and one should include **time delays as wasted resources** as well. Apart from inadequacy of investment incentives, one respondent especially points out (privatized) incumbent

[359] Resource allocations and funding mechanisms for production related issues are discussed in Chapter 6.3.5.

operator's unwillingness to make substantial investments in these networks due to financial preferences of its (previous) owners. In fact, as it is stressed more than once, this is similar to the previous discussions in that failure of liberalization process has resulted in underperformance of the sector in various criteria including fiber network expansion rates.

In this context, one policy mechanism stands out among others in terms of social objectives in addition to market-oriented aims. This is called 'universal service policies' and widely adopted throughout the world to extend coverage of broadband internet access and usage to relatively disadvantaged segments of a population. It can also be seen as a resource mobilization beyond market mechanisms and regarded as an important tool for minimizing digital divide problem. It is known that there is widespread application of this policy in well developed countries (in terms of telecom network coverage and availability) such as USA and UK.

Especially in a country like USA where the free-market mechanism is emphasized, the breadth of universal service applications is remarkable. It consists of four components as high-cost support (given to companies in high-cost areas), low-income support (given low-income households), schools and libraries support and rural health care support (given rural health care providers). Another issue that may be of greater interest to (our) sector is the four main (written) principles of this regulation.

These are fiscal responsibility (aiming to minimize inefficiencies and waste), accountability (includes both public organizations and payment receiving companies), incentive-based policies and modernization of the fund for broadband (meaning continuous upgrading to satisfy peoples' needs and requirements)[360].

The reason for giving the above example lies in the answers of the participants. Indeed, as it is also perceived in several parts of the previous chapter (i.e., usage of the fund), they responded as "*how this fund has been used should be explained transparently…"* and asked several questions such as *"…what is the total amount collected in this fund and how much of this income is spent...what is the breakdown of the expenditure?"* It is evident that even people (in the sector) have not much knowledge about the

[360] https://www.fcc.gov/general/universal-service

implementation of universal service fund in the country. In fact, some of these figures have been disclosed in Turkish Court of Accounts reports recently, (Çalışkan, 2021). This report states the fact that only about half of the revenues collected have been used for services specified in this legislation within the 15-year implementation period.

Furthermore, the report concludes that the purpose envisaged by this legislation has not been fulfilled at the desired level and it is necessary to ensure that the universal service revenues should be used in the provision of related services.

Similarly, many interviewees complained mostly about **nontransparent and irrelevant use** of this funds' sources over those years. Unfortunately, this topic has come to the fore as a result of recent earthquakes.

After this event, many people have criticized the operators and responsible public organizations due to communication problems in the region.

As a result of these problems and criticisms, SBO (2023, pp. 85-86) has prepared a report mentioning short- and long-term policies in this regard.

One short term recommendation is to use ICTA revenues (collected from operators) in upgrading broadband infrastructure of these regions, i.e., universal service policies.

Assessment of the need for public support in fiber infrastructure installations, determination of support mechanism, providing fiber infrastructure support in industrial zones and reconsideration of the settlements to be serviced within the scope of universal service after the earthquake are stated in mid-term policy recommendations.

Long-term policy recommendations include development of a fiber support model in accordance with the new zoning plans of those cities, which are affected by the earthquake, to enable 5G infrastructure [361]. In fact, most of these policy

[361] The other policy recommendations are as follows. Review of damaged infrastructures in the region and ensuring the presentation uninterrupted and quality communication services, exploring possibilities of a new generation base station that can be less affected by earthquakes and allows transportation, preparation of new investment plans according to the changing socioeconomic and demographic conditions of the region are in the short-term category. Evaluation of communication infrastructures together with other infrastructure investments within a strategy, effective implementation of regulations

recommendations have been expressed or discussed by participants in these interviews. Furthermore, one could not say whether these will be implemented in the near future by looking into past experiences as well.

At this point, one can say that although these (policies) are shared by sector experts and in fact discussed and/or stated by them previously, they are very late to be implemented by now.

Unfortunately, **time delays in actual implementation processes** have often observed in conversations and interviews by the author. **In other words, one of the main problems of the sector is not lack of policies but delays in implementation, lack of follow-ups to find reasons for possible problems and not correcting mistakes for current/ future works**.

Here, Ms. Nebil (2023) similarly complains about one of these delays in practice. Briefly, referring to a policy statement that recommending use of ICTA's revenues for the construction of network in earthquake affected regions, she continued like this, *"…but if SBO had published this sentence before, for example, after the 2019 earthquake or even before there was an earthquake, after the new Presidential structuring, in 2018, I would have congratulated it. Today, however, I consider it simply degassing[362] and here I say to SBO: Good morning"*.

In the light of above considerations, it can be concluded that usage of universal service fund should be made more transparent and available for public observation, along with establishment of accountability for related actors, ***(Assertion- 6)***.

Finally, one can further discuss the role of sectoral associations and lobbying efforts here, since they are more related to resource maximization efforts of companies[363]. As

(including facility sharing, permission and right of way etc.) by ICTA to enable establishment of infrastructures that will provide fast and quality service delivery, provision of Domestic base station equipment such as ULAK, ÇINAR and MİLAT for mobile operators at a reasonable cost, preparation of regional action plans that determines the coordination and response mechanisms of operators and public actors to ensure the continuation of communication in case of disasters are in the medium term category. Finally, elaboration of provisions regarding communication requirements in case of disasters and emergencies in new authorizations after the expiration of the concession agreements, ensuring effective regulation in the earthquake zone as it should be in the whole country, preparation of necessary regulations for broadband services offered over low orbit satellites, ensuring broadcast over LEO satellites instead of VSAT after the disaster are mentioned in the long-term category.

[362] In Turkish exact wording is "gaz alma". It is used in the meaning of calming down public opinion.

[363] Please note that, similar to some other topics, this issue can be examined in other categories like 'counteract resistance to change' etc.

it is seen from the previous chapter (5.1.1), although there are many associations, few of them are publicly seen in the sense of publishing reports, opinions and keeping up to date web pages to inform people about their activities. When asked about the objectives of associations in the sector, one participant told their association has worked to **protect members' interests** by mainly published reports, opinions and press releases. Respondents also mentioned the fact that bigger companies and smaller ones (in terms of revenues) have formed different associations since they have different agendas. It is normal to expect this differentiation but the situation is more complex in the study case due to the fact that two of the biggest operators are controlled by the Wealth Fund. In this respect, interviewees claim, *"…there is even no need for these operators for lobbying due to obvious reasons…"* and add that other sectoral associations have encountered problems in communicating with public organizations. Accordingly, *"...especially in recent years, public organizations in general do not consult our opinions and do not take into account the reports and opinions that we have prepared… They do not give positive feedback to our meeting requests."* Another participant complained about insufficient participation of these organizations in legislation-making processes. In their words, "…in case we have sent our opinions etc. this often takes *the form of unilateral consultation...after sending these, we are often not informed in later stages and no discussions take place before finalization of these institutions (regulations)."* These opinions are shared by Ms. Nebil (2023) in her article, again. She alleges that related public organizations do not want operators to make public comments and at the same time has tried to prevent conferences, whose topics could not be controlled by themselves. Having discussed this topic, it is understood that sectoral organizations, at least representing alternative operators, **do not think that there exists a satisfactory level of interaction** between public organizations and themselves. As a natural extension of this argument and thinking about various benefits of these organizations not only for their members but also for public in giving information, policy advise and accountability, it is certainly beneficial to increase interactions between these actors in different respects.

According to participants, this will also help in establishing a more participatory and transparent regulatory environment ***(Assertion- 4)***.

Before completing this section, it may be useful to briefly mention two other topics that can be considered in resource mobilization category. Similar to recommendations of joint infrastructure company, participants want policy makers to support sectoral collaborations as a means of resource maximization. As an example, one interviewee (Int. 4) told *"…Collaborations should be supported and encouraged, especially in a sector where significant developments in technology take place in a very short time. For instance, international cooperation should be supported between the operators already authorized in our country for LEO satellites and the companies that want to provide this service abroad."* to emphasize importance of this type of projects.

At this point, another topic is 'location-based regulation' that has been mentioned in the previous chapter. As stated, this type of regulatory approach has been found in several policy papers up to now but there is no specific implementation seen up to now. The author asked this question of whether participants find this as a useful tool for better resource utilization and provision of more tailored services to customers that have different profiles or not. It seems that there is not much support for this approach and some even argue that the regulatory framework has been suited for a general implementation and there may be legal problems in case it is applied in certain regions, e.g., different tariffs for the same service based on geographical locations. More specifically, one interviewee (Int. 5) has responded as *"Any regulation should be implemented uniformly throughout the country. If there is a suitable environment, the operators will already do the necessary work everywhere."* Another attendant (Int. 21) considers universal service policies can compensate these issues to some extent on the basis of income differentials. They point out some of the network investments that have been financed by the fund and recommend more extensive use of it to increase these investments. Moreover, some households' internet access can be compensated from this source according to them.

In sum, the author does not find unanimous support for location based regulatory approach from conversations with participants and at least, it can be concluded that this regulation is not in the priority list of sectoral needs and requirements, ***(Assertion-5).***

6.2.6 Knowledge Development, Education and Training

Since telecom service providers have been in the market for a long time and mostly used a given (mature) technology, one can say that there is not much novel knowledge generation activity among these companies. Notwithstanding to this, participants emphasize considerable degree of user-producer relations and learning effects for these firms in adapting/ using these technologies in domestic market. Furthermore, this general picture has also been changing due to increasing effects of convergence and development of ICT and other digital technologies in recent periods. Because of this trend, one can see acquisition activities in the sector as well. Especially with the advent of 4G (and later 5G), mobile operators begin to provide various digital services that necessitate some degree of R&D and inhouse knowledge development activities. As given in Table-47, bigger operators dominate R&D spending and patent activity in the sector. Interviewees mostly expect this trend to continue, due to scale, scope economies and large size of their budgets, after 5G transition, in which many other sectoral usages will be possible as observed in the study. Accordingly, they (e.g., Int. 22, 23) point out increasing demand for programmers and computer engineers in the sector as well. This is also valid for hardware production part. Indeed, the boundary between service providers and producers are blurring taking into account the fact that software and computer programming are increasingly becoming essential parts of network operations of these companies[364]. Although not analyzed in this study in a thorough way, participants draw attention to decreasing availability of qualified personnel due to (increasing) overseas job opportunities. Furthermore, working in home office methods for foreign companies (based in other countries) are another factor causing difficulties in finding suitable people, according to their opinions. On the other hand, some respondents have argued that the quality of university education is gradually decreasing in recent years[365].

Since, this topic is not mentioned much in other conversations, it is not further elaborated in the study, as well.

Apart from macro level problems and needs in education (in a sense main knowledge

[364] These issues are further discussed in Chapter 6.3.6.

[365] These issues are common to both of these two parts. A more general level of discussion does not mean that they are insignificant for increasing sector performance. On the contrary, "increasing quality of related education and at the same time increasing number of qualified personnel through these educations" form one of the most crucial aspects of any sectoral development policy in a long-term perspective. The study does not analyze these topics further because of size limitations and focus on more sector specific regulatory issues.

production source) subject, one thing in a more micro level should be mentioned as well. The regulatory authority has started educational programs in ICT fields. It is seen from ICTA (2021) annual plan that there are nearly 800.000 registered users in 179 different categories (and the numbers are continuously increasing), mainly related to software programming subjects.

Having observed increasing demand, this initiative can be considered as beneficial for helping people to gain some skills. When asked about this practice, respondents find it as a positive contribution to upgrade knowledge levels of potential and current employees in whole ICT sector. On the other hand, some of them questioned priorities of the regulatory authority. Int. (23) has made a remark as "*While the main problems in the sector remain and many projects have not been completed up to now, although beneficial, does this work lie among the most urgent topics of the ICTA?"* Here, one can argue that there are different departments of this organization and these projects/activities do not affect other works of different departments. However, taking into account various delays and uncompleted projects, it is also normal to ask this type of questions, according to participants. Furthermore, some respondents (e.g., Int. 7, 21) questioned the legal status of this project (these works), i.e., Are those kinds of education provision stated in the responsibilities of the authority in related legislations? At this point, one can at least say that it may be better to revise these topics (in a legal amendment etc.), together with organizational restructuring process, which is discussed beforehand. It may also be more suitable to continue this educational service under the umbrella of a wider ICT umbrella, i.e., inclusion of digital office responsibilities to ICTA and possible within a more specific ICT or existing industry and technology ministry.

A similar situation can also be observed in events/ activities hosted by ICTA in recent periods. A quick inspection shows the majority of events are related to cyber security and secondly (to some extent) software programming topics[366]. This does not mean

[366] For instance, the author has compiled some of the recent events hosted in ICTA. The name of these programs are: 'Cyber Shield', 'Cyber Security Drill (Exercise)', 'Opening of Cyber Security Training Program and Cyber Star Award Ceremony (Fetih Siber Talimhane Eğitimleri Açılışı ve Siber Yıldız Ödül Töreni in Turkish)', 'Hacktrick Cyber Security Conference', 'E-safe Cyber Security Summit',

that these are irrelevant, but it can be used to show preferred topics as opposed to regulatory issues in telecommunications sector as argued by some participants, (e.g., Int. 21, 22 & 23).

Apart from this role, ICTA is also preparing several reports to serve as an information source for the interested parties. Respondents consider ICTA and few other organizations as information providers in the sector. It should be mentioned that especially "Quarterly Market Reports" are found useful by sector experts. In the words of one interviewee *"…ICTA has published …reports quarterly. however, it is observed that some of the data disclosed have been reduced…on the contrary more details and topics should be included in this report. For instance, it would be appropriate to include data center management and cloud services…"* Similarly, contributors (Int. 1 to Int. 8) want a more detailed report giving information on different segments of the sector. For instance, coverage details of broadband and mobile connections both in terms of types and regional bases are among the most requested statistics by the respondents. Moreover, provision of universal service and network resilience statistics can be considered as well. The preparation of these new types of data may take time but it will be beneficial for increasing information available to interested people. Especially, as network resilience topics have begun to take more place on the public agenda after the earthquake, provision of various figures related to network incidents and failures can provide feedbacks to market actors as well.

Apart from regulatory organization, other most cited ones include (in this context) Telkoder, Tubisad and afterwards TOBB. Some respondents have also argued that bigger operators should provide more reports, knowledge sources to inform public about the developments, trends and problems related to the sector. In the end, participants consider these knowledge sources as beneficial for not only sector actors but for all interested people as well. Nevertheless, some of them want public organizations to pay more attention (or interest) to prepared documents, reports in their

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'Digital Gaming Workshop and Seminar', 'Data Management Technologies Platform', 'Cloud Ankara Event', '3rd International Intelligent Transportation Systems Summit', 'Safe Internet Day', 'Huawei R&D Coding Marathon', 'a1g0ritmAnkara Project', 'ICTA Career Summit', 'Cooperation Protocol Signing Ceremony between the Ministry of Youth and ICTA (BTK)'.

regulatory works. Lastly, one can mention the observation that learning by doing and on-the-job- training are considered as essential sources of knowledge exchange and learning sources especially for new recruits. It should be noted that the situation is similar in production related part, which is discussed in section 6.3.6. Apart from this and particularly relevant to services part, dominant operators' have extensive training programs for their employees as can be seen from their web sites[367] and from respondents' views. This observation also indicates the resource capacity (e.g., financial sources) differentials between bigger operators and other firms that are active in the sector. In this subject, as detailed in the study, experts think that increasing number of conferences related to sectoral problems and number of related documents can be beneficial for knowledge exchange and learning activities, as well.

6.3 Telecom Equipment Production Part

As seen from the above discussion, some of the issues are also related to equipment production part of the sector. For instance, some arguments about difficulties in finding qualified personnel (discussed above) are valid in this section as well. Taking into account this fact, this part will focus on more specific issues that are on the agenda of the sector actors, which are mainly involved with equipment (including software) production. Nevertheless, some similar topics are also put forward by participants and these are stated in more brief terms. It should be mentioned that, as in the previous section, while the section follows main functions in general terms, emphasis will be given to derived findings (observations) and participants' views on main problems.

6.3.1 Market Structure and Formation

As known, Chapter 5.5 summarizes the works and projects aiming to increase domestic sectoral production capability in a historical perspective, especially after the introduction of mobile telecom technology in the country. Before starting to discuss main issues with participants, it may be useful to highlight two policy tools that has shaped the market development. These attempts have been firstly started after 3G authorizations with purchase requirements of mobile operators from vendors that had R&D branches in the country. After 4.5G authorizations, these operators have more

[367] As an example, apart from providing in-firm training services, Turkcell has a web site called 'Turkcell Akademi' from which several programs can be provided to customers as well.

stringent domestic product purchase obligations of up to 45% from their total network investments. This policy has influenced market formation which would have been different if there is no such a regulation from the start. At this point a relevant question asked by respondents is “how much is the difference in reality?” and the study will discuss this point below.

At the beginning, participants mention ICTA, MTI, MT and DTO as main public organizations that have relations with their firms. They state TUBITAK, Technology Development Foundation of Türkiye (TTGV) and technical universities among main research organizations. TELKODER, Software Manufacturers Association (YASAD), Turkish Electronics Industrialists Association (TESİD) are presented among the active non-governmental associations according to respondents.

It is interesting to note that some interviewees (Int. 9, 10, 11) include CTC (Communication Technologies Cluster) in this category owing to the reason that, it helps to make their voices heard in various channels (according to their opinions).

On the other hand, there are much more commercial actors related to this segment in one way or another, e.g., especially software firms, taking into account convergence effect. Indeed, when asked about the categorization of telecommunications sector as services and equipment production, some experts have included software products to this categorization.

For instance, one participant (Int. 9) positioned their firm as “software products and services that include value-added digital services”. Other one (Int. 10) put their firm in the same category giving a more detailed list including operation support systems and network management software products, services. Int. 11 & 12 define their firm as *“we are a company that can provide end-to-end solutions in the telecom industry.”*

Accordingly, it should be mentioned that the study has also included software and computer programming (related to network operations) to equipment part.

Notwithstanding to this, one can (similar to the above classification in services part) divide these companies as dominant (bigger) and other (smaller and mostly domestic) businesses in terms of market revenues and shares. Dominant players are also global scale vendors that have presence in other countries of the world. These are mainly Huawei, Ericsson and Nokia. After these comes some other foreign owned ones like ZTE, Samsung and Cisco.

Participants point out the increasing share of Huawei in recent years as opposed to other two firms' dominance in the early years of the market, i.e., GSM phase.

Although there is no specific market share ranking, one CA Board Decision[368] has given a detailed picture of these companies in the supplier category, which is confirming participants' observations.

The list comprises of base stations, antenna, towers, power systems and battery, air conditioning and core network categories[369].

Interviewees (Int. 10 to 14) point out towers, air conditioning and power systems as categories in which domestic firms have relatively more presence in the market. Among them, especially tower category is dominated by those firms due to nature of the business, i.e., construction and need to use local inputs such as steel etc. In the other two categories, both foreign and domestic firms are active and make business in the market.

These are also relatively not in high tech part of networks as opposed to other parts such as base stations. At this point, it is worth looking at the firm level sectoral study examined in the chapter 4.5.2.2 (related to a Chinese firm). As noted in this case, these global firms aim to maximize their scale and scope economy advantages and use various marketing strategies to establish their presence in foreign country markets. Participants (Int.13, 14) argued that *"…they can provide whole network and can make considerable discounts in some parts knowing that if they get the deal then there is also a long term after sale relations between these parties…"* In this context, it is understood that while domestic firms complain about competition disadvantages due to these marketing strategies of global vendors, customers (mainly three operators in

[368] Competition Authority Board Decision dated 30.05.2019, https://www.rekabet.gov.tr/Karar?kararId=f2ee2700-f4af-4c6b-83b5-ca4fbba08a57

[369] *According to this list, main firms in each category is as follows, base stations (Huawei, Ericsson, Nokia, Samsung, ZTE, Ulak), Antenna (Kathrein- Ericsson, Commscope, Huawei, Comba, Tongyu, Aselsan, Mobi), Towers (MİTAŞ, ERSAN, BARAN vb.), Power Systems and Battery (Huawei, Ericsson, Nokia, ZTE, Emerson, Delta, Leoch, Shuangdeng vb.), Air Conditioning (Daikin, Arçelik, Alarko), Core Network (Huawei, Ericsson, Nokia, Cisco, Mavenir, Affirmed, ZTE).*

the sector) argue that there are not enough domestic products in certain categories and companies could not get every item, which meets adequate standards, on time.

This point leads one to other side of the coin, number of customers (potential buyers) are far less than service part where there are millions of consumers (end users) that want to purchase mobile telecom services. Indeed, there are three main customers for nationwide network establishment and after sale services with the exceptions of other (relatively) small-scale buyers in different ICT categories[370]. This gives some kind of countervailing buyer power to these operators but it is argued that business relations are medium to long term between these companies, which means reducing this power to some extent, (especially in the short term). However, this buyer power is much more for domestic product sellers according to participants views.

Apart from these considerations, establishment of CTC and ULAK has affected market developments to some extent in recent years. Although several topics related to these projects are further discussed in the below sections, some concerns of participants related to market formation are mentioned in this part. First of all, it is clear that the market for these (domestic) products is an artificial one (especially for those in high tech part) formed by regulation and supported by public organizations (especially by ICTA). In spite of these efforts, the current outcome is far from satisfactory especially when looking into details of implementation process. In simple terms, one can examine share of base station numbers, produced by this domestic firm, in total amount. There is unfortunately no regular and/or publicly available statistics in this regard and according to latest available figures (dated 2021), there were nearly 200 thousand base stations in the whole country. One participant (Int. 10) has mentioned about 2000 active base stations produced by ULAK, making 1% of total number. This is an undoubtedly low figure considering the fact that majority of these base stations are purchased by using universal service fund. There are many factors for this outcome as mentioned above. Some participants agree that operators have encountered difficulties in getting domestic products in accordance with their quantity, quality and timing considerations. This is an expected argument given investment requirements (i.e., coverage, quality of service etc.) of operators and small-scale production capabilities

[370] It should be noted that as it is seen in the related study (Chapter 4.5.2.2), these global vendors have many other products and services but these are not included in our study topic.

of ULAK. The situation is getting more difficult taking into account very large scale and scope economies enjoyed by global vendors.

At this moment, it can be said that necessary attention should be given to these observations before 5G auctions and related measures should be taken for domestic producers to reach the required capability. Otherwise, similar problems can be encountered in 5G related purchases, i.e., time delays, quality considerations etc.

6.3.2 Guidance of Search

As a brief summary, there are various objectives in high level policy papers since the beginning of 2000s, (Chapter 5.4.5). Starting with 9th five-year development plan (2007-2013), public procurement policies to support development of ICT infrastructures have been included in almost all of these documents. For the first time, 10th Five-year development plan (2014-2018) stated importance of vertical sector usages and emphasized development of these applications along with software sector. Before 11th Five Year Development Plan (2019-2023), 'ISAP' and 'NBSAP', covered wide ranging topics in ICTs along with telecommunications topics. Among these, 'domestic production and R&D support' was particularly related to efforts on increasing sectoral production capabilities. Moreover, the focus on vertical usages had been detailed including smart cities program, smart transportation systems, cloud computing etc. in these documents.

In spite of these various policy documents, participants do not have optimistic opinions about their implementation in practice, in line with those in the services part. To begin with, they think *there is no vision and furthermore there is no authority and willingness to form a vision.* At this point, Int. 11 added that "…*unfortunately this is left to the initiative of companies*…" When asked about the existence of policy goals that are observable and reliable, one interviewee responded as *"…although some high-level strategic plans are made, implementation and follow-ups are not effective."* In this respect, it is understood that the situation is similar to analysis in the service sector where **implementation and post evaluation problems** have been discussed very often. Moreover, some participants regard the problem of *ownership in communications sector (in their words, meaning several responsible organizations)* as the biggest obstacle in front of establishing and implementing vision, policies and argue that different government organizations claim some parts (of the whole picture), leading to inefficiencies (delays, overlaps etc.) in practice.

Without repeating similar arguments, one of the main policy objectives of these plans can be discussed further to shed light on those problems. In fact, this objective (i.e., procurement of domestically produced equipment in predetermined rates) is stated in license agreements of operators and are legally binding provisions as well. As it is examined, although these R&D and procurement requirements are beneficial for increasing capabilities of the domestic sector (in fact one can argue that there would be complete dominance of foreign vendors if these regulations had not been introduced), some problems have occurred in the implementation phase. The most controversial one is the realization of specific requirements, i.e., procurement of domestic products min. 30% in the first year, min. 40% in the second year and min. 45% in the third and successive years. Participants consider this institution as a useful guidance to sector actors for medium term but they have complained about inadequate levels of inspection and lack of transparency in implementation details. In official terms, policy makers have proudly spoken about the increase from 1% in 2016 to 33% in 2021. This means a growth of 3200% in five years' time. Here, there exists two arguments. One is that even though this increase is remarkable, it still does not satisfy formal requirements. Secondly, respondents are very critical for these official figures. Interviewees (Int. 11 to 16) have making criticisms about untransparent process of these calculation methods. When asked about whether they can follow the implementation of related regulations in a transparent manner, they responded negatively and even told similar words like *"No, it doesn't mean anything when they say that we have reached 50 percent in locality."* For the question of recommendations in this context, one interviewee suggested that product lists should be shared and the weight of foreign manufacturers should be seen. Moreover, it should be explained why products with domestic alternatives are preferred. Apart from suggestions of sharing product lists, weight of foreign products and reasons for foreign product preference, some experts question the relevance and validity of '**domestic goods certificate**', which is used in these calculations.

Participants think it is easy to get these certificates and according to them, *"…although it appears to be local on paper, it is of no use to the country in reality and there is no* *transparency."* Accordingly, it should be helpful to revise institutions related to 'domestic & national product concept and domestic goods certificate'. Indeed, Şimşek (2020) has drawn attention to this issue in several dimensions. As his title 'domestic product certificate game' indicates there are some problematic areas in this institution. Firstly, domestic contribution rate in a product should be at least 51% to get this certificate. Here, he questions the fact that there is no sectoral differentiation and, in some products, what is essential is to produce (for example) even 10% part which is a more critical component. Secondly, a company can use another domestic company for some kind of manipulation. That is to say, it can purchase some intermediate goods from domestic firms that imported these beforehand. Thirdly, he criticizes the approval of these documents by the Union of Chambers and Commodity Exchanges of Türkiye (TOBB), on the assumption that there may not be a rigorous process in obtaining these papers.

In this regard, participants have also criticized ICTA for not doing adequate inspections for the fulfillment of these obligations. Two interviewees point out to the fact that *"...even though, (they said) they could not find domestic products to buy, they knew from their licenses that they have to comply with these obligations…"* Similarly, in another article, Şimşek (2022) has also blamed the delays of regulatory authority in inspecting and penalizing mobile operators for not complying with this institution. According to him, regulatory authority acted very late and paved the way for foreign products of Huawei, Ericsson and Nokia.

Nevertheless, respondents still find these types of obligations useful for market development and want it to be retained in 5G licenses for guidance of future search and investment decisions. In fact, some of them have argued that in the absence of this type of regulations, global vendors can more easily operate by using their marketing strategies and there would be no development in domestic sector, at all.

They accept the fact that even though current picture is not so satisfactory, these regulations can help domestic firms to increase their capabilities in specific product/software segments.

In sum, as it observed several times before, they have emphasized the words **'nontransparent process'**, **'inability to follow detailed lists'**, **'inadequacies of**

domestic product certification' and **'inspection failures'** as problems in implementation phase. Hence, it can be concluded that there should be similar domestic procurement conditions in 5G licenses to increase production capabilities of (domestic) actors but implementation processes should be more transparent and observable by public with a revised procedures for obtaining domestic product certificates. In the end, to repeat, participants uniformly agree on the necessity of continuing similar regulations with the provision that implementation and inspection procedures will be in place from the start, ***(Assertions- 10 & A-10.1).***

6.3.3 Entrepreneurial Activity

To begin with, market entry and ensuing activities are not specifically regulated[371] in this part of IS as opposed to telecom services sector, in general terms. Telecom network products are main exceptions to this generalization and together with some equipment (e.g., wireless sets etc.) importers, they are subject to ICTA's regulatory approvals. Notwithstanding to this, one can add numerous software companies and even power supply producers to a very long list. In fact, there are about 7.500 enterprises included in telecommunications sector according to TSI (2021)[372]. Here, member firms of CTC show fairly representative sampling of companies that have operations (ranging from software, hardware to power and air conditioning systems etc.) in telecom network equipment part.

In any case, as it is seen from the previous chapter and above-mentioned arguments, few firms dominate this segment, but unfortunately there is no available statistics on specific market share information. In this picture, smaller firms (i.e., SMEs and entrepreneurs) have to compete with mostly global vendors with their (financial, expertise etc.) powers and market capture strategies. According to participants (Int. 12,13 14), market entry is difficult because buyers (customers) are looking for products with references. Especially foreign buyers have asked for references, before finalizing commercial deals. Indeed, entrepreneurs (Int. 10, 11) emphasize the critical role of getting references from domestic companies by saying *"…these are prerequisites for*

[371] This is used in the meaning of sector specific regulations. Otherwise, it is evident that any firm has different obligations imposed by various public organizations like tax payments and ensuring employee safety etc.

[372] https://data.tuik.gov.tr/Bulten/Index?p=Kucuk-ve-Orta-Buyuklukteki-Girisim-Istatistikleri-2021-45685

foreign market entry." Apart from this, they regard operators' buying processes as too bureaucratic. This is an expected consequence of above statements that mobile telecom operators have a 'considerable degree of countervailing buyer power' especially against domestic firms.

These considerations lead to necessity of additional supporting mechanisms especially for SMEs. At this point, establishment of CTC (HTK in Turkish) by OSTİM in 2017 can be seen as an attempt to increase entrepreneurial activity by mobilizing resources[373] with some support from public organizations.

More specifically ICTA coordinated the process by bringing various actors (especially SMEs) and helping to utilize TUBITAK's funds for the project called 'End to end Domestic (Local) and National 5G Communication Network Project'.

According to participants (Int 10 to 15), there are several benefits of this cluster formation.

One was the initial funding opportunity of 253 million TL from TUBITAK sources. Apart from this, many firms think that they have better reach to operators and public organizations as a result of (being a member of) CTC.

Indeed, this benefit is not insignificant, taking into account the fact that they are mostly SMEs, which have relatively lower bargaining powers and fewer channels of communication with related organizations. Int. (11) told that *"... coming together would generate synergies and form a more powerful stance against bigger actors… it has increased our voice in public organizations and we could organize events and trainings as a result of this establishment."* Moreover, they add that the cluster has beneficial effects in terms of knowledge sharing, productivity and innovation, economies of scale and marketing opportunities like participation in events, exhibitions etc. Respondents find number of firms in the sector sufficient but think their competences are low in terms of commercializing products (including software) that they have developed in general terms. This is similar to above observation that there are many players in different segments of network equipment production. Apart

[373] Please note that, as stated previously, some policy mechanisms can be related to more than one function.

from more standard segments (e.g., tower, air conditioning), software development companies can increasingly find opportunities in this sector as well.

However, one contributor (Int. 13) has stated that it is difficult to enter the sector because purchasing processes of bigger customers are quite complicated for entrepreneurs and called these (processes) as quite bureaucratic. At this point (in the conversations) too, the extent of operators' (countervailing) buyer power can be observed in the sector.

On the other hand, participants have different thoughts on the adequacy of funding and support mechanisms provided by public organizations[374]. In other words, there is not much consensus on the sufficiency of incentive mechanisms for entrepreneurs in this field. Some interviewees (Int. 12, 13) consider that supports are sufficient, but more criteria are needed in selection and utilization processes, i.e., allocation to right companies.

It is important to what level of expertise these funds will be given and whether they are private sector SMEs. In the absence of these criteria, when technology companies owned by operators and large defense industry/public companies demand these funds, those funds do not reach the right target.

This is in turn blocking the development of SMEs and entrepreneurs in the sector, according to their opinions.

In more detailed terms, respondents criticize the incentive system as having a complex structure leading to coordination and evaluation problems. That is to say, existence of numerous organizations in this field without an efficient coordination mechanism has reduced the effectiveness and contributed to inadequate levels of post evaluation analysis of the outcomes. Another point made in these conversations is that large scale firms has benefited more from these incentives than SMEs.

It should be noted that the main argument is the same kind of incentives that are shared by different scale companies. Int. (13) complained about SMEs same treatment (i.e., evaluation under the same conditions) with *'defense industry foundation companies*

[374] Please note that these issues are also related to resource mobilization.

(DIFC) and 'operator affiliated technology firms (OTF)', which sometimes leads to unfair competition in the industry. From these conversations, it can be understood that SMEs are somehow disturbed by the presence of these companies in the sector. These are understandable for following reasons.

On the one hand, DIFCs are state owned companies and compete with private firms in the market and in the allotment of funding resources, which are scarce and on the other hand OTFs are in essence a member of a holding company which already dominated service market and has a considerable buying power (especially) against small scale domestic firms at the same time.

As a last point, some respondents (e.g., Int. 16, 22) brought the objectives of what can be called 'import-substitution' oriented incentive provisions by public organizations, on the agenda. Here, participants have also emphasized the need for continuous evaluations related to development of sectoral competitiveness against foreign companies. In their words, *"…otherwise we will continue to support them indefinitely and as soon as these (incentives) are stopped then these firms may have lost their market shares and have encountered difficulties in selling their products…"*

In sum, participants see CTC becoming a credible organization whose opinion is consulted in the development of strategies related to the sector. They argue that the establishment has an accepted position in the eyes of both mobile operators and other public organizations, especially due to the support of ICTA. Linked to this argument, they think sectoral collaborations, which are also involving mobile operators as end users in most projects, are both useful and possible with collaborative support at hand (e.g., TUBITAK Sayem Support). However, they mainly criticize same kind of treatment given to DIFCs and OTFs as indicated above, as well. In other words, majority of participants (especially from SMEs) regard same kind of treatment given by public organizations to bigger, state supported firms and smaller sized businesses lead to competition and efficiency problems in the sector.

Accordingly, it is not easy to accept the notion that co-existence of two similar organizations (i.e., ULAK and GTENT) are leading to inefficient use of scarce resources, ***(Assertion- 13)*** on the condition that *a more selective support, funding mechanism will be implemented in the sector.* Apart from this, some participants even consider a bigger firm (whether state owned or not) is necessary to undertake more ambitious projects. At this point, they also point out that SMEs should not be excluded in these projects and ULAK (or a similar scale firm) can take lead role in joint projects, as well.

6.3.4 Legitimation and Counteract Resistance to Change

Since many of the points discussed in the previous section apply here as well, it will not be repeated in this part. Accordingly, the discussion will be limited to some of the issues that the participants emphasized. However, it should be noted that although there is one coin, it has two sides. It appears that small companies (that are in the production part) do not have much complaint about any resistance to new technology since they only take part in component production business (including software development as well) as opposed to operators' that face with some difficulties in base station installations.

Notwithstanding to this observation, one interviewee commented that there exists useful information in ICTA's web page about the regulation of base stations and they even used this page as a refence, when needed. Similar to the findings (in the previous section), they recommend informing people more by using such information in various media channels. To summarize, it should be noted that there is no need to legitimize production of these equipment by domestic firms. While there are health and privacy concerns associated with their use, people's needs and demands (for this technology) easily surpass these concerns.

Another factor that increases legitimation (of domestic production) is the growing concern for national and cyber security risks in every country of the world. As indicated previously, many countries have legitimized their efforts in minimizing use of foreign technology by using need for security arguments. It is certain that there is some truth in this argument as people live in an (increasingly) digitalized world. One can give too many examples for the sensitivity of these digital applications provided from mobile telecom networks. Vertical usages range from autonomous vehicles to management of smart city components (traffic, electricity, surveillance management etc.) and security risks, incidents (interruption of service, theft of data etc.) in one of these may bring in catastrophic results. In this context, for instance, USA government has led the campaign of blocking use of Chinese equipment throughout the world, in varying degrees of success. Main arguments behind this campaign are given by them (USA Government, 2021) as *ownership of Huawei is not transparent, the company has a history of illegal practices and China does not have a law on prohibiting the misuse of data.*

Without going into further details (since some of these are discussed previously), notable countries in Europe to follow this were UK and France. Especially, BT (in UK) has announced that taking out Huawei's products from the core network will require 500 million pounds of expenditure. Here, Germany's attitude is not so clear cut compared to these above-mentioned countries. It appears that German government do not want to impose specific bans on a single company and may prefer increasing security provisions & standards for all market players in this category (Pitel, 2023).

Indeed, some recent cases in this country shows the risks of any foreign technology (even an allied one) like banning use of Microsoft 365 in schools on privacy concerns.

This example is particularly relevant for (our) the case study, as well. Huawei is the dominant player in the sector and no arguments against this company have been found in the sector up to now. However, at this point, respondents have claimed that every foreign technology has some kind of risk and for this reason the best way is to use national technology[375] at all. They added *"...taking into account the fact that this is not hundred percent possible, we should increase our security standards and precautions as well."*

Apart from these security concerns, there is also some truth in socio-economic domination arguments. It is known that there exists a technology war between two superpowers of the world now (Weinland, 2022). USA government is extending restrictions and bans on Chinese companies in high tech related products and applications and urging her allies to follow these policies in these areas as well. In this context, security arguments have also been used for legitimization of this dominance struggle. As mentioned, some countries are still prioritizing economic considerations (e.g., Huawei's low-cost offerings etc.) as opposed to some others like UK that accept

[375] Please note that even in this case, no communication technology is exempt from security risks. Hence, continuous security checks and measures should be necessary in any case.

some extra costs in network investments. This point leads to another legitimization tool, namely 'reduction of foreign trade deficit' of the country. The argument is focused more on reducing import expenditures of mobile telecom operators in the domestic market. Indeed, policy makers are using this reasoning to increase legitimization of those activities. Notwithstanding to importance of this argument, it is evident that, production for mainly domestic market can also be counterproductive in the long run. Here, participants (e.g., Int. 13, 22) especially underline the need for prioritizing some parts of the network, as discussed in resource maximization section. On the other hand, Int. 15 has pointed out some concerns of mobile telecom operators (i.e., inefficiencies resulting from these obligations) but they claim that, these operators knew the obligations and included these in their valuations (i.e., paid amount), beforehand.

In the light of these observations and discussions (with the participants), it can be concluded that sector players need to intensify their efforts to develop critical parts of the network with domestic capabilities. At the same time, increasing the ability of industry actors (operators and public institutions) to monitor possible security risks of foreign technologies should also be taken into account in this context.

6.3.5 Resource Mobilization

It is already mentioned that several high-level government officials (including the President of Türkiye) have stated importance and their commitment to increase the (country's) sectoral production (including technological) capabilities with strong words like *"...we won't pass to 5G unless we construct our domestic 5G network infrastructure".* In spite of such statements, participants in general do not think that there exists a strong commitment and resource mobilization to achieve this target, in practice. This does not mean that there is not any effort, but these are clearly not sufficient for this objective according to participants' opinions. Notwithstanding to this observation, some contributors (Int. 9, 11) consider these statements as a general direction rather than a concrete goal in a short term.

Several other respondents share this opinion and think that whether there is a general direction or not, this is an unreachable target in the short/ medium perspective, especially given current capabilities and financial, human resources at hand. For this reason, majority of participants prefer some kind of prioritization in network parts, along with more specific and larger supports. A more detailed analysis of which components and/or specific technology areas to be prioritized is beyond the scope of this study but in any case, participants prefer more attention given to software products since these are less dependent on resource capabilities. In the words of one respondent, "…RF equipment production requires a long-term experience and capabilities than software related products. Furthermore, equipment production necessitates much more time and investment in the form of testing, trials before final usage etc." In this regard, they emphasize core network products (software based), operations support and business support systems (OSS and BSS), other software like billing management etc. After these types, some others recommend focus on hybrid products such as software installable hardware like remote radio unit (RRU) and later base band units (BBU), and antenna equipment, all of which basically complete a base station. Accordingly, (it appears that) participants believe most of the related equipment components can be produced in a well-planned time frame, ***(Assertion- 11)***. However, various supporting conditions are obviously necessary for this planning to be successful in the end. First of all, it is evident that production of these equipment makes sense in a larger scale as opposed to the current practices in existing situation.

In this regard, availability and allocation of financial resources are another indicator for this category, as well as supporting entrepreneurial entrance and activity in the sector. As it is seen from the previous section, public organizations have introduced several incentive mechanisms to support especially SMEs in the related segment of the sector. In this respect, they regard TUBITAK, MI&TECH and MT (e.g., e-Turquality supports), as main funding sources of the sector. What is more interesting here is that they have not mentioned MTIs funds, the reason for which is discussed below, that can be used for resource mobilization and market support.

Here, both quantity and provider of these sources can be analyzed to get a clearer picture of the situation. Firstly, although participants have found initial funding provided by TUBITAK was not sufficient, they think that together with other benefits of being in a cluster, it is a useful starting point for this project. Apart from TUBITAKs other funds (reviewed in the previous chapter), MTI, which is a main actor (along with ICTA) in 5G Policy, has various resources that can be used for this purpose, as well.

However, participants have added Ministry of Transport's Transportation, Maritime and Communication Research Center Presidency (UDHAM) funds as a potential resource complainingly, since this (source) has not been used since its foundation **in 2018.** In fact, Int. (11) criticized the ministry for not using this resource in spite of the fact that policy makers have used very assertive slogans of domestic and national telecom networks. Without going into further details[376], it is observed that the latest meeting between this organization's officials and mainly CTC (not limited to) member companies have been made in June 2023.

Since the meeting's subject is 'R&D Support Call Information Meeting', one can deduct that there is not yet an actual funding or supporting project started and implementation may begin in 2024. If history is a lesson, then even this prediction may not be realized given five years of non-implementation period.

As another essential topic, although participants support the statement that *public procurement and adoption of usage cases developed by domestic firms should be prioritized to increase indigenous production capabilities*, ***(Assertion- 12)***, there are some problems in application stage. In spite of this obvious statement (in addition to various similar statements in policy papers about public procurement), they don't believe that public organizations wholly commit to this policy in practice.

For instance (more related to this IS), some participants also criticize MTI for not supporting domestic production by using universal service funds in a manner parallel to resource maximization and ambitious objectives. In more detailed terms, some respondents argue that universal service funds should be used to purchase only domestic products, but they claim that (mostly) a global vendor's products' have been purchased from this source. Indeed, this is similar to public procurement and policy makers should use it for supporting domestic firms. Accordingly, it may be appropriate to ask the question that how can production and sales quantities be increased to meaningful numbers, given the situation that more limited universal service fund purchases are not completely made from domestic products. Linked to disappointments (of participants) related to MTI, sector experts propose some other

[376] Please see Chapter 5.4.2 for a more detailed analysis of this organization and its fund.

solutions, similar to those found in services part. As a policy initiative for resource mobilization in a sense, one replier (Int. 12) has recommended establishment of a more specific ministry by using these words as *"...Although there are specialized ministries that have budgets and structured in the fields of education, defense and health, which are the main responsibility of a state, there is unfortunately no separate ministry for telecommunications. Even the ministry has no 'communication' word in its name*". According to them, therefore, a high-level strategy could not be established due to the responsibilities distributed to each public organization at certain rates. Although ICTA has authority on this issue, it is imperative that there should be a ministry at the top and only responsible for communication. Another one (Int. 13) continued the discussion by saying that telecommunication responsibility of state has direct and indirect effects on many areas such as defense, health and education, which are its' other responsibilities. They have also suggested that, the Ministry of Communications should be established in the first place and other organizations in this field should be restructured under this Ministry.

6.3.6 Knowledge Development, Education and Training

Participants consider universities, institutes and companies that have R&D investments are among the main sources of knowledge development in the sector. In this context, it should be stated that respondents agree on the low level of novel knowledge production as can also be seen from the comparatively small number of patents (obtained in the IS) vis a vis some other countries such as China and South Korea. Furthermore, in a more general context, universities are regarded as primary educational organizations that provide human resources for the sector. Participants see some other public organizations educational and training activities as beneficial for development of this source, as well. On the other hand, they find on the job training as essential for their employees to satisfy work requirements.

This is more particularly relevant for new recruits, who they think do not have necessary skills either because of inadequate experience or insufficient quality level of university education.

Before proceeding to other specific issues, it may be appropriate to mention education related topics. Without making repetitions, participants consider availability and quality of ‘human resources’ as another essential issue to be dealt with a detailed and at the same time comprehensive public policy. Indeed, this topic has also been regarded in financial problems category since human resource costs have increased two to three times due to the pandemic and inflation in the last two years, according to their arguments. At this point, Int. (22, 23) indicate the fact that, there are different issues and time frames in this topic. One is the need for increasing both quantity and quality of university education in ICT related subjects. They (and some other respondents as well) consider this as a long-term policy and mainly in the responsibility of university level education regulation organizations, i.e., especially Council of Higher Education. Furthermore, same respondents (as indicated in several EU policy papers) have reminded vital role of lifelong education, even starting from preschool periods to prepare both necessary human source and expand digital literacy (e.g., learning use of digital applications etc.) throughout the society.

It is understandable that further discussion of educational needs is outside of the study’s main topics. Nonetheless, due to critical role of this topic, it is worth repeating some observations and mention few educational (human resource) issues that participants bring to the forefront of these discussions. Together with rising costs of hiring qualified personnel, some respondents have complained about decreasing quality of university graduates in recent years. This study does not make any generalizations about this type of complaints, but it is normal to expect policy makers to consider these arguments from business people. Secondly, some participants also do not consider global vendors’ employment policies are very beneficial for contributing to local human resource capabilities. According to them, they hired some personnel that had previous experience in these companies, but could not find their capabilities (qualities) much different from others. In fact, they connect this to the argument that these people had not been given responsibilities in R&D related works (in global vendors local establishments).

Similar to the above observation (in this paragraph), the study does not make any comprehensive inferences about these alleged practices of these vendors. Thirdly, increasing working opportunities in abroad and/or home-office working in foreign based companies definitely seem to exacerbate these problems. One can state some opposite arguments that these are also increasing experience and well-being of Turkish engineers (in ICT sectors) at the same time, but it should be reminded that the study's main focus is on the working performance of Turkish telecom IS in a short- and medium-term perspective.

Lastly, educational[377] activities of ICTA have been discussed with participants. This issue is also mentioned in chapter 6.2.6. Respondents (especially in the equipment production part) generally find ICTA's mostly cyber security and software programming educational services as beneficial and do not comment on this further. Similar stance exists in the 5G and Beyond Partner graduate support program as well. Here, they want the number of scholarship holders to be increased more, in the coming years[378]. However, Int. (12) mentioned one negative development that one operator (as one of the fund providers) has withdrawn from this project[379].

It is early to observe whether this incident has a negative effect on this program or not, but certainly not a good development taking into account the participants' expectations to enlarge scope (e.g., increasing number of scholarships etc.) of this program. In the end, participants want from ICTA that these supportive programs/projects to be expanded and more attention should be given to projects such as 5GTR Forum, which seems to be not actively working and 5G Test Valley, according to their opinions.

When asked the question related to availability of (knowledge) infrastructure elements, interviewees (Int. 12 to 17) find testing facilities as inadequate and admit that they have made use of international knowledge sources in software areas.

On the other hand, there are very few patents and publications originated from the sector, indicating low degree of (novel) knowledge generation. Indeed, this issue has

[377] Please note that, this word is used as a general term covering all kinds of educational and training activities such as software development courses and cyber security related trainings etc. At the same time, one should not consider them as specifically tailored to individual company needs (i.e., replacing on the job training etc.) since they are designed in the general objective of developing human resource capacity in ICT related topics.
[378] According to most recent data, the total amount of researchers has been reached to 99 since 2018, with the addition of 13 new ones in the 2022-2023 education year.
[379] The participant did not want the name of the operator to be written since this news has not been publicly disclosed.

been examined in an international context, especially with an emphasis on leading global vendors such as Ericsson.

Without repeating these arguments (and particularly leading country firms' patent numbers and R&D expenditures), one can look at some data related to Türkiye's context.

Table 50- 5G Specific Patent Applications

Year	2017	2018	2019	2020	2021	2022	2023	Total
Number of Patent Applications	7	7	20	13	12	16	7	82
Number of Registered Patents	2	4	11	4	8	10	3	42

Source: Turkish Patent and Trademark Office (TPTO)
Search Criteria: "5G" or "5. Nesil" or "beşinci nesil" / enhanced mobile broad_band" or "eMBB"/ "ultra-low latency communication" or "urLLC"/ "massive machine_type communication" or "mMTC"

Even looking into data given in Table-50 shows very low level of patent numbers in the IS, as compared to other leading ones.

The fact that the leading company (Huawei) had over 5600 5G patent numbers as of September 2021, indicates the extent of difference in terms of this category. As another (and more general) comparison, Table-51 gives patent applications in a broader classification[380].

Table 51- Patent Applications in Different Countries

Years	Türkiye	Europe Patent Office	USA	Japan
2018	343	15.300	28.727	8.707
2019	287	14.268	32.035	7.332
2020	214	14.565	35.018	6.167
2021	186	8.896	34.237	4.108
2022	84	2.211	24.635	2.346

Source: Clarivate database, Yalçıner Patent Office

[380] HO4w Wireless Communications Networks. It should also be stated that, any company can apply to foreign country patent offices and the general purpose here is to indicate the differences in general terms.

These figures also show the position of the IS in comparison to others, in terms of a broader categorization. Returning to more specific patents (with 5G heading), one can see the dominance of telecom service providers and universities as opposed to equipment manufacturers. It is not very meaningful to further compare patent data given inadequate situation, but it may be interesting to note this discrepancy between the IS and other countries.

For instance, Turkcell, Turk Telekom and Vodafone have more than one patents and in university category especially Istanbul Medipol University has stand out as the leading patent holder. On the other hand, Huawei, Qualcom, Samsung, ZTE, LG, Nokia, CATT and Ericsson had more than 70% share in the total number of 5G patents all over the world, as of November, 2021, (IAM, 2021)[381]. Apart from patent activities, levels of R&D spending and R&D related personnel numbers (per company) are also very low in the IS as compared to other leading country sectors. Here, it is sufficient to look only Ericsson which is examined in other country IS examples and in **Appendix-D**. This company's R&D department has nearly 29.5 thousand employees, which amounted quarter of the total employees and approximately 4.7 billion USD R&D expenditures in 2022.

Apart from specific company statistics, participants point out general trends of R&D spending related to the IS. Total R&D spending from central government budget had become 6,7% for telecom, transport and other infrastructure category in 2021 figures according to TSI. Unfortunately, a comparable data has not been published by the organization either before or after this date. Furthermore, since the category covers three different segments (i.e., transport, other infrastructure and telecom), there is no way to see exact amount of each one. In addition to this, private sector R&D spending can give some indication of knowledge development level of the IS. Here, relevant OECD statistics[382] show not an optimistic view on this topic, especially in recent years. This amount had reached to its peak in 2015 with 512.42 million USD (in PPP dollars) and then continuously decreased after this peak year. It became 222.19 million USD in 2020 (the latest year showing this data) after decreased as low as 100.48 million

[381] Please note that there are different 5G patent categories. Since the main aim here is to see general trends, these distinctions are not important for this study purposes.
[382] https://www.oecd.org/sti/inno/researchanddevelopmentstatisticsrds.htm

USD in 2017. Within the background of such data, participants are not very optimistic of reaching competitive powers especially vis a vis the global vendor firms and their countries in telecommunications sector as a whole. Notwithstanding to this, they (inevitably) see two paths in this regard. One is prioritization or focus on some parts of telecom (more broadly ICT) and the other one is to increase both quantity and quality of patents in general terms, in a longer-term perspective. It is evident that detailed analysis of patent policy is beyond the scope of this study but, some of the participants' comments are briefly mentioned here. Int. (22) have said that, *"…this topic encompasses several different areas and it can be emphasized that even elementary school curriculums should be revised to give initial knowledge of this, let alone revision of university education to support thorough patent policy. We can add many others such as need for revisions in tax, incentive policies and inspection of techno park firms that even do not have one patent after many years of working in such environment etc."*

These arguments also lead to topic of university-industry collaborations that are indeed among the most discussed issues in industrial policy settings of many countries.

At this point, participants admit a small number of firms has working with universities in some projects.

They think that although firm-university interactions[383] are developing, they are not at the desired level and should be increased considerably. Linked to this argument, Int. (11, 12) said that *"...Although we are sometimes participating in joint development projects, we are not satisfied with the level of these programs…"*

Here, the limitedness of such programs, the skeptical approach of the companies as a general attitude and lack of sufficient experience in commercial modeling of outputs are stated as reasons for low level of joint projects. Notwithstanding to this, most of the respondents want joint projects should be encouraged more. They believe it is more beneficial for companies to question each other in successive works, rather than the

[383] Unfortunately, there is not much available international and up to date data in this context. For instance, World Bank prepares an internationally comparable 'University-industry collaboration in Research & Development index' but the last one dated 2017, gave value of 66 for Türkiye. A more recent one can be found in Global Competitiveness Report (2019) and in this report Türkiye ranks 86th (out of 141) in multistakeholder collaboration category, where Israel occupies the first position.

support institution's supervision. However, there is also a need for an authority to find a solution in some cases, according to their opinions.

The general consensus on the availability of user-producer interaction (collaborations) have also regarded as insufficient. One interviewee (Int. 10) told that "*Commercially offered solutions are made on a project basis and as a project that solves the operator problem. Being a product only gains meaning when it is offered to other operators and multiplied as an export.*"

As a last topic in this heading, interviewees mention some knowledge exchange activities that are implemented by themselves.

It is understood from the participants' words that firms are participating in exhibitions, conferences and sending employees to such kind of activities. Some of them have supports for their employees who are continuing graduate programs.

They expect some benefits like increase in the quality of work output etc. as a result of such kind of trainings.

6.4. Concluding Remarks

Having analyzed interview results, this section briefly states main topics encountered during these meetings. Since further comments and evaluations will be included in the conclusion part, a separate summary of above analysis is not made at this point.

Nevertheless, it is evident that nearly all participants from both sector segments see common obstacles in functioning of the IS as a whole.

Among them, most crucial one can be expressed as existing regulatory framework in structural and organizational aspects. In other words, conflict of interest problems, overlapping organizational roles and inadequate levels of adherence to good governance principles such as transparency, accountability can be seen almost in each function heading as principal reasons for more specific regulatory problems by sector actors.

In terms of functional categories, one can also point out some topics to conclude this section. For the services part, in market structure heading, participants concentrate on competition problems and complain about the resulting dominance of three operators in the sector. At this point, interview results show that sector actors expect new market opportunities with the introduction of 5G, provided that necessary institutions will be implemented by the (regulatory) authority. For guidance of search and resource mobilization functions, respondents think that public organizations have failed to generate a sectoral vision and attainable policy objectives as well.

The situation in knowledge development function is not successful either as reflected in interviewees arguments related to difficulties in recruiting qualified personnel and decreasing quality of higher education, among other factors.

One can derive similar inferences from the interviews more related to equipment production part of the sector. In fact, same sort of problems in guidance of search and resource mobilization function categories are also observed in this setting including presence of similar public organizations that have overlapping responsibilities and resulting time delays etc. Furthermore, market actors especially demand utilization of policy tools such as universal service and R&D funds from related organizations in supporting domestic sector, without further delays.

In sum, it can be said that if policy makers are planning a sectoral reform, they should start from the fundamental topic, i.e., revision of regulatory framework and structure. Referring to main problems that are given in the introduction part (Section 1.2), the interview findings single out this issue as a fundamental systemic and structural problem that impede the effective functioning of the IS.

In a sense, sector experts regard existing regulatory framework as the main problem instead of considering this conducive to solution of specific topics for the development of the sector. Similar comments can also be made in the context of production and innovation capabilities of Türkiye’s eco-system in the field of 5G Technology. According to interviewees, already inadequate capabilities and resources of the sector could not be utilized to maximum effect due to these regulatory failures, as well. With these observations in mind, the next chapter provides a more detailed evaluation of problems and possible policy recommendations to reduce these obstacles in the more efficient functioning of the IS.

CHAPTER 7

7. POLICY RECOMMENDATIONS AND CONCLUSIONS

This chapter has three parts. Starting from summary of main conclusions, second part gives several policy recommendations to be considered for the improvement of sectoral problems and inefficiencies. Third part discusses some limitations of the study to shed light future works in this subject.

7.1 Main Conclusions Revisited

Having analyzed various documents and observed participants views on the IS, it can be said that there are many problems and bottlenecks related to the sector. Like any sector, some of them are related to more general economic conditions, while some others remain more sector specific ones. In the first category, some topics has come to the foreground of interviews. Although, these are not at the core of this study (scope), they are nevertheless essential for functioning of the IS[384].

Among them, taxes and similar kind of financial burdens are one of the most heavily criticized topics by most participants from the private sector. In fact, they point out decreasing revenues (in real terms) and consider (heavy) financial obligations play an important role in this outcome, along with deteriorating macroeconomic conditions of the country. From firms' point of view, they bear a heavy tax and fee burden and have become a serious tax revenue generator for the state. They argue that it is necessary to optimize this burden on both business firms and on last users. Without going into more detail, if one thing is stated in this subject, it is the observation that main actor is MTF and not MTI or ICTA regarding these issues. Although, this is a simple statement in reality many policy papers seem to be prepared without thorough consultation with this actor. Indeed, most of the policy papers, related to telecom and/or have telecom

[384] Please note that some policy recommendations for these general topics are discussed in this part, as opposed to more specific policy recommendations in the next section.

sector part, had objectives concerning reduction of tax burdens (especially related to last users, e.g., special communication tax) but, on the contrary, these taxes have been increased almost continuously[385].

Ironically, as a conclusion in this subject, it may be better to state that there will be no increase in any plan period, with the condition that MTF's opinion is obtained.

Parallel to the importance of human resource topic, which is related to more than one function like knowledge production and resource maximization etc., participants have expressed their concerns about this wide- ranging issue. In fact, respondents have argued about many things such as difficulties in recruiting qualified personnel and decreasing quality of university education. It is evident that these topics are more related to education provider organizations ranging from MNE, Higher Education Institution and universities to name a few of them. As a general conclusion in this subject, it is clear that policies and attempts to increase both quality and quantity of necessary human resource should be given more priority by related organizations, taking into account other country examples. The need for continuous education, digital literacy and lifelong learning has been emphasized in various EU policy papers, as well. Furthermore, increasing people's awareness (legitimacy and safe usage) are gaining even more importance with the passage to 5G technology and proliferating digital applications, vertical usages.

Another closely related topic to education and knowledge production is patent policy and R&D supports given to firms in the sector. Looking into related data, it is unfortunately beyond doubt that the IS does not have a competitive stance against the countries that have global vendor companies. Notwithstanding to this, the country should continue to develop her capabilities within limited resources in a long-term perspective. It is evident that both of these policies require a multisectoral approach as discussed in the previous chapter.

As observed, some participants consider a comprehensive patent policy covering even pre university education issues. On the financial side, it can be argued in general that

[385] As a more recent example, value added tax related to telecom services has been increased from 18% to 20% in July 10th, 2023, (https://www.turktelekom.com.tr/yardim/bireysel-mobil/faturali-ve-faturasiz-hat-vergileri)

relations between patent efforts and R&D supports should be emphasized more to increase these numbers in the medium to long term. As for short-term issues in R&D supports and in the light of participants views, some conclusions and related recommendations can be stated as follows. In general terms, it is observed that participants mainly criticize too much bureaucracy in in these procedures. Apart from more difficult improvements (especially increasing the amount of available funds given current macroeconomic conditions), this simplification in related procedures (e.g., shortening time periods and documentation procedures to obtain funding etc.) seems easier to implement in the short-term. Without going into details, they also point out the need for more emphasis on product commercialization phase. In any case, these recommendations should be evaluated in the context of a comprehensive R&D support policy revision that should be discussed with related actors in a participatory environment.

Having observed some of topics what can be called multisectoral issues, it is appropriate to focus on more sector specific topics[386] that occupy central roles in the eyes of sector experts. If there is ranking of them, 'current structure of the regulatory framework' takes the first position according to their opinions. In fact, most of the respondents[387] think there exists conflict of interest problem and redundancy of organizations that lead to inefficiency and unnecessary time delays in the sector, as stated in some findings of the study, ***(Assertions- 1, 1.1. & 1.2)***. Above everything, their most used evidence for this assumption (i.e., conflict of interest) is the fact that a deputy minister of MTI is at the same time chairman of the board of Turk Telekom. Of course, this is not a criticism for the person but people consider this as incompatible with one of the most important tenets of the regulatory framework, in a theoretical perspective.

In the second part of this discussion, it is evident that presence of public organizations with similar duties led to inefficiencies in the sector. As evidence for this assumption,

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[386] 'Sector- specific' word should be understood in the context that MTI and ICTA as the main actors in dealing with these problems as opposed to 'multi-sectoral' as the main actors are different such as TUBITAK in R&D funding etc.

[387] Please note that some of the respondents do not comment on this issue due to their positions. Some others told that 'they do not have enough information about details of regulatory problem but they also think there are many public organizations responsible for similar topics.' For some other details, please see Appendix- I as a summary note of these issues.

participants have sometimes observed power struggle and sometimes seen risk-shifting behaviour among the executives of these organizations. For this reason, some regulatory works (projects, problems etc.) have not been completed on time and even not completed (solved) at all.

These arguments lead to another statement of the thesis; existence of similar policy papers have generated some kind of confusion and lack of (for most of the time) ex post analysis reduced the effectiveness of these documents, ***(Assertion- 2)***. In general terms, participants do not seem to consider existence of similar policy papers as a major problem, but mostly agree on the unavailability of evaluations after their implementation periods. Closely linked to this, respondents uniformly think regulatory impact analysis are useful institutions and want to see more extensive use of this kind of evaluation works. Accordingly, it is easy to conclude that the number and coverage of publicly available regulatory impact analysis should be increased to evaluate possible costs and benefits of these regulations, ***(Assertion- 3)***.

In this context, another related issue is the observation of smaller players' difficulties in reaching to government officials. Indeed, respondents (mainly in service segment) have complained that especially in recent years, they could not communicate with the regulatory authority effectively either by meetings or written documents. Taking into account the fact that most of the bigger operators are controlled by the state, this problem has become more important in reality. As a logical extension of all these observations and statements, most of the participants support the proposition that *interactions between public agencies and sectoral associations, non-governmental organizations should be increased to establish a more participatory institutional framework*, **(Assertion- 4)**.

Coming to more specific (regulatory) tools, (***Assertion- 5)*** states that location-based regulations (i.e., regulation on regional bases) can increase market competition and consumer well-being by providing services tailored to different regional needs and requirements.

However, this proposition has not been found much support from participants. Only few respondents consider this as applicable provided that related legislation is well prepared and implemented accordingly. Majority of others, who discussed this topic, do not think this differentiation is necessary and as long as regulations are implemented in a transparent and impartial way, there is no need for this tool, at all.

In conclusion ***(Assertion- 5)***, it can be said that there is not much support and/or request for this regulation both by the participants and by other sector experts, i.e., there is no related statement in other interviews, journal articles etc.

Anyhow, policy makers should inform public about why this tool included in several strategy papers (e.g., ISSAP and NBSAP) and the reason for not implementing it, in the end.

Another specific but essential topic, which is discussed in the text, for bridging digital divide is the use of universal service policies.

In fact, it is emphasized that even developed countries extensively apply these policies by (especially) using universal service funds. Türkiye has also adopted such policies but the main problem lies in the relatively untransparent use of related fund along with no detailed knowledge (available) about the scope of application.

In this context, majority of participants consider more transparent usage of this fund and enlargement of the scope critical for better universal service policies in the country, ***(Assertion- 6)***.

Similar to the assumption that, variety is important in IS framework, presence of different access technologies is accepted beneficial for increasing competition and therefore for consumer well-being in telecommunication markets.

It is seen from the study case that, alternative access networks have not widespread coverage in the country and only after introduction of 4.5G, mobile networks have beginning to offer more adequate data speeds (still very low compared to fiber access), at all.

Within this background, policy makers have attempted to increase both quantity (i.e., coverage) and quality of Cable TV network in the country. The study analyses some main ones including policy objectives and sectoral associations' recommendations on this subject. In spite of these efforts, the outcome has not been satisfactory and this network does not provide a significant alternative to fixed telecom network of the country, currently. Accordingly, respondents also believe that failure to implement regulations to expand this network (e.g., alternative privatization methods, access regulations etc.) can be seen among the reasons for inadequate developments in market competition and access coverage, ***(Assertion- 7)***.

Apart from structural problems [388] (i.e., conflict of interest, independence, organizational inefficiencies etc.), 'insufficient coverage of fiber network' is one of the most discussed problems (of the sector) by the participants. Most of the respondents, irrespective of their positions, accept the problem and think that the investment rate should be increased considerably before passing to 5G technology. They argue that unless conversion to fiber is increased, there will be no significant development in internet access quality and also expected benefits of 5G will not be achieved fully in technical terms. Coupled with international comparisons and other numerous sources (e.g., interviews with CEOs of operators and journal articles), it is evident that insufficient fiber coverage (infrastructure) presents a major problem inhibiting the performance of communications services in terms of speed, latency and user experience. Moreover, respondents point out that the problem will be more critical if there is not any progress made until introduction of 5G in practice, since mobile networks depend on the high capacity of fiber especially in backbone part, ***(Assertion-8)***.

Having discussed some topics related to conditions of 5G passage, it may be suitable to proceed with the technology's introduction phase. At this point, participants uniformly agree on the statement that there will be no change in the number of mobile operators in the market. However, they expect new opportunities after introduction of this new technology, ***(Assertions- 9 & 9.1)***. Since the reasons behind these findings are discussed in length, they are not repeated here, but if one thing should be emphasised, it is the fact that much of the realization (of these opportunities) will depend on the actions of public organizations, (especially regulatory authority) in the end.

Turning on the other side of the coin, it is observed (in the study) that especially

[388] Many experts see these problems are inseparable and in fact consider these structural problems as main reasons for more specific issues. The reason for analysing them separately is to focus on each topic as well.

developed countries have increased their efforts to produce telecom network equipment or at least tried to use their more trusted partner countries. As examined in the study, ever expanding coverage of vertical usages and digital applications are further raising the importance of using trusted equipment, cyber security and measures against digital threats. Here, along with cyber security policies, ICTA has been trying to develop national capability to produce related hardware since the introduction of 3G technology in the country. Since then although some progress has been achieved in this regard, the outcome is far from satisfactory and there exists various complaints, problems about implementation details ranging from inspection to domestic goods certificate obtainment procedure. Notwithstanding to this, all the interviewees, who answered related questions, want domestic good procurement obligations to continue in the forthcoming 5G spectrum auctions, but with more stringent conditions. Furthermore, they agree on the necessity for transparent implementation of this regulation and availability of information to the public, ***(Assertions- 10 & 10.1)***.

In the world of scarce resources and limited capabilities, another question is the scope of national and domestic production of related equipment. The study shows the difference between available resources and technological capabilities (e.g., R&D budgets, patent numbers etc.) between global vendors and domestic firms. Accordingly, it may be unrealistic to set competition goals with them in all segments. Following this, respondents prefer prioritization and focus on specific product groups instead of aiming to produce all components of a 5G network, ***(Assertion- 11)***.

In this context, one thing should be made clear, what is meant by prioritization is the direction of public support, i.e., guidance of research and selective usage of public funds.

Another similar issue (in the scope of domestic production support) is the use of public procurement policies and preferential treatment of SMEs in project supports. The role of state as a lead user in all ICT sector is undoubtedly critical for supporting national firms in various aspects like helping commercialization of products, gaining experience in product development etc.

Participants also uniformly support the statement that public procurement and adoption of usage cases developed by domestic firms should be prioritized to increase indigenous production capabilities, with some reservations, ***(Assertion- 12)***. Although, these policy tools (especially public procurement) have been in the agenda of policy makers for a long time, both participants and sector experts have many complaints in practice. In fact, one can make generalization (of these complaints) to whole ICT sector, as well. As an example, it is known that a national operating system (Pardus) has been developed by TUBITAK, but the use of this remains very limited even in public organizations, at all. Same criticisms can be directed to core telecom equipment purchasing from universal service fund, from which a global vendor's products have been purchased along with other purchase of domestic products in lower quantities. As a last statement, it is observed from some of the participants and journal interviews that, there exists some criticisms about presence of different type of firms in the sector, which lead to inefficient use of scarce resources. In more specific terms, they complain about the same kind of treatment (especially in project support funding) given to ULAK (which is owned by DIFC) and operator affiliated technology firms in the sector. Apart from this, some participants point out leading role of ULAK in especially bigger projects and find this as beneficial in development of the sectoral capabilities. Accordingly, there is not much support for the statement that co-existence of similar organizations, but different in terms of ownership (i.e., SMEs, operator owned and state owned), lead to some problems in the sector, with one notable criticism in the context of public funding process, ***(Assertion- 13)***.

7.2 Policy Recommendations

Since the study covers wide ranging topics, it is normal to focus on some of the issues that are more related to the core subject of this work. Accordingly, this part includes more sector-specific regulatory topics, as opposed to some general issues such as human resource problems and patent policy etc.

Hence, the study proceeds with sector-related organizational and regulatory policy propositions, followed by considerations related to 5G license policy.

More specifically, this policy should encompass several objectives for the country in digital transformation process. Firstly, policy makers should continue and even aim to further increase their efforts to expand broadband internet access coverage throughout the country. In this context, design and structure of 5G licenses can be seen as an important step to achieve this aim. As it is seen from previous experiences and other country examples, new licenses should provide some incentives for market actors to increase their investment rates, without neglecting inspection procedures in practice like quality of service and coverage requirements. At the same time, public policy can support market competition by providing new opportunities for alternative firms. For instance, new 5G policy should provide an environment for MVNO operators to enter in the market and provision of specific spectrums for vertical usages in other sectors by different companies to generate variety in the IS. Moreover, universal service policies should be given even more emphasis to minimize digital divide problem in this ever more expanding digital world. Lastly, policy makers should take necessary lessons from past experiences related to domestic and national production programs, regulations and aim to establish a more transparent and well planned (e.g., product prioritization, scope of public procurement, usage of universal service fund etc.) institutional framework.

7.2.1 Structural and Organizational Considerations

At this part, without repeating related analysis and observations, it is by now evident that some kind of restructuring in the regulatory framework is necessary in various aspects. Starting from organizational issues, the number of similar organizations can be considered unnecessary and inefficient due to overlapping responsibilities and resulting time delays etc. Of course, there are more than one way of restructuring and there are costs and benefits of each different alternative. This proposition below is one of them, which are considered after analysing related organizations and having obtained views of sector participants.

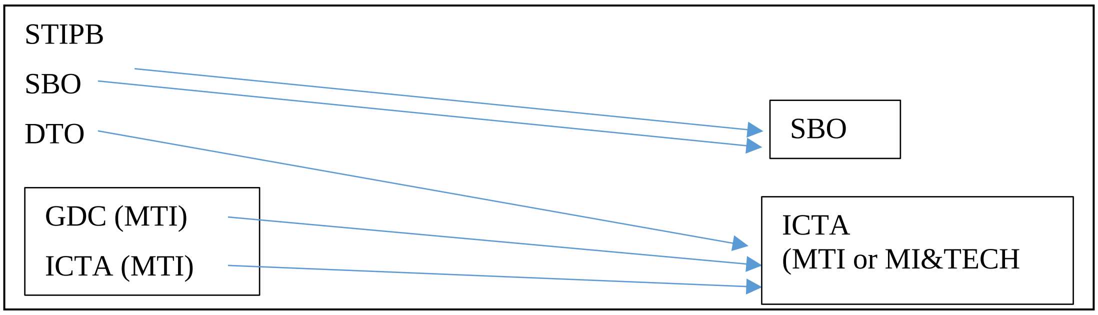

Figure 39-Alternative Organizational Structure

As shown in Fig-39, it is recommended to consolidate three organizations (DTO, GDC and ICTA) into one body (ICTA). In practice, the study shows that some of the roles, responsibilities have already been transferred between them, from time to time. Sector experts also agree on the fact that simplification of regulatory structure can lead to efficiency gains, since there will be less confusion for related actors and/or conflict between these organizations. On the other hand, consolidation of STIPB into SBO can be considered again for simplification purposes, but this may not be considered as essential, since this entity does not have a permanent organizational structure. In this respect, another critical issue that needs to be addressed is the determination of ICTA's associated ministry. It is seen that MTI has responsibilities in different modes of transport and related infrastructures ranging from roads, railways to airports and ports. Within this background, during the interviews, participants mostly complain about the less attention given by the ministry to telecommunication sector. Some of them even have argued about establishment of a separate telecommunications or ICT ministry to exclusively deal with the sectoral issues, at all. In any case, if there will be a new reorganization, the option of choosing MI&TECH may be more preferable given the responsibilities of this ministry in ICT and control over various supports like R&D funds etc. Taking into account much repeated convergence concept and ever-increasing vertical usages in many sectors (starting from automotive etc.), this alternative should get even more attention to policy makers in digital transformation process.

Apart from presence of different public organizations with similar duties and problems caused by this phenomenon, there exists critical structural problems in regulatory framework of the IS. In fact, as discussed before, this is considered as the most important problem in the sector by majority of sector experts. It is evident that independence of a regulatory authority is regarded one of the cornerstones of the regulatory framework, which is adapted by Türkiye as well. In this context, one should clear the use of this concept, although some analyses have been made in the previous chapters. First of all, the word 'independence' causes some confusion in public opinion and can be even used to generate a negative image.

For this reason, the author prefers not to use this word much, and instead emphasize 'conflict of interest' word to describe the resulting situation. In fact, it can be said that independence in a regulatory context is a tool for minimizing conflict of interest problem and ensuring impartiality especially towards protection of smaller firms, in general terms. As a first step to deal with these issues, it is evident that current executive structure should be changed to weaken the connections of former incumbent operator, regulatory authority and the ministry. This is of course not a guarantee for everything but at least it will be a signal to both existing and potential market players and investors. In addition to this, appointment procedures of regulatory board members are often criticized by sector actors. It is seen that countries, which have similar regulatory systems, are using several criteria to enable more transparent appointment procedure. Although these are also necessary precautions in this framework, it may be unrealistic to expect such kind of revisions in the IS, taking into account path dependency and current conditions. The study has even observed problems in the early days of regulatory authority regarding these issues. A thorough analysis of administrative status of regulatory authorities (in other sectors as well) are beyond the scope of this study. As a more general observation, it appears that just taking some parts of the framework (e.g., establishment of a board with specified number of members) and not adopting others (e.g., appointment procedure) could have exacerbated these problems in the end.

On the other hand, there are some other problems partly connected with above mentioned topics. It is observed in the study that several policy papers have been prepared to account for the problems and proposed solutions to them, but usually there is no publicly available evaluations after implementation periods. Some projects were included in successive plans but they have been completed after a considerable time delay. Some others even have not been completed at all, without mentioning any reason for this outcome. Participants also have doubts about the credibility of strategy, work plan papers and do not consider objectives are well planned and adequately followed by public organizations. Furthermore, especially smaller firms have complaints about difficulties in reaching public organizations' executives in recent years.

These observations both from participants and from analysis of policy papers point out inefficiencies and governance problems in the regulatory framework, as well. It is well known that 'good governance' is gaining importance to increase overall efficiency of public organizations and the concept covers wide ranging issues from transparency, accountability to other social issues[389]. Although most of them are very important for public organizations, especially transparency, accountability, responsiveness, efficiency, rule of law and sound financial management can be brought to the fore for this study purposes. Without detailing each of these topics, one can see the need for improvements in application of these principles in the IS context. As an illustration, a regulatory project (work) has several steps from preparation period to implementation and even post evaluations in the end. Almost each step requires participatory decision making with stakeholders and transparency related to time, resource planning and performance evaluation.

In practice, one can say that making improvements in some of these categories can be easier (or more possible) than making a comprehensive restructuring and organizational change as discussed in the above paragraph. For example, SBO (similar to former SPO's role) may impose or demand more effort from public organizations in this regard, but whether its sanction power is sufficient or not is another question. In any case, these efforts should come from inside of related organizations and should be endorsed by executive officers of them. Otherwise, one should not expect much improvement in these topics, given the previous experiences.

Before completing this section, one should emphasize another topic which is equally important as the need for organizational restructuring issue in the sector and what is different from this, is the probability of occurrence in the near future.

This can be called as re-privatization of Turk Telekom and even Turkcell in a sense. It is near certain that these sales are made in the short to medium term period and policy makers should take necessary lessons from the previous experiences in this regard. This may also provide some opportunities for organizational restructuring.

As a starting point, practices related to occupation of executive positions by same person/s can be terminated after these sales. However, although this will be an important step (or signal) to market actors, it is obviously not enough to establish

[389] For instance, (Council of Europe, n.d) has stated 12 principles of good governance. These are, 'Fair Conduct of Elections, Representation and Participation', 'Responsiveness', 'Efficiency and Effectiveness', 'Openness and Transparency', 'Rule of Law', 'Ethical Conduct', 'Competence and Capacity', 'Sustainability and Long-term Orientation', 'Sound Financial Management', 'Human Rights, Cultural Diversity and Social Cohesion, 'Accountability'.

impartial image of public organizations in the sector. In any case, (especially) regulatory authority should give more attention to above mentioned good governance principles to improve this current perception. In addition to that, public authorities should control workings and financial operations of new owners of (especially) Turk Telekom to avoid past mistakes.

Above all other considerations, one can state that accountability and transparency should be given utmost importance in this procedure as well.

7.2.2 Specific Regulatory Considerations

Having discussed fundamental topics related to regulatory framework, this part proceeds with some of the more specific issues. Without going into each topic, these are mainly among the most discussed ones in the interviews.

The need for fiber network expansion and facilitation of infrastructure installations: If there is a ranking made about the technical priorities of 5G transition, this topic most probably occupy first place by a considerable margin. Indeed, as in many other sectoral needs or requirements, one could usually find either a project or policy proposal to solve them in recent history of the IS. As a matter of fact, it is known that a joint infrastructure company project had been initiated as early as 2016 but with no outcome in practice. After nearly 8 years, it is evident that, there is still a need for such kind of projects to speed up infrastructure investment rates.

Although the details of establishing such a company or a similar project are important, similar kind of projects to increase network expansion and at the same time to reduce duplication of infrastructure investment costs have already been implemented in various countries. At this point, the real issue is the determination and the lead role of public organizations. Otherwise, as witnessed in the past, there is no use to delve into other implementation details. Apart from this main proposition, one can mention some other proposals. It is seen from country examples that, several governments have used support mechanisms such as tax incentives and universal service funds, among others.

Without even mentioning these examples, it should be enough to state that NBSAP (2017-2020) had similar policy objectives like establishing a ‘financial support model for regions where broadband infrastructures is difficult to expand commercially'. In any case, the implementation probability of these projects that are dependent on public sources will not be high, given current macroeconomic conditions. On the other hand, it is also discussed that 5G networks require much greater number of base stations and small cell (base) stations than the previous generations. In this respect, (future) 5G operators will certainly need suitable places to put this equipment especially in urban centers. These places include traffic lights, street lamps (i.e., passive carrier infrastructures) that are controlled by different organizations. Furthermore, establishment of a coordination (or a commercial agreement) with other utility provider companies such as electricity, natural gas etc. can be helpful for easing these installations.

Lastly, one should also mention a general complaint of sector actors in every kind of infrastructure investment process. This is high fees demanded by local governments and unfavorable conditions imposed on them. It is understood that a significant portion of the costs in fiber investments are obtained from the fees given to municipalities under different names. These include different categories like repairment of the ground destroyed during excavation and asphalt works. Apart from the fees, the application of unfavorable application and excavation processes by the municipalities prolongs or hinders the infrastructure installation times. One can include some other topics as well, but the important conclusion (for this study purposes) is the scope of work that needs to be done by the regulatory authority. In other words, especially the regulatory authority should prioritize these works and provide a less bureaucratic and less burdensome environment for infrastructure investment of telecom firms.

Topics related to increasing indigenous production capabilities and universal service policies: On the other side of the coin, there are also many problems related to indigenous production capabilities and implementation of regulations. Without repeating same arguments, inspection problems, some confusion on the current level of domestic product share partly due to usage of 'domestic product certificate', insufficient production capabilities, prioritization of some product groups should be handled by ICTA with the participation of related actors. In other words, firstly public organizations should make it clear to interested parties (potential bidders/investors) that procurement obligations (along with others of course) will be inspected on time and without any time delay and/or postponement.

Secondly, public organizations should re-evaluate 'domestic product certificate' procedure (this is not a duty of ICTA) and at least in telecom sector, the regulatory authority should take domestic sector participants' views on this subject before the forthcoming 5G auctions. Thirdly, to minimize arguments related to unavailability of domestic products, it is better to make preparations also before these auctions. The authority and other actors have undoubtedly an experience in these processes (e.g., availability certain products, equipment needs and supply capacities etc.) and this knowledge/experience can be used to guide market actors in the 5G era. In this regard, as a more assertive proposition, policy makers should prepare necessary background to ensure a large-scale order from new operators by using new licenses and supporting regulations. Otherwise, it can be said that the efforts related to increasing domestic production capabilities may not achieve intended outcomes as domestic firms do not achieve some kind of experience and more cost-effective production scale at all.

Thirdly, public organizations should increase their commitments and efforts related to public procurement policies. It is seen that without a more committed action in practice, these policies have not achieved their intended objectives. For instance, MTIs R&D and universal service funds should be utilized for this purpose without further time delays. Especially, it should be stressed that universal service fund (and policies) has two main roles in the sector. On the one hand, universal service fund should be used exclusively for domestic products and this also gives opportunities for testing this equipment before final commercialization stage.

On the other hand, as related to service expansion and important for last users, the coverage and scope of this policy should be expanded as well. In this regard, one can say that there is no need for legislative work (since it is already present and some amendments can be considered) but problems exist in implementation phase, without repeating necessity of improving transparency issues, like many other regulations in the sector.

Transition to 5G: The last topic is indeed the climax of this study in several aspects.

After detailed discussions on development and the current stage of IS, it is apparent that some preparation and works should be completed before introduction of 5G technology in the country. Indeed, most of these works are long overdue and have been on the agenda of sector actors for a long time. To reiterate, there is not sufficient coverage of fiber network and the expansion rate could not be raised to reach more satisfactory levels. There still exists investment obstacles for operators especially in urban areas. Taking into account the fact that infrastructure requirements will even be much higher in 5G era, this situation should be dealt with thoroughly by ICTA beforehand.

For the equipment/software segment, as mentioned above, there exists several issues to be dealt with public organizations before the passage to new technology. It is evident that some preparations are necessary for prioritization and availability of related equipment, testing them etc. if policy makers are realistic in their objectives of raising the rate of domestic products in total picture.

After this preparatory period, regulatory authority should use ‘5G spectrum auctions’ to regulate this market, in a more innovative perspective. Different from previous licenses, the authority can impose additional criteria on (potential) operators to better control and monitor these procedures.

For instance, ICTA may demand from potential bidders a more detailed investment plan that include which parts of it can be purchased from domestic firms, before current investment year/s.

It is already known that existing operators submit yearly investment plans and realizations in each year, this kind of additional requirements may bring more discipline and make inspections easier, at the same time.

Lastly, public organizations should think about whether desirable to achieve (or increase) planned domestic product shares with the inclusion of a global vendors’ products or not. Of course, one can argue that as long as they have domestic product certificate, there is no problem in this calculation.

Passing to other issues that should be evaluated in 5G auctions, duration periods of licenses present another topic. As seen in the study, ICTA has recently extended duration periods of 2G licenses to 2029, which is the expiry date of other licenses, (i.e., 3G and 4.5G). This may generate some kind of confusion in 5G transition period, (Fig-40).

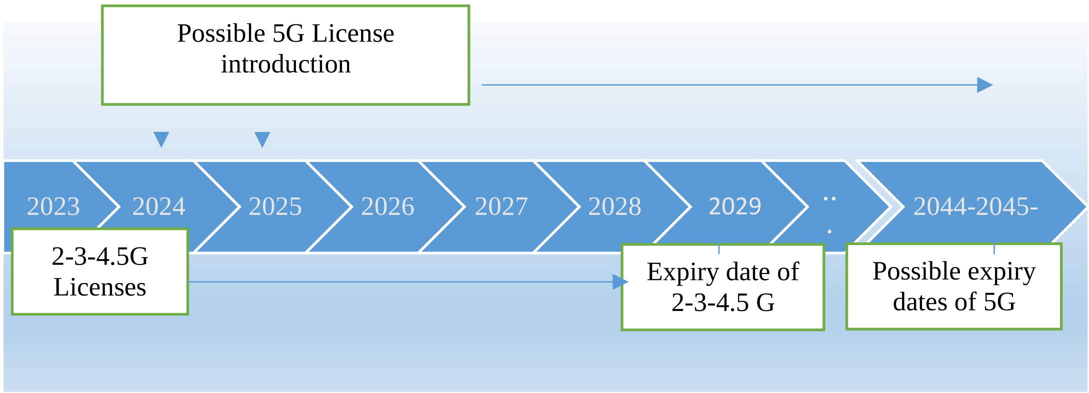

Figure 40-License Periods

Within this background, public organizations have three options. One is giving 5G licenses for twenty years duration, without considering other license periods. Second one is giving them for 4-5 years duration and the third one can be stated as waiting for 2029 without issuing new licenses in this period. The last option (i.e., no nationwide 5G introduction until 2029) is apparently out of consideration (because of relatively long waiting time and possible revenue considerations etc.) and this gives two choices in the end. Looking into past practices, it can be said that, probably the first one will be selected by the public organizations, provided that related auctions are made in a short to medium term.

In addition to timing, geographical scope and number of licenses are also crucial for the market. In this context, it is most probable that there will be same number of nationwide operators in the market. The real change may come from use of private networks in 5G era. It is seen from examples that many countries are giving such licenses for specific industry usages in a limited location. It is evident that the other alternative will be continuation of current practices, i.e., nationwide operators own the spectrum and construct these specific networks.

In spite of this, taking into account thoughts of participants, the study findings recommend introduction of some new (innovative in a sense) tools (e.g., use of private networks, spectrum sharing and trading, enabling MVNO entry etc.) in the market.

Thinking about the current dominance of mobile operators, policy makers should think about introducing some variety to the IS. Otherwise, competitive level of the sector will be further reduced given expanding role of these already dominant operators. In addition to this, regulatory authority should aim to develop MVNO market segment to increase competition and consumer choices in the market as well.

In sum, the study considers passage to 5G technology and aftermath as an opportunity to improve sector efficiency and development, provided that necessary revisions and regulatory works are completed on time. Otherwise, it may be wrong to expect major changes or improvements as compared to existing technology and the structure of the market.

In this regard, preparation of a specific 5G strategy paper can be beneficial as a guidance for sector actors. It seems a little bit confusing to recommend such a paper, after criticizing them in various aspects, but they are certainly useful if public organizations show commitment and make effort to implement their provisions. In the end, this does not mean that every policy or objective will be achieved or the optimal ones will be selected (even if they are made by sector experts in a participatory environment) every time, due to many unforeseen factors. What is more important is the evaluation of these outcomes and try to find new ways to solve problems in a collective and transparent manner. In the end, to reiterate, it can be suggested that policy makers should complete necessary preparations before 5G auctions. This can also give the sector actors an opportunity to solve and/or minimize most of the problems that are inhibiting sustainable development of the IS, provided that a more participatory and transparent regulatory environment can be established, beforehand.

7.3 Limitations of the Study and Further Research Topics

Since related issues about the methodology has been discussed in chapter 2.5, these are not repeated in this section. Notwithstanding to this, it can be said that although some kind of quantitative data has been used, different types of (e.g., covering different subjects such as prediction of future usage trends in numerical terms etc.) quantitative analysis can be used further to assess sectoral developments in various aspects. Returning to qualitative analysis part, one may conduct a social network analysis to better understand the degree of sector actors' interactions and possible benefits of these networks.

Another limitation of the study can be more exclusive focus on mainly business firms' executives and public sector experts. Here, it should be noted that, as expected, participants from public sector can refrain making comments on many subjects than from business firm participants.

In any case, this participant profile has resulted in less space to especially academicians and other experts, who are working in especially knowledge production fields.

Apart from this, although the study has analysed consumers (last users) complaints in a general level, individual user opinions about the experiences and perceptions of the sector are not obtained due to scope limitations.

Furthermore, although marketing (and market capture) strategies of global vendors have been mentioned by using different study examples, there is no detailed evaluation concerning their activities (e.g., costing, bundle offerings etc.) has been made in this work.

Nevertheless, this may also be very difficult to analyse given difficulties of obtaining quantitative data such as cost, pricing and market share figures. As a last remark, including service and equipment production sub sectors has undoubtedly extended the scope of the study. However, this can be a more suitable approach if one aims to emphasise regulatory aspects of the telecommunications sector, as a whole.

It is evident that much of the above-mentioned issues can be selected as separate research topics. By selecting each segment and even subsegments of the whole sector, one can make a more detailed analysis on each subject, as well.

For instance, one of the most important subjects should be evaluation of individuals' access to broadband internet and usage of digital applications in this era. This topic is also related to universal service policies that are applied in many countries of the world. In this respect, detailed evaluation and comparison of these policies across countries can be stated among useful research recommendations. On the other hand, a more detailed analysis of equipment production support policies to avoid only locking into domestic market (i.e., reaching competitive capabilities in international markets) will be very beneficial information source for policy makers.

One can add many other research topics, but as a last recommendation, it may also be useful to study the role and the place of regulatory authorities (not necessarily only in telecom sector) in the country's administrative structure in a comparative perspective with other countries.

Moreover, comparisons of different regulatory models between EU, USA and some other countries such as Japan, where there is no separate authority, will be helpful in observing the role and efficiency of alternative organizational and administrative settings in a sectoral development process.

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APPENDICES

A. ICT AND MEDIA & CONTENT SECTORAL DEFINITIONS (ISIC REV.4)

Sub-sectors	Products/Services
ICT Manufacturing	2610- Manufacture of electronic components and boards 2620- Manufacture of computers and peripheral equipment 2630- Manufacture of communication equipment 2640- Manufacture of consumer electronics 2680- Manufacture of magnetic and optical media
ICT Trade	4651- Wholesale of computers, computer peripheral equip. & software 4652- Wholesale of electronic and telecom. equipment and parts
ICT Services	5820- Software publishing 61- Telecommunications 6110- Wired telecommunications activities 6120- Wireless telecommunications activities 6130- Satellite telecommunications activities 6190- Other telecommunications activities 62- Computer programming, consultancy and related activities 6201- Computer programming activities 6202- Computer consultancy and computer facilities management activities 6209- Other information technology and computer service activities 631- Data processing, hosting and related activities; web portals 6311- Data processing, hosting and related activities 6312- Web portals 951- Repair of computers and communication equipment 9511- Repair of computers and peripheral equipment 9512- Repair of communication equipment
Content& Media	581 Publishing of books, periodicals and other publishing activities 5811 Book publishing / 5812 Publishing of directories and mailing lists 5813 Publishing of newspapers, journals and periodicals /5819 Other publishing activities 591 Motion picture, video and television programme activities 5911 Motion picture, video and television programme production activities 5912 Motion picture, video & television programme post-production activities / 5913 Motion picture, video and television programme distribution activities 5914 Motion picture projection activities / 592 Sound recording and music publishing activities 60 Programming and broadcasting activities / 6010 Radio broadcasting 6020 Television programming and broadcasting activities / 639 Other information service activities / 6391 News agency activities 6399 Other information service activities n.e.c.

Source: https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf

B. SPECIFIC 5G MARKET DEVELOPMENTS

As it is known, some countries have already been mentioned several times in the study. The reason for this, they occupy leading positions for mobile telecommunications technology development and deployment levels within their borders.

This part further evaluates these countries' market structures in a more detailed manner.

Hence, in what follows, the study examines developments in EU member states (larger ones), USA, China, South Korea and Japan.

This can also be helpful to compare different markets and for assessing our market performance as well.

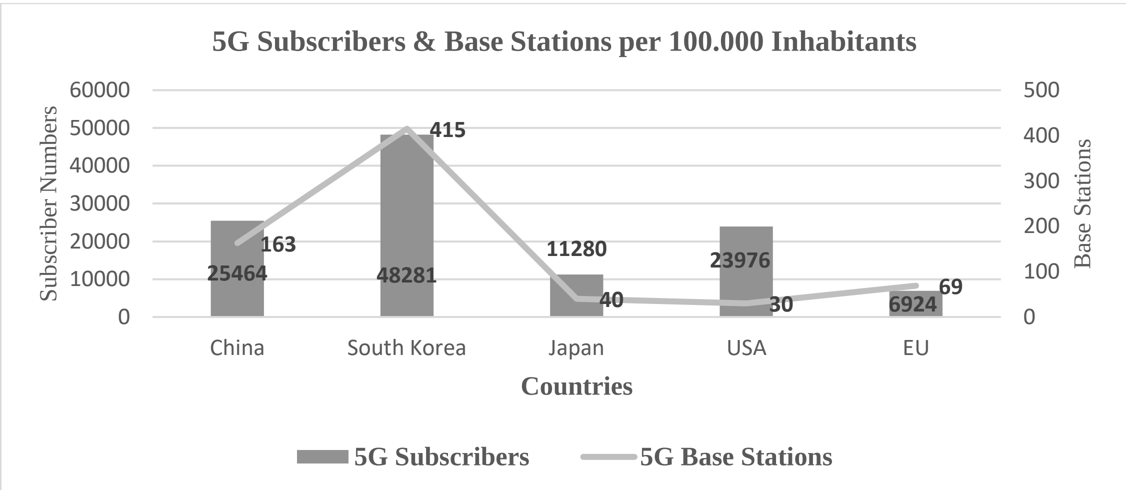

Figure B.1- 5G Deployment Comparisons Between Leading Countries

Source: 5G Observatory Biannual Report, April 2023.

Figure- B.1 gives a comparison between leading countries in terms of 5G network deployment levels.

According to this calculation (subscriber and base station numbers per 100.000 inhabitants), it can be seen that South Korea has the most widespread 5G coverage both in terms of penetration levels and coverage rates.

For instance, this country has nearly six times more 5G base stations (per 100.000 inhabitants) than EU countries. From this it is evident that South Korea has a much better coverage and quality (i.e., higher speeds and lower latencies) of service parameters than EU as a whole.

B.1. EU Member States

EU policy makers have prioritized 5G technology development and adoption to stay competitive especially vis-à-vis other leading countries, namely USA, China, Japan and South Korea. In this context, the latest 5G Observatory Quarterly Report[390] has indicated that 5G services are available in all (27) countries of the union[391] as of January 2022. However, as a starting point of market formation (i.e., market entry condition), most of the EU countries fell behind the 5G action plan targets in terms of spectrum assignments (availability for use). Only three countries have assigned all the pioneer spectrum bands (700 MHz, 3.6 GHz and 26 GHz) to this network as of March 2021. Nevertheless, commercial services are starting to become available in several metropolitan areas in parallel with the increasing availability of devices[392] (suitable for 5G technology usage) from 2019 and the pace of 5G network deployment and spectrum assignments have been increased, especially in the last year. Accordingly, number of countries that have assigned at least 50% of 700 MHz band and 3.6 GHz has reached to 23 and 25 countries respectively, there is only 10 countries that have done this in 26 GHz in the category as of April 2023.

As observed, EU countries (together with EC) are still implementing many projects to develop the technology and vertical usage areas.

Some of them are targeting network deployment in metropolitan areas, major roads, railways and transport hubs while others are working to solve possible cross-border service problems (e.g., uninterrupted connected car mobility across countries). On the other hand, the number of projects and their trials are increasing in other sectoral usages like e-health and smart manufacturing, to name a few of them. After general evaluation, this part proceeds with evaluation of market developments in larger EU

[390] This section draws heavily on this report, unless otherwise stated.
[391] Last addition to this list was Lithuania.
[392] As of March 2021, the number reached to nearly six hundred in various brands.

member[393] and other leading countries in terms of this technology. As the most populous country of the union, **Germany** started 5G related works in 2016 following initial 700 MHz frequency assignments in 2015. The regulatory authority (Federal Network Agency[394]) first published spectrum policy related paper in 2016 and the government prepared its policy paper called ‘5G initiative for Germany’ at the same year, (Bundesnetzagentur , 2016). The next policy paper ‘5G Strategy for Germany’ planned five important areas for action as network deployment (together with fiber infrastructure investments), allocation of spectrum, enabling cooperation between telecommunications and vertical sectors, R&D efforts and availability of 5G in cities by the year 2025.

In this framework, auctions for 3.5-3.7 GHz made in 2019, generating more than 6.5 billion Euro from three operators, (DW, 2019). Here, it is worth noting that the government has used some of these revenues in supporting 5G research and universal service purposes. For instance, the Federal Government allocated 44 million Euro funding to set up 5G networks in six model regions to test and develop this technology especially for industrial purposes like port road management operations, (Freist, 2019). Duration of corresponding licences are 20 years and the regulatory authority imposed very detailed obligations that are increasing gradually for these firms including targets for coverage, speed, latency and base station numbers in different geographical locations. In more detail, R&D works entail many other activities other than just the funding process.Registration of different activities in a single database and establishment of cooperation between different bodies including knowledge transfer can be regarded as equally crucial actions in this effort, (Federal Ministry of Transport and Digital Infrastructure, 2017). At the point reached, the country has completed assignment of all pioneer bands and covered nearly 93% of the population as of March 2023. All major operators (Telefonica Deutschland, Vodafone Germany and Deutsche Telekom) are continuing their investments to extend and improve their 5G networks. For instance, Deutsche Telekom are planning to cover 95% of the population with 5G technology by 2025. In the infrastructure (production) part, one operator (Vodafone) is working with three partners[395] to install 5G stand-alone network starting with major

[393] Most populous countries are selected for observing the market developments in the union.
[394] Bundesnetzagentur.
[395] Ericsson, OPPO and Qualcomm.

German metropolitan areas, (Ericsson, 2021c). On the other hand, dominant operator (Deutsche Telecom) of the country is trying to diversify its suppliers, one of which (in fact main) is Huawei for radio access equipment. It appears that recent allegations and accusations of US government has an effect on this company's vendor policy. In fact, the top executive (CEO) of the company has recently declared that, they should not be depended on one supplier, irrespective of politics. According to him, US vendors make up thirty percent and the remaining parts mainly shared by EU and Chinese vendors taking into account the whole business of the company, i.e., all countries where it has presence, (Reuters, 2020a). The other mobile operator (Telefonica Deutschland) has established a partnership with Ericsson in constructing 5G core network, (Tomás, 2021a).

As another example from market diversification trends, German Airport operator Fraport started to work with a Japanese firm (NTT) in the project of EU's largest private network, which is based on 5G technology in 2022.

France, as the second most populated country, started 5G technology adoption process similar to Germany. Likewise, first public consultations were made in 2016, after allocations of initial 700 MHz frequencies in 2015 and these auction revenues reached to 2.79 billion Euro, (Capacity, 2015) Afterwards, the regulatory authority (ARCEP) prepared 5G Roadmap in 2018. This roadmap has targeted preparation of related spectrum (for 5G use), new infrastructure installations and vertical sector usage developments in technical domain. Furthermore, the document stressed the importance of transparency and disclosure of these processes to the public knowledge. Currently, four mobile operators have 5G licences in the market. These operators paid nearly 2.8 billion Euro for 3.5 GHz spectrum in 2020[396]. The duration of licenses are 15 years. Among the coverage requirements, these operators have under the obligation to start 5G services in 3.000, 8.000 and 10.500 sites respectively at the end of 2022, 2024 and 2025, (5G Observatory, 2020). As of March 2023, nearly 89% percent of the population has been covered by 5G networks by mobile operators. Assignments in 700 MHz band has been completed and 75% assignment rate has been achieved in 3.6 GHz

[396] Two auctions have been made in 2020. The operators paid 350 million Euro each in the first auction for the 50 MHz blocks. Then, the total amount of revenue in the second auction reached to 2.8 billion Euro for different blocks of the spectrum.

spectrums. In spite of this progress, the country has not yet made any assignments in 26 GHz band. In the equipment production side, Orange made partnership with Ericsson and SFR worked with Nokia on the radio access network, (Ericsson, n.d.) & (Sharma R. , 2018).

Free mobile declared that they have used mostly European based firms' equipment in the construction of 4G and 5G networks, (Tomás, 2020a). Notwithstanding to this, one can say that French public authorities (organizations) and firms have been affected by the US allegations against Chinese vendors. In fact, French cybersecurity agency (ANSSI) has declared to the operators to refrain from adopting Huawei's equipment if they are not already using them. Furthermore, they have started to grant this vendor's equipment shorter (operational) licence durations compared to European vendors. Reuters claim that these limitations may actually push the firm out of the market by 2028, (Rosemain & Barzic, 2020).

With a population over 60 million, **Italy** is the third most populous country of the union. The country started the process in 2016 with 5G strategy, followed by launching of trials in 2017.

The interesting point here is that the regulatory authority granted provisional licences (valid from 2017 to 2020) for trial purposes in five pre-selected cities. Different from most other EU countries, Italy allocated all three-spectrum bands, i.e., 700 MHz, 3.5 and 26 GHz bands. Four operators paid one of the highest amounts throughout the Europe especially for the first two bands, while giving less demand for 26 GHz band. In total, these auction revenues amounted to 6.5 billion Euro. Licence durations are 19 years for 3.5 and 26 GHz bands, while 700 MHz band licences last 15.5 years, (Donkin, 2018). In Italy, the Ministry of Economic Development has determined coverage requirements of mobile operators. These obligations are very detailed ranging from national population coverage, national road and rail transport coverage and finally touristic places coverage targets.

For instance, the 5G license holder operators should cover all the main road and rail transport routes within 42 months (starting from the availability of these spectrums) collectively. From this, it is understood that the public authorities prioritize a general (total) coverage of all these operators rather than separate requirements in the short run. Furthermore, two of these operators have established an agreement for network sharing to accelerate infrastructure coverage in the country. They have also combined their portfolio of nearly 22.000 antenna sites (towers) to reduce their investment expenditures, (Vodafone, 2019). Lastly, operators have attained nearly 100% (99,7% exact) population coverage with full spectrum assignments in 700GHz, 26 GHz and 80% in 3.6 GHz as of March 2023.

In the production part, the country's operators seem less affected by the accusations related to Chinese global vendors. WindTre has established a partnership with ZTE, Vodafone utilized 5G equipment from Nokia and Huawei, whereas TIM is using Ericsson's technology for the deployment of 5G network, (Tomás, 2021b).

As the fourth most populous country of the union, **Spain** released 5G National Plan 2018-2020 at the end of 2017. The plan had three milestones, starting from spectrum road maps and preparation of pilot project proposals in 2018. Second phase covered development of these projects. Public authorities targeted commercial deployments in 2020. In this regard, first auctions were made in 2018 for 3.6- 3.8 GHz range and generated 438 million Euro in total, (Weissberger, 2020).

However, allocation processes for 700 MHz band were not completed after several auction postponements until 2021. The Spanish government has finally made these auctions as the end of July 2021 with raising over 1 billion EUR, (5G Observatory, 2021). In line with the government's intention to complete 26 GHz auctions in 2022, (5GWorldPro, 2021), this band have been assigned to operators (Movistar, Vodafone and Orange) with a revenue of 36.2 million EUR in December 2022, (Telegeography, 2023). Coverage obligations of license holders are similar to other EU countries in terms of residential areas and transport routes. For instance, operators have to start their services (availability of 5G coverage) in all residences that have more than 20 thousand residents in three years period.

According to recent statistics, 82.3% population coverage has been achieved in the country with full assignments in 700 MHz, 26 GHz and 95% in 3.6 GHz.

In the equipment production side, operators have been trying to diversify their supplier bases like many other EU countries. Most importantly, Telefonica has begun to establish commercial contacts with several vendors. Previously, it had depended completely on Huawei's equipment for 4G network deployments. Notwithstanding to this, the CTIO of the company has declared that the company will continue to purchase some components (e.g., radio and antennas) from Huawei, (Reuters, 2019b). In any case, European based vendors (i.e., Ericsson and Nokia) become dominant equipment suppliers in the country, (European 5G Observatory, 2020).

As another large country in terms of population, **Poland** has not allocated any of the three spectrum bands through auctions. National Broadband Plan covering 2020-2025 period set deadlines of August 2021 for 3.5 GHz, July 2022 for 700 MHz and December 2022 for 26 GHz band assignments. However, existing operators started 5G services in 2.1 and 2.6 GHz bands in 2020. It is understood that there was no separate auction related to the use of these bands for 5G. For example, Polkomtel and Nokia started 5G services by using 2.6 GHz band in the capital and some of the major cities in the last quarter of 2020, (LightReading, 2020). According to sector experts, Poland's government is planning to commence auction process in 3.6 GHz in the last quarter of 2023, (Barton, 2023). As of March 2023, 82,3% of the population base has been covered by 5G networks.

Netherlands with a population of nearly 20 million inhabitants, published 5G related policy papers relatively late in 2018. The public agencies preferred multi band auctions (i.e., 700, 1500 and 2100 MHz) in one setting. This auction generated 1.23 billion Euro in the second half of 2020. The duration of licenses are 20 years and coverage obligations include 98% of all municipalities along with minimum data speed requirements for home and business uses. Spectrum bands of 3.5 GHz and 26 GHz range are not available yet and authorities have begun planning to make auctions starting from 2022. More specifically, the Dutch government is planning to make an auction in 3.6 GHz band at the end of 2023. Taking into account the fact that this auction is not made as of today, only 700 MHz assignments were made in the country so far. Even so, it is seen that 100% of the population has been covered by operators in this country as of March 2023. In the infrastructure equipment side, one can observe a similar story in that operators are beginning to change their suppliers at the expense of Chinese ones. For instance, T-Mobile Netherlands has switched from Huawei to Ericsson in 5G network deployment operations, (International Finance, 2020).

Austria prepared 5G strategy document in April 2018 after establishing a steering group in February 2017. This strategy document announced milestones as pre commercial tests in 2018, deployments in major cities in 2020 and availability of service in roads in 2023 followed by countrywide coverage in 2025.

In addition to this, Broadband Strategy Paper dated 2019 set a gigabit capacity internet service by the end of 2030.

There are three 5G operators active in the market and spectrum auctions made in 2019-2020 generated 202 million Euro for 700, 1500 and 2100 MHz frequencies and 188 million Euro in the first auction for 3,4-3,8 MHz frequencies, (RTR, 2019).

The regulatory authority is planning to make auctions in 3.6 and 26 GHz bands starting from December 2023.

The country has nearly 92% (91,7% exact) coverage rate with 100% assignment in 700 MHz, 97,5% in 3.6 GHz and there is no assignment made in 26 GHz currently.

In the infrastructure production part, each of these three operators have worked with three different global vendors. These are ZTE, Huawei and Nokia, (5G European Observatory, 2019), & (Morris A. , 2019).

It is interesting to note that these supplier relationships are in line with the country's strategy of deploying infrastructure by different vendors and at the same time ensuring interoperability and compatibility between these networks.

This measure stated in the new legislation related to security measures for 5G networks along with other provisions. Some of these are submission of periodic audit reports, notification of an incident that can affect the security of the network, monitoring all critical parts and ensuring physical protection of these components.

Apart from individual country efforts, EU level policies (coordinate by EC) are also important for development of digital technologies including 5G and other related mobile applications in various sectors.

Among these policy undertakings, 5G Infrastructure Public Private Partnership (5G-PPP) stands out with its particular focus on new mobile telecom technologies and its inclusive structure that covers producers, service providers, universities, other research agencies and SMEs.

B.1.1. 5G-PPP Projects in each phase and their contributions[397]

Since its establishment, 5G-PPP has enabled many projects related to the mobile telecom technology and its applications. Starting in 2015, there were 19 projects (selected from initial proposals) in the Phase-1. Project durations were mostly between 24 to 36 months. There were nearly 15 to 25 participants in each project. Participants in each project composed of different actors ranging from equipment producers, telco operators, universities, research organizations and SMEs. Big equipment producer firms included Nokia, Alcatel, Ericsson, Intel and Huawei. Deutsche Telekom, Telekom Italia and Orange were among the telco operators involved in these projects. Universities from several member countries such as King's College, University of Bristol, Universita DI PISA and T.U. Kaiserslautern. Numerous SMEs and other research organizations were also from different European countries such as Keysight Technologies (from Denmark), Real Wireless Ltd. (from UK) and Nextworks (from Italy) to name a few of them.

Within this organizational structure applicable to all phases, each projects' main objective and description can be summarised as follows. **'5G-NORMA'** planned to develop novel radio multiservice adaptive network architecture with the aim of increasing network customisability and satisfying requirements of different service portfolios. **'Flex5Gware'** targeted more efficient and flexible hardware/software platforms for 5G networks, e.g., lower energy consumption. Here, it is stated that this project's outcomes contributed to the standardization organizations works and some of them have been published in journals, as well. '**Metis II'** concentrated on advancing the 5G radio access design. **'5G-XHaul'** focused on converged methods to connect small cells to the core network. In the security dimension of 5G technology, **'5G-ENSURE'** involved in advancing security enablers including privacy, trust, security monitoring, network management and virtualization, authentication, authorisation and accounting. Among other benefits, this project outcome contributed to the 5G security standardisation process. **'SESAME'** proposed cloud-enabled small cell concept.

[397] https://5g-ppp.eu/ (Please note that this section draws on 5G- PPP web page for project descriptions)

‘SELFNET’ concentrated on improving 5G (virtualized and software defined) network management. Likewise, **‘CogNet’** aimed to increase efficiency of 5G network management by using machine-learning technology. ‘**VirtuWind’** as a project oriented to usage cases aimed to develop software defined networking and network function virtualisation in wind energy industry. In a similar manner, **‘SONATA’** worked on flexible programmability of software networks and the optimisation of their installations. **‘5G Exchange’**, on the other hand, planned to achieve collaboration between operators to support the foundation of cloud and networking services through a unified infrastructure service market in the EU. ‘**SUPERFLUIDITY’** also intended to design a converged cloud-based 5G concept. **‘FANTASTIC-5G’** targeted development of the air interface for 5G New Radio for the frequencies below 6 GHz with different innovation clusters to address different requirements in this topic. **‘COHERENT’** concentrated on the need for coordinated control and spectrum management for 5G heterogeneous radio access networks. ‘**5G-Crosshaul’** planned for an integrated backhaul and fronthaul transport network to handle (enormous) data traffic expected in these new generation mobile telecommunication systems. **‘mm-MAGIC’** involved in R&D activities related to Millimetre-Wave Based Mobile Radio Access Network. **‘Speed5G’** specialized in the quality-of-service provision and capacity expansion topics. Finally, **‘Euro-5G’** intended to establish cooperation between all the above-mentioned projects in the **Phase-1.**

Even a brief observation of projects in the second phase **(Phase-2)** shows advancement of 5G technology in terms of technical upgrades and new solutions to vertical usages. To start with, ‘**5G ESSENCE’** focused on the development of embedded network services for 5G technology. As one of the most important applications of mobile communications technology, automated car connectivity was handled in **‘5GCAR’** project. Among other objectives, this undertaking proposed new business models and spectrum usage alternatives for 5G vehicle to everything communication services with the participation of industry actors including Bosch, Volvo Cars and PSA Group.

Moreover, it is projected that 5G would play important roles in metropolitan areas by enabling many public services run more efficiently and more pervasively than before. In this regard, **‘5GCity’** planned to advance an open platform cloud-based network to benefit all the actors in the value chain including end users, infrastructure and service providers and public organizations. As part of the project, tests and demonstrations performed in three different cities. **'5G Media'** involved in upgrading programmable edge to cloud virtualization for the usage of 5G in media sector like virtual reality applications. **'5G-MoNArch'** aimed to advance 5G architecture with several innovations like inter-slice control and cross-domain management. The team tested this project in two different vertical cases as seaport and touristic city usages (e.g., virtual reality-based museum tour). **'5G PICTURE'** designed an integrated, scalable and open 5G infrastructure for end user services in vertical applications. The infrastructure was tested in different use case scenarios and locations including railway, smart city and stadium environments. '**5Gtango'** planned to develop flexible programmability for 5G networks. Another project named **'5G-Transformer'** targeted design of mobile transport platform for vertical usage, which was tested in automotive, entertainment and e-health sectors. '**5G-Xcast'** aimed to upgrade broadcast and multicast point to multipoint capabilities of the technology for more efficient usage in vertical applications like automotive. In the category of quality of service, '**IoRL'** worked to reduce congestion, interference and other concerns for better user experience. In a similar manner, other projects such as '**MATILDA', 'Bluespace', 'METRO-HAUL'** all proposed to increase network performance by advancing different components of the network. Some other projects like '**Global5G'** and '**To-Euro-5G'** focused on coordination and supporting roles for all these projects ranging from events, active participation in international conferences and activities related to global vision and standardization works.

Lastly, 5G-PPP has started **Phase-3** in 2018 with twenty-five projects (three of them are complementary) grouped in four parts. Infrastructure projects form the first category. '**5G EVE'**, '**5G-VINNI'** and **'5GENESIS'** are the projects in this category and have implementation periods of three years. Their main objective is testing and upgrading advanced 5G infrastructures throughout the union. Automotive projects form the second part. There are also three projects in this category, namely **'5GCroCo'**, '**5G Carmen'** and **'5GMOBIX'**.

At this stage, related projects more generally attempt to provide uninterrupted service to connected vehicles across different countries of EU. For instance, 5GCroCo project team plan to trial 5G technologies between the borders of France, Germany and

Luxemburg. This phase consists of eight projects involving advanced 5G validation trials in different vertical usage areas. **'5G Solutions for European Citizens'** works on testing innovative use cases such as factories of the future, smart cities, smart ports and media- entertainment sectors in five countries. Likewise, **'5G-TOURS'** project is focusing on end-to-end demonstrations especially in e-health, media and transport related use cases in three different cities. In a similar manner, '**5G-HEART'** project is planning to specialize use cases in healthcare, transport and agriculture sectors. It is stated that, the project team is going to work on both product innovations like car components, healthcare devices and novel application developments. While, '**5G!Drones'** is targeting unmanned aerial vehicle applications, **'5G SMART'** project involves in testing 5G integrated manufacturing applications like industrial robotics and machine controlled remote operations. Similarly, other projects '**5GROWTH'** and '**5G-VICTORI'** plan to address development and testing of vertical usages in manufacturing, energy and media sectors. One project (**Full5G**) is different from the others in this part, being non-technical.

This programme aims to make impact analysis of 5G-PPP projects and to promote the outcomes of these undertakings.

In the last part, projects cover especially longer-term vision of next generation mobile telecom technologies. 5G-PPP defines the longer-term vision as the achievement of pervasive mobile virtual services as opposed to initial objectives of local network upgrades like radio access level. Eight projects ('**5G Complete', 'ARIADNE', '5GCLARITY', 'INSPIRE-5Gplus', 'LOCUS', 'MonB5G', 'TERAWAY' and '5GZORRO'**) in this context are trying to fulfil this perspective by improving different segments of the technology.

In sum, 5G-PPP gives the key achievements of each phase and this shows the evolutionary nature of any technology development. It is emphasised that whereas projects in phase one-two were more oriented to technological innovations, phase three projects are mainly involved in trials and demonstrations.

For instance, early phase projects were focused on 5G spectrum investigations, functional, logical and physical architectures, network management, novel radio systems and air interface, among other upgrades and revisions.

As indicated, in parallel with the maturation of the technology, Phase-3 projects mainly target vertical usage areas including automotive, industry 4.0, agriculture, smart city applications, public safety, smart ports, energy, e-health, media & entertainment and tourism in the form of trials, pilots and experimentations.

Infrastructure projects are related to further advancement of 5G network and architecture such as software security, privacy and resilience.

The remaining ones concern the business side of this technology along with standardization and regulation issues.

In the end, it can be said that these research and development activities are not confined to 5G technology and its advancements are also preparing the groundwork to pass to next generation (i.e., 6G) communication technologies that are expected to be used in the 2030's.

Having seen some EU countries experiences and recent developments briefly, one can also look at other leading countries' experiences to compare relative positions with each other.

B.2. Other Leading Countries (in terms of 5G development and deployment)

It is already discussed from Figure-B.1 that South Korea, China are clear leaders in terms of this technology deployment, followed by USA, Japan and EU member countries. South Korea has 415 5G Base stations with near 50.000 5G subscribers per 100.000 inhabitants.

On the other hand, in spite of her enormous population and large country size, China has 163 5G Base stations with near 25.000 5G subscribers per 100.000 inhabitants.

While USA has allocated largest amount of high band spectrum, she has 30 5G Base stations with near 24.000 5G subscribers per 100.000 inhabitants.

As one of the leading countries in terms of equipment production, **USA** (Government) has not enacted a comprehensive public strategy specifically related to 5G technology and network deployment. In this regard, the regulatory authority (FCC) has announced a one-page document titled 'The 5G FAST Plan'.

This document has stressed the significance of rapid adoption, covering topics as flexible use of spectrum, encouragement of infrastructure investments and modernization of outdated institutions.

In the spectrum side, FCC targets four band categories to allocate enough spectrum for 5G use. Accordingly, they have first prioritized allocation of high band spectrum in 24, 28, 37, 39 and 46 GHz. Several auctions in this category generated more than 10 billion USD in 2019 and in 2020.

On the other hand, it is seen that the most valuable spectrum lies in the mid-band range. FCC obtained over 4.5 billion USD from the auction for 3.5 GHz in 2020 and over 81 billion USD, which is the highest amount obtained from spectrum licenses in the world, from 3.7 GHz band. The authority aims to improve the usage conditions and opportunities in the remaining low band (600-900 MHz) and unlicensed (Wi-Fi in the 6 GHz and above 95 GHz) categories, (FCC, n.d.-a).

For supporting infrastructure investments, FCC has enacted new regulations to minimize any obstacles in deployment of small cells. As 5G technology requires installation of many more small cells than the required number of cell towers in previous generations of mobile technology, the regulatory authority emphasize the importance of time-limited approval procedures for related state and local public organizations to avoid unnecessary delays in deployment processes.

In the last category, FCC has planned to revise and modernize several other regulations related to 5G technology development and adoption. These regulations include or cover *restoring internet freedom, one-touch make-ready, speeding the IP transition, business data services and supply chain integrity.* It appears that FCC has used supply chain integrity concept to ban use of foreign companies' (i.e., Chinese) equipment and/or services in 5G domain if they are deemed a national security threat to the integrity of the country's telecom network. FCC claims restoring internet freedom aims to protect internet openness. Here, in a similar manner one may argue that this policy can also be used to serve her firms' interest in global markets. In addition to these regulations, the authority has established a universal service fund related to deployment of 5G in rural areas. This fund has nine billion USD to support projects and one billion USD allocated for agricultural undertakings, (FCC, n.d.-b).

After these spectrum auctions, four main operators are now active in the 5G services market: Verizon, T-Mobile, AT&T and Sprint. From these, Verizon preferred to work with Ericsson in the core network, radio access and transport services. This operator also made partnership with Nokia and Samsung. AT&T and Sprint have also chosen these two vendors. Lastly, T-Mobile opted to work with Ericsson and Nokia as vendors. US government removed Huawei from this market because of alleged security concerns, (DeGrasse, 2019).

Notwithstanding to these developments, some experts have argued that USA needs a more comprehensive strategy to pursue different objectives in this field other than FCCs '5G Fast Plan' and 'National Strategy to secure 5G' announced by the White House. In this context, Brake (2020) emphasise that such a strategy should cover all aspects of rapid network deployment, ensuring network security, widespread adoption and productive use of this technology, along with production side policies. These policies include funding pilot programs like smart manufacturing, smart city and early adoption & use (i.e., lead user) of 5G applications by public organizations. R&D support for technology development such as virtualization of network functions, 6G & next generation mobile telecommunications and protection of intellectual property rights are also mentioned in this category.

Furthermore, the author divides wireless ecosystem in various categories to analyse US firms' competitiveness vis-a-vis Chinese counterparts in each one. He defines a basket of technologies that enable final output (i.e., efficient communication) as *foundational technology*.

This group (of technologies) aim to increase the efficiency of spectrum usage by various innovations such as improving battery performance and processing power etc. The importance of such technologies is coming from the fact that technology developers have gained competitive advantage before the maturation of technology if they have patented these innovations and succeeded in contributing standard settings. For this reason, almost every equipment producer (vendor) has made considerable R&D expenditures and is active in technology development and standard setting arena.

Indeed, it is remarkable to see the efforts of Chinese firms in this standard setting process. Some experts give an example that Chinese actors had submitted 40% of the standards and 32 % of the documents in 3GPP[398] 5G related works up to that time, (Shi-Kupfer & Ohlberg, 2019). Similarly, Rutkowski (2019) has given information about the number of input documents for 3GPP- 16 standard.

Here, Chinese firms had the largest share made up from several companies beginning with Huawei, which submitted over 1500 documents out of 12.000 total number.

As known, network equipment industry generates considerable amount of revenue streams and plays a vital role in the functioning of telecommunications system. Hardware requirements can be grouped in core and edge of the network.

Core part covers mainly wired components like fiber cables. Edge of the network mainly requires wireless technology and these are classified into radio access technology (RAN). Brake (2020) has criticized competition policy of US for decreasing market share of her firms.

Historically, AT&T's Western Electric dominated the sector and after series of decisions involving separation of this company, the European firms acquired market leadership until the beginning of 2000s. In the last two decades, Huawei climbed to the world dominance. Here, he argues that this is (i.e., Huawei's success) partly due to the protected home market and government subsidies.

Apart from these, other actor groups include end user devices and equipment components, operating systems, applications and new product/service producers. It is evident that these firms serve needs of operators (in the case of US, four major operator) and of end users (especially smart phones and operating systems like Android).

Other than smart phones, numerous other devices can be connected to telecom networks like sensors and IoT hardware, modems etc.

This hardware themselves are made up of several components including semiconductor chips. In general, some US firms have still competitive advantage and

[398] 3GPP is an international standard setting organization to work collaboratively for the production of evolved Mobile System specifications and has been formed by seven different standard development organizations. There are more than 700 members from the sector as of June 2020, (3GPP, 2007), (3GPP, 2020).

market leader in main categories such as Qualcomm’s position in modems and chipsets.

With the advent of 5G, the role of software has started to increase in the network infrastructure. DeGrasse (2019) has pointed out that software oriented 5G technology structure is enabling entry of non-traditional companies into this market segment. For instance, several US firms like VMWare and Mavenir have increased their presence in the sector thanks to virtualization technology. Some other more established firms such as Cisco and IBM are also active in this relatively new category, (Haranas, 2021). In this context, one can also emphasise that this type of telecom infrastructure technologies may give market entry opportunities in various segments to other latecomer country firms in this field.

As noted, rising dominance of Chinese vendors and resulting allegations & counter measures (of USA) to curb the position of these companies (in 5G field) are continuing to occupy the political agenda of this technology race. For our purposes, it is important to get some idea of the reasons for this market dominance by looking into main **Chinese** government policies and the status of this market. It is already observed that almost every developed country government has actively involved in advancement, deployment and adoption of mobile telecom technologies.

Notwithstanding to this, it can be said that Chinese government involvement level is the highest among all others, thanks to centralized control of the country’s socio-economic structure. The government has prepared & implemented a top-down plan for 5G (this is the case for all digital technologies) ecosystem covering wide ranging topics such as R&D, hardware development & production, application development and country-wide adoption.

Building on her experience in mobile telecom technology, **China** has started next generation related tasks as early as 2013 with the establishment of IMT- 2020 (5G) Promotion Group.

The group worked towards the establishment of 5G standards in collaboration with EU, USA, Japan and Korean counterparts. The outcomes of these undertakings then submitted to 3GPP standardization activities. Following this, Chinese government enacted ‘Made in China 2025’ and ‘13th Five-Year Plan (2016-2020)’ both of which aimed the development and launching (commercialization) of 5G by the year 2020 as a strategic priority.

Furthermore, Ministry of Industry and Information Technology (MIIT) and the National Development and Reform Commission each launched ‘5G Development Guidance’ documents in 2018.

As a more recent policy paper, ‘14th Five-Year Development Plan (2021-2025)’ has a separate chapter on technological innovation.

The plan gives utmost importance to raising innovation capabilities of the nation to counter US efforts to block imports of some ICT components and to increase self-reliance in high-tech fields, among other socio-economic objectives.

Accordingly, it gives special emphasis to digital economy with *5G, AI, Quantum Technology, Integrated Circuits, Aerospace Technology, Deep Earth and Deep Sea Technology* are among the prioritized areas, (KPMG, 2021).

Furthermore, Chinese government has put 6G technology development in the plan, (Yu & Yıran, 2021). It is understood that the country has already started to work on next generation technology since 2017 and the strategic plan is going to increase these efforts.

As an example, a smart phone producer (Oppo) has an R&D budget of 7.7 billion USD for 2020-2023 period and one of the selected areas is 6G technology[399].

Experts predict that the technology will be ready for commercialization in nearly 10 years’ time after completion of similar steps in 5G including research, testing, equipment production and environmental analysis etc., (CCPIT, 2021). China government is allocating significant resources to achieve these goals. Although it is very difficult (if not impossible) to obtain exact figures for total amount diverted to digital economy goals, one can say that mobile telecom technologies are among the

[399] Some experts predict that the data transmission speeds of 6G will be around 100 to 500 gigahertz, nearly 100 times faster than the current generation and will play a central role in the integration of space-air-ground-sea communication technologies, (CCPIT, 2021).

top receivers of these supports. To give just one example of these financial supports, several public investment organizations[400] have established a fund with the budget of 724 million USD to invest in 5G related technology companies in 2019, (Shijia, 2019).

On the other hand, four state-owned companies have 5G licences in the service provision part. China Mobile, China Telecom and China Unicom have started their services from November 2019. China Broadcasting Company which is a cable TV provider will give 5G services in collaboration with China Mobile, (Tomás, 2020b). Ministry of Industry and Information Technology has instructed these operators to share 5G indoor access networks to increase the deployment and adoption rate in the country. The number of 5G compatible base stations were reached to nearly 720.000[401] with 260 million subscribers as of February 2021.

In this regard, The USA- China Economic and Security Review Commission has summarized the reasons (policies) of Chinese success (in this field) in six headings. Briefly, this government has enacted detailed strategic plans and is providing considerable financial sources to the sector actors with the main objective of establishing (and supporting) globally competitive companies and they have all actively involved in standard setting works. Additionally, the commission indicated the role of state procurement, localization targets and restriction of (domestic) market entry of foreign competitors. Finally (and most controversially), the report accused China of cyber espionage and intellectual property theft.

Japan is another country that are among the leading states in terms of technology development and adoption rates. Ministry of Internal Affairs and Communications (MIC) has first started related works by preparing a roadmap in 2014. Afterwards, sector actors established the 5G Mobile Communications Promotion Forum in the same year to promote R&D activities. Accordingly, these projects were started in 2015 following 5G trials in 2018 and 2019.

The roadmap had aimed to start 5G services in 2019 with the main objective of 5G

[400] Beijing Yizhuang International Investment and Development Co Ltd and State-owned China Jianyin Investment Ltd. The fund has targeted on investing in leading high-tech firms across the entire 5G industrial chain.
[401] It is evident that this figure is continuously increasing in monthly bases. For example, a more recent figure indicated this number as 792.000 at the end of April 2021.

ready environment of Tokyo Olympic Games in 2020[402]. In this regard, a funding for the size of 300 million USD provided to support digital technology development projects in different fields such as IoT, big data, robotics etc., (Clari & Poucher, 2019). Another important development in the trial phase was the establishment of R&D collaboration between Japan and EU in 2015, (EC Press Release, 2015).

Currently, four operators are active in the service provision segment, starting from April 2019. The important difference of the Japanese case is that unlike other countries that have liberal economies, there is no spectrum fee required from the operators in mobile communication services sector, (Duchâtel, 2020). MIC has allocated 3.7 GHz, 4.5 GHz and 28 GHz bands to operators through a beauty contest process. In return, these operators have several requirements to follow in the lifetime of relevant licences.

Some of them are similar to EU practices like coverage obligations. NTT Docomo and KDDI, which are larger operators, have the obligation of over 90% population coverage whereas Softbank has 64% and Rakuten has 56% population coverage requirements. Additionally, they have to take precautions (in their networks) to address emergencies like earthquakes and make efforts to deploy base stations in remote locations. Other specific requirements ranging from security measures to opening up their networks to MVNOs, (Atsumi & Sakai, n.d.). Apart from these, minimum infrastructure investment requirements are obligatory according to the provisions of licences. For instance, NTT Docomo has to invest 7 billion USD while the figure is 1.7 billion USD for Rakuten, (Duchâtel, 2020).

In the hardware part, it is observed that domestic equipment producers have lost their previous market positions to foreign competitors. Additionally, Japanese operators are minimizing their partnerships with Chinese vendors, especially Huawei. In fact, Softbank decided to replace even existing Huawei's equipment in 4G network with the Ericsson and Nokia's hardware, (Duchâtel, 2020). NTT Docomo has worked to diversify its supplier base by making commercial agreement with different vendors. It has recently signed an agreement with Samsung to obtain 5G equipment. Nokia and NEC are among the other firms that are in the supplier list of the company, (Reuters, 2021). Another mobile operator, Rakuten is working both traditional vendors and new

[402] As known, the tournament was postponed and the new date was set for July 2021.

comers including NEC, Nokia, Altiostar, Cisco, Mavenir, Intel, Qualcomm and Airspan to construct a cloud-native 5G network, (DeGrasse, 2019).

In addition to these developments, Japan public authorities have tried to support 5G technology R&D and usage in other sectors by devising several policies. More recently (Feb. 2020), Japanese government enacted a legislation to give tax incentives and low-interest rate credits for the firms that develop and use 5G technology in their operations, (Reuters, 2020b).

On the other hand, **South Korea**, as one of the leading countries in terms of ICT usage (e.g., fiber connections), has started 5G development works as early as 2008. Since this date onwards, Korean policy makers have established collaborative agreements with other pioneer states to develop standards related to next generation mobile technologies. Gillispie (2020) links this cooperative attitude (from the beginning) to very small scale of the country and the export-oriented nature of her actors.

These stakeholders include several public agencies, operators, vendors, academicians and other related people from the industry and non-public organizations, as well as foreign organizations such as Intel, Nokia and Ericsson.

Although the type and grouping of these actors are similar to other country settings, the author points out the high degree of collaboration among them. With the inclusion of these stakeholders, Korean government enacted 5G+ Strategy. Afterwards, 5G Strategy Promotion Committee and 5G Forum with 26 member organizations were established to oversee the implementation of related development works. The government initially diverted 1.5 billion USD for the development of this technology, (Gross, 2014). This development strategy has five main objectives as increasing public sector investment, supporting private investment, raising indigenous 5G technical capabilities, participating in global standard development works and expanding utilization of the technology in the country. Among them, public sector investment category included deployment of 5G in public services, establishment of 5G connected smart city, assisting demand and experiments in five preselected services (i.e., immersive content, autonomous vehicles, smart manufacturing, smart cities, and digital healthcare). Stimulation of private investment covered provision of financial incentives (e.g., tax credits), promotion of SMEs’ usage of 5G applications and supporting immersive content market and productivity innovations in major sectors, foundation of test facilities and related infrastructure.

Expanding utilization consisted of policies related to performance improvements and system maintenance such as cost reductions, revision of regulatory institutions, enabling safer user environments, provision of universal service etc. Establishment of a domestic 5G technical capability encompassed supporting of 5G start-up ecosystem and strengthening the competitiveness of the sector. Lastly, Korean government prioritized the participation in standard setting works and aimed to achieve a leading position in such activities, (Gillispie, 2020, p.4).

South Korea’s service market differs from other country examples in one important aspect. The public authorities and related operators have decided to deploy one 5G network to reduce duplicate investment expenditures.

Accordingly, existing three operators share each component in the network under the coordination of government. The Ministry of Science and ICT declared that vast increase in the number of required small-cell base stations (between four to eighteen times higher than the required number of previous generation) is one of the main reasons behind this decision, (Horwitz, 2018).

In the hardware provision part, Samsung is the leading vendor of the country and well suited for the Korean objective of founding (and supporting) competitive global ICT producer firm. Although the country is very small in terms of size and population, this company has used home market as a base to export their equipment to global markets. All these domestic operators (SK Telekom, KT and LG Uplus) worked with Samsung in 5G technology deployment process of the country. Furthermore, USA pressure on Chinese vendors (especially Huawei) give advantage to other country firms including Samsung. Accordingly, the company increased its efforts to gain market share in Europe, India, Australia and Southeast Asia. In this regard, Reuters (Reuters, 2020c) reported some of its new deals with Verizon for 6.6 billion USD in USA and NTT Docomo in Japan. Without going into much detail, it is perhaps sufficient to refer from a top-level executive of the company’s statement that *they won the Verizon deal only after nearly ten years of continuous effort* to understand the difficulty of competing in this market, i.e., telecom hardware sector.

Apart from this, other dominant vendors like Ericsson, Nokia and Oualcomm are also active in this country. Lastly, one can mention the fact that Korea's geographical proximity and close economic relationships puts her in a more sensitive position vis a vis China. For instance, while Huawei is a competitor (and alleged security threat for other countries) for Samsung, it is also a main buyer of some components like memory chips, further complicating the situation, (Hemmings, 2020).

B.3. Private 5G Networks

In addition to public 5G networks, people are beginning to see more location specific adoption of this communication technology. In fact, with the maturation of 5G technology and increasing usage areas, private organizations are starting to adopt what is called 'private networks' for their own operations. As the name implies, private networks are open to restricted user base (i.e., depending on the owner's permission including workers, employees, supply chain collaborates, customers etc.) as opposed to traditional public networks that are open to everyone that have subscription in any form.

Westrup (2020) indicates the fact that establishment of private networks are more expensive than other wireless communication services like Wi-Fi. For this reason, organizations that need large-scale connectivity between everything (i.e., users, IoT) demand this type of network adoption.

With proliferating usage areas like manufacturing, warehouses, energy sector, airports etc., it is evident that demand for these networks will continue to expand in the future.

Even taking only one country example (Germany) shows the potential of the market and variety of these usage areas. Indeed, regulatory authority (the German Federal Network Agency) has begun to allocate spectrum for private utilization in return for usage fees. These fees even reached to one million Euro proportional with spectrum requirements. It is observed that especially automotive companies have started to deploy private networks in their facilities. Mercedes-Benz is working on the world's first mobile private network in one of its automotive factories. Actually, Telefonica Deutschland and Ericsson are constructing the network and after completion, the automotive company will operate this in production processes, (Daimler, n.d.). GSMA reported first use cases (implemented in the factory) including automated quality control to test the car on the production line (eliminating the post-production controls), use of automated guided vehicles and screwdrivers through 5G network, (GSMA, n.d.-b). Volkswagen is planning to adopt 5G technology for the operations of over 5.000 internet-connected robots in its factories. BMW is also following this trend by obtaining a spectrum for construction of a private network.

One can extend the list of companies that have already used and/or planning to deploy this type of network from other sectors. Briefly, to name a few of them, Lufthansa, BASF, Bosch, Siemens along with some facilities such as Hamburg Port have either started operations or working on completion of their projects, (Stupp, 2020).

In the light of these developments, it is clear that the number of these network types will continue to increase and they will be in the regulatory agenda of other follower countries' public authorities as well.

C. SELECTED SECTORAL 5G USE CASES

This part gives a more detailed evaluation of some usage cases that will be more widely used after adoption of recent mobile telecommunication technologies in the near future. Since the study focuses on adoption of an enabling technology, this subject is given as an annex to emphasize potential of various applications [403] while not prolonging main part with vertical sector usages. Furthermore, considering the fact that adoption of digital technologies has been started first in manufacturing industry, other late adopter sectors are examined to indicate expanding role of these technologies, which depends on an up-to-date telecom infrastructure.

For this reason, below review is starting with one of the oldest sectors and at the same time most essential one, namely agriculture[404].

C.1- Agriculture and Farming Industry

Market Developments and Key Drivers: Agriculture and farming are among the oldest industries in the world. Archaeological evidence reveals that first innovations for producing food, fuel and other goods by the systematic raising of plants and animals began roughly ten thousand years ago, making permanent settlement possible for the first time in the history (New World Encyclopedia, 2020). People have dealt with agriculture for ages successfully and yet despite centuries of practice, innovators are still devising new ways to make farming more efficient, cost-effective and aim to produce higher crop outputs to satisfy ever-growing food demand (SGW , n.d.). Historians assert that the modern world began in the late 18th century with simultaneous breakthroughs in both industrial and agricultural methods of production (Clark, 2002).

Thanks to innovations and mechanizations in agriculture, sector outputs have

[403] It should be noted that the use cases and application areas are increasing almost on a continuous basis. Accordingly, it is not wrong to say that use cases will permeate to all sectors in the near future. Here, these use cases have been especially selected to indicate this trend and further growth potential.
[404] The significance of this sector has only increased further as the recent world crises like Covid pandemic and wars that are disrupting international trade in basic goods including agricultural products.

increased tremendously since then. However, lack of adequate supply has always been a problem in some parts of the world. Today, the possibility of worldwide shortages is low but some countries face with severe problems. Food and Agriculture Organization of the United Nations (FAO) stress the fact that these shortages become worse if these countries will not implement proper action plans.

Moreover, the growth rates of world agricultural production and crop yields have decreased in recent years, exacerbating the problem (FAO, 2002).

Currently, there are three main factors responsible for the industry-market transformation: Population growth, climate changes and demand for more quality food (NGMN, 2016, pp. 25-26). FAO predict that world population will exceed 9 billion in 2050 and this necessitates 70% increase in food production between 2005- 2050 period (FAO, 2009). Secondly, it is evident that agriculture output has been highly depended on weather conditions. More importantly, recent changes like global warming and pollution caused by radiation etc. will continue to affect the sector more drastically in the near future. Thirdly, demand for more quality and high-energy food will surge simultaneously with increasing buying power of consumers in spite of population growth (FDI, 2011).

Taking all these developments into consideration, the application of ICT in agriculture is becoming more important in both quantitative and qualitative considerations.

Usage Cases: ICT use and application of modern technologies are not new concepts in the agriculture industry. Notwithstanding to this, mobile telecommunications and usage cases have beginning to change more conventional methods adopted in the industry, more recently. Farmers are increasingly adopting mobile applications to obtain, observe and to assess data instead of traditional methods like using pen and paper (Cespedes, 2013).

Boyacı and Yıldız (2017) argue those above-mentioned considerations (e.g., product quality, ecological concerns etc.) necessitate integration of knowledge, information, and services in the sector by using agriculture information system. Furthermore, they highlight the role of information system performance on the agricultural development of every country (Boyacı & Yıldız, 2017). This concept can be seen as a network composed of different shareholders and multidimensional perspectives that contain relations, policies, sources of knowledge, methods of communication, knowledge production, information sharing and decision making for increasing crop yields and efficiency (Vidanapthirana, 2019). In a more specific definition, Singh et al. (2014) underline ICTs role in the system to aid farmers in managing information and policy decision-making process.

Considering these arguments, it is clear that new mobile technologies' role in the industry will continue to increase in the near future. In this respect, experts see next-generation 5G networks, which can transmit data about 100 times faster than the previous technology (i.e., 4G), as a radical innovation to disrupt conventional processes by enabling more efficient communication between devices. As will be discussed in more detail below, producers have already begun to use new devices and applications like drones, sensors and mobile applications. For instance, drones with 5G technology are assisting farmers in Netherlands to increase efficiency in potato production. In Japan, 5G sensors monitor water temperature and salt concentration of oyster farms. As another example, Farmers in the UK are using a mobile application called "me+Moo" that monitors connected cows health and behavior to take necessary actions on time if they become ill or pregnant etc., (Lewis, Burnell, & Pursley, 2019).

Digital and Data Driven Agriculture: As indicated, the role of data and its analysis are getting more important every day in agriculture like almost all other industries. Data acquisition, analysis and sharing between relevant parties form one of the fundamental structures of a well-functioning agriculture information system. In such a system, every component (e.g., farm, animals) produce data and in turn stakeholders (e.g., farmers, cooperatives, and suppliers) can access and analyze these inputs (USAID, n.d.).

In this context, Hayden (2015) defines data driven agriculture as *thoughtful use of big data to supplement on-farm precision agriculture. It means having the right farm data, at the right time, to make better decisions.*

Digital agriculture produces different kind of data for several uses. Firstly, farmers produce and manage localized data such as fertilizer and water use. Imported data like forecasts make up the second category. On the other hand, governments and other stakeholders also use data generated from this system for agricultural analysis or for other policy purposes. Mobile communication technologies enabled sensors, IoT, cloud based computing and big data analysis all contribute to this digital transformation. Sensors and IoT collect wide-ranging data from soil quality, yield estimation to detection and mapping of crop threats to name a few (Moshou, n.d.). Data obtained from ecosystem then transmitted to designated cloud platforms for detailed analysis. Big Data platforms are necessary to process various inputs generated from interconnected things (machines) that send data over the Internet (GFAR-GODAN, 2018, p. 26).

Together with big data analytics and wireless sensors, agricultural and farming applications are increasing in parallel with the advent of mobile telecommunication capabilities. Irrigation management, farming system monitoring, pest and disease control and many other applications to increase output and product quality are developing thanks to new generation mobile telecommunications and this trend will further accelerate with the more widespread coverage of 5G networks.

Automation: Since the advent of first industrial revolution and new technologies, mechanization & automation have been continually expanding in the agriculture sector. With the development and more widespread availability of mobile communication networks, automation levels will continue to change almost all the production processes. Like driverless cars, farm machinery like tractors and crop loaders can work without human drivers and at the same time can transmit several types of data related to both machine’s status and field conditions. Drones are used in field surveillance and play a role in monitoring large agricultural areas. They can take precise aerial photos and record video.

These devices can even detect health of crops by using infrared sensors while conducting surveillance sorties, (Alexander, 2018). Automated farming devices also enable producers to record data on details including quantity of fertilizers or other inputs used in the crop growth processes.

This benefits farmers in terms of cost reduction (e.g., timing and optimal amount of fertilizer usage etc.) and increases information details provided to consumers about the quality of the agricultural products leading to efficiency gains in the market.

In the sector, communication involves machine to machine and machine to network types. Data to cloud uploading involves machine to network communication type. Driverless farm machinery and drone operations both require short latency & high reliability. Together with data driven farming, automated processes bring several important business opportunities for the ecosystem; availability of network, usage of connected sensors and vehicle to everything (V2X) services. Although for some services like inspection of water level etc., previous generation of mobile technologies can be sufficient, for other latency sensitive & high reliability requiring services like automated farm machinery, farmers may need more advanced technologies, (NGMN, 2016, p.27-28).

Due to importance of the sector and in this background, different countries have worked on strategic plans and started implementing various automation programs in agriculture sector. Among them, Chinese government has put agricultural machinery in its 'Made in China 2025' campaign. Because of ageing population and lack of enough agricultural work force, they set an automation target as one of the most important objectives in this action plan. According to this, national economy should produce almost all the country's farming equipment by 2025. Currently, it is observed that semi-automated technology has already some degree of availability on farms similar to USA, but fully automated tractors & other related devices are not mass-produced and not available at affordable costs to farmers. Chinese government is assisting the workings of the industry group Telematics Industry Application Alliance (TIAA) to accomplish this demanding seven (2018-2025) year target. State-owned tractor maker YTO Group, navigation systems producer Hwa Create and a combine harvester producer (Zoomlion Heavy Industry Science & Technology Co Ltd.) in collaboration with universities formed this alliance.

Industry experts (Gu & Patton, 2019) think that a domestic satellite navigation system called Beidou also give advantage to these producers since they can access and use this system'[405]. They also emphasize the need for more advanced sensors that can

[405] In this context, it is important to note that a comprehensive policy program should evaluate several aspects of the problem. Here automation may contribute to solution of the problems in agriculture sector, but technology by itself cannot eliminate all these shortcomings. Chinese experts indicate the fact that small size of farms constitute one of the main obstacles to increase the efficiency of the sector.

monitor farm conditions and able to adjust other devices more quickly to diverse conditions. Automation and digitalization in the agriculture is also in the 2019 digital agenda of the Union [406] (EC, 2019b). Digital day targets to stimulate digital transformation in major areas by making collaborations throughout the Union. Although EU agricultural sector is among the leading ones in terms of productivity and quality of its products, there are various problems, some of which are global such as climate change and warming. Like China, member countries in general have a shortage of farm labour along with ageing rural population. To address these problems, EU policy makers believe sector actors should adopt 5G enabled digital technologies and use them pervasively.

For this reason (i.e., comparatively low adoption of digital technologies), policy makers have selected agriculture as one of the topics in the digital agenda of EU. Experts state broadband coverage limitations, inadequate digital skills and (inadequate) knowledge about these technologies as among the most crucial barriers to slow down adoption rates. To begin with, rural broadband deployment in EU is relatively low versus urban areas similar to other country statistics. Therefore, member states give priority to increase broadband coverage and adoption in these areas.

While, nearly half of the population (47 percent) had access to this infrastructure[407] at the end of 2017, this rate reached to around 60% in 2019 (EC, 2020) .

It is evident that availability (coverage) is only the first step in the infrastructure provision. The second step meaning widespread usage necessitates an affordable tariff structure and digital knowledge (awareness) of people living in rural areas.

In fact, in the EU declaration (2019) member states jointly state that realizing full benefits of the digital transformation in the agricultural sector is only possible if such technologies are available everywhere and adopted by all farms and rural populations

Moreover, they cite varied geographical conditions, terrain and high costs as other barriers in the development of the sector.

[406] The other items in this year's agenda are artificial intelligence ethical guidelines, cooperation on advancing digitalization of cultural heritage, promoting greater participation of women in digital.

[407] This infrastructure definition covers new or upgraded access networks, which provide high broadband speeds including fiber, cable and wireless technologies, with the exclusion of traditional full copper-based transmission methods. These high-speed broadband networks are grouped under the name of next generation access (NGA) in general terms.

across EU. Ubiquitous, high performance digital connectivity is a prerequisite for increasing adoption of new digital technologies and services in these areas.

EU plan involves three related sub topics; enhancing support for research and development, building an innovation infrastructure and establishing a European dataspace for smart agri-food applications. Research and development priorities include digital innovations that foster productivity, advancement of bio-economy and eco-friendly solutions. In technological terms, low-power wide area wireless networks and IoT projects related to agricultural usages benefit from related funds. EU also support blockchain technologies especially in the food traceability system. Apart from these technological considerations, they put special emphasis on development of innovative business models, innovation ecosystem building and projects dealing with digital divide problem. For the innovation infrastructure, they recommend continuation and expansion of initiatives including 'SmartagriHubs[408]' network and strengthening of linkages between agri-food digital innovation hubs throughout the union. Besides, in line with agricultural knowledge and innovation system objectives, policy makers aim to increase training and skill development programs for the farmers by using several means such as Digital Europe Programme. Lastly, member states will facilitate data sharing and forming a European dataspace for smart agri-food applications. The declaration also states the importance of establishing close cooperation with the EU space programs (Galileo, Copernicus etc.) for the efficient functioning of automated farm machinery, drones and big data analysis mechanism. Digital Europe Programme, the European Agricultural Fund for Rural Development and European Structural and Investment Funds are most important mechanisms to implement these policies and achieve digital transformation targets of the union, (EU, 2019).

C.2- Automotive and Smart Driving

The automobile industry is one of the most affected sectors by developments in mobile telecom technologies in recent years. At present, semi-autonomous technologies are

[408] The name of a project with a budget of 20 million EUR under the framework of Horizon 2020 program. It aims to support digitalization of the agriculture sector and has more than 164 stakeholders from member countries (SmartAgriHubs, n.d.).

mainly used ones in the market. There are many companies working on autonomous vehicles and the date given for the full autonomous vehicles is around early 2020s, the time set by ITU as the completion of the standardization studies for 5G.

However, market analysts do not expect significant deployments of fully autonomous vehicles in any situation before 2030s, (LMC, 2018).

In fact, some experts argue that the industry is at the beginning of a radical change that will span nearly two decades, involving huge amounts of investments in state-of-the-art vehicle technologies leading to increasing efficiency, new safety systems and eventually fully autonomous (driverless) vehicles.

These next generation means of transportation necessitate advanced mobile data transmission capabilities to communicate with traffic management and control systems, manufacturers and other value-added service providers, (Huawei, 2016).

In line with these changes, experts predict that the market will expand in an increasing rate especially in ten years' time.

According to LMC (2018) forecasts, global sales of autonomous vehicles will surpass 10 million units before 2035.

These figures rise to 70 million in a middle case scenario, while in a breakthrough case reach to 90 million level in 2050's. Improved efficiency (e.g., less energy consumption, reduced pollution) and enhanced safety (e.g., decrease in accidents) will be among the most significant factors for increasing demand throughout the world.

As in other vertical sectors, usage cases follow an evolutionary path in parallel to technology advancement levels.

Communication between passengers and communication of traffic and navigation information are among the first services also given through 3G and 4G networks.

Presently- as shown in Table-C.1- connected vehicle environment include vehicle-to-vehicle (V2V), vehicle to infrastructure (V2I), and vehicle to pedestrian (V2P) type of communications. Finally, vehicle to everything (or the network) complete these systems representing a generalization and all other services like entertainment and cloud-based applications (Arena & Giovanni, 2019).

Table- C.1 Smart Driving Scenarios

Major Communication Categories	**Applications**	**Communication Types and Technology**
Vehicle to Vehicle (V2V)	Wireless inspection, Guidance for emergency, Signal priority	Wireless data transmissions between motor vehicles.
Vehicle to Pedestrian (V2P) (Includes a broad set of road users such as people walking, children in strollers, people using wheelchairs, people riding bicycles etc.)	Pedestrian detection systems in vehicles like blind spot detection, intersection movement assist, hand held device applications for pedestrians like signalized cross walk warning.	Short distance networking and cellular communication
Vehicle to Infrastructure (V2I)	V2I sensors can get infrastructure info and yield users with real-time advice, providing data on road conditions, traffic jams, any accidents in the roadway, the presence of construction sites and the availability of parking areas.	Different from V2V communication, that enables the exchange of information only among vehicles, the V2I enables vehicles in transit to interface with the road system. These components include RFID readers, traffic lights, cameras, lane markers, street lamps, signage, and parking meters. Commonly, V2I communications are wireless, bidirectional, and similarly to V2V, using Dedicated Short-Range Communication (DSRC) frequencies to transfer data
Vehicle to Everything (V2X)	Vehicles as mobile telecom terminals enabling entertainment, web browsing and cloud services	Cellular Communication

Source: (ITS, n.d.), (Arena & Giovanni, 2019), (Huawei, 2016)

For autonomous and smart driving, 5G technology is a prerequisite to satisfy latency and transmission rate requirements, (Table-C.2 Autonomous driving levels).

Usage applications include both vehicle-to vehicle (V2V) transmission and communication between vehicles and proximate environment, (ITUNews, 2019). In parallel with maturation and diffusion of technology, industry analysts predict exponential growth rates in revenues and other economic gains in several related sectors.

Table-C.2. Autonomous Driving Levels and Communication Specifications

Level	Automation Degree	Cases	Latency (ms) / Transmission Rate per vehicle (Mbit/s)
1	Driver Assistance	Active Cruise Control with Stop & Go function, which independently adjusts the distance to the car. The Collision and Pedestrian Warning with City Brake Activation, which prevents collisions via automatic braking etc.	10-1000 0.2
2	Partly Automated Driving	Semi-autonomous driving assistance systems, such as the Steering and Lane Control Assistant including Traffic Jam Assistant	20-100 0.5
3	Conditional Automation	The biggest leap from Level 2 to Levels 3 and above is that starting at Level 3, the vehicle itself controls all monitoring of the environment. The driver's attention is still critical at this level, but can disengage from "safety critical" functions like braking and leave it to the technology when conditions are safe.	10- 20 16
4	High Automation	Fully autonomous driving, although a human driver can still request control, and the car still has a cockpit. In level 4, the car can handle the majority of driving situations independently.	1-10 100
5	Full (driverless) Automation	This level of autonomous driving requires no human attention. There is no need for pedals, brakes, or a steering wheel, as the autonomous vehicle system controls all critical tasks, monitoring of the environment and identification of unique driving conditions like traffic jams.	1-10 100

Source: (BMW, 2020), (Harner, 2020), (Huawei 2016)

Allied Market Research predict global market for autonomous vehicles will reach to nearly 557 billion USD by 2026, (Garsten, 2018).

To highlight the importance of the sector, EC forecast that (EU) automotive industry revenues rise to 620 billion EUR in 2025 along with 180 billion EUR revenue generation in the EU electronic sector (Alonso, et al., 2018). In addition to these economic benefits, EU policy makers stress the social welfare gains like reduced air pollution and accidents resulting from automated and connected mobility throughout the continent. Consequently, they aim to achieve zero traffic fatalities by 2050, called vision zero objective (EC, 2011, p. 144). EC states that cooperation between every stakeholder from regional actors to industry players and a coordinated approach are necessary to achieve this objective in reality. The Commission (2018a, p. 5) also emphasize the importance of key infrastructure, technology, service development and production together with supportive regulatory framework to stay competitive against USA, China and other technology developer countries.

C.3- Transport and Logistics

Transport and logistics sector has faced with both opportunities and new problems mainly because of globalization, continuously increasing world trade volume and changing demographics. It is a given fact that urban population is ageing in average terms and urbanization is continuously increasing all over the world. These factors contribute to economic (e.g., rising energy costs, on time delivery, capacity utilization), safety (e.g., traffic problems, accident reduction issues, regulations) and environmental (e.g., pollution, awareness and regulations) concerns. Along with increasing world trade, rise of global internet platforms like Amazon, Alibaba changes the dynamics of logistics in terms of delivery speed and new supplier relations. Start-ups and other small-scale businesses are establishing connections with such platforms, multiplying demand for transportation sector, (Ekol, 2017).

In a more industrial look, Forbes Insights Research (2018) highlights four drivers of change in the sector. These are *shifting economic and industry structure, consumer demands for rapid delivery (i.e., amazon effect), advances in both frontline and backline technologies*. Frontline technologies are very similar to applications used in connected cars. They range from more basic ones such as car safety systems to truck platooning and finally to driverless vehicles. On the other hand, back line technologies comprise big data, artificial intelligence, machine learning, blockchain and IoT/telematics. Industry experts underscore the role of data and in this regard, digital technologies are improving decision-making capabilities of these firms both in real-time and in short to medium term basis (Forbes, 2018). Industrial internet consortium state that industrial internet reduces expenses and breakdowns, leading to operational improvements for logistics companies. These operational improvements include collision avoidance, automatic traffic adjustment and speed optimization for distribution chains. Moreover, contribution of industrial internet to the sector will continue in forming logistics systems that can monitor and respond to different conditions on a real time basis, (Industry IoT Consortium, n.d.). Within these key technology drivers, advanced mobile telecom technologies enable provision of several usage cases in a supply chain process.

Semi-Autonomous Driving and Truck Platooning: While autonomous cars and trucks look same concepts, there exists crucial differences between these two types of vehicles. On the negative side, maneuvering and braking of trucks are more difficult to handle due to their weights.

At the same time, there are many opportunities for this category of vehicles. For instance, some of these are used only in specific locations like mines, eliminating the need for more sophisticated traffic monitoring necessities. These locations with defined routes and low traffic suitable for fully automated transport vehicles in the first place.

For instance, Volvo tested the first autonomous (level 5) transportation vehicle in an underground mine, covering 7 km and descending 1.3 km underground. The vehicle equipped with sensors that scan adjacent areas to evade all kinds of moving and stationary hurdles. During the voyage, AI system can collect and analyze data to optimize fuel usage and other driving related processes, (Volvo Press Release, 2016).

In a similar fashion, some public service special vehicles such as waste disposal trucks that travel slowly and in relatively quiet traffic provide opportunities for early uses of artificial intelligence, (Walker, 2019).

Before fully autonomous driving, sector players have been introducing and experimenting with several intelligent use cases in this category. These usage cases correspond to level four automation in general terms. Logistics firms plan to increase safety and cut down operational expenditures by allowing autonomous driving in certain conditions. It appears that using this level in a more widespread manner is major aim of sector players in short to medium term. Like steps in a ladder, autonomous pilot in suitable weather-road situations constitute the first step in this regard. Here, drivers can rest and make other job-related works while take handling of vehicles in heavy traffic, poor quality roads, loading and emptying moments.

In this category, an autonomous vehicle technology firm (Otto) acquired by Uber completed the first shipment of a cargo by using a self-driving truck on the highway, (Post & Parcel, 2016).

After this step, ‘platooning’ is regarded as a cornerstone of future transportation system. It means joint movement of trucks in a close group formation. These convoys lead by a head truck and fuel consumption can decrease as much as 12 percent. Scania (one of the leading firms in the production of transport vehicles) commenced a project with Swedish National Road and Transport Research Institute (KTH) and some other partners to test platooning in real life situations on a nearly 500 km road in Sweden (ITJ, 2017).

Currently, Scania has been actually implementing real-life platooning operations in different countries like Spain[409].

In the short term, general aim of these projects to permit driver in the lead vehicle to command other trucks controlled by artificial intelligence systems. Besides this, Scania R&D department head affirm that fuel cost reduction is no longer the sole objective of this technology. Indeed, platooning seen as an integrated part for future logistics.

Progress in digital technologies, especially IoT and high data transmission capabilities with low latency (i.e., 5G) enable full connection opportunities not only between vehicles but also between different actors in an ecosystem (Scania, 2018a). Governments are also effectively supporting these projects all over the world.

For example, UK government initially granted more than 10 million USD to perform platooning trials. The Transport Research Laboratory (TRL) undertook these tests and Department for Transport and Highways England funded this Project, (Tomás, 2018).

Augmented Reality and Minimization of Supply Chain Risks: As outlined before,

[409] Operations in Spain covers two routes with a distance of 350 and 200 kilometers respectively. Other project partner is a Spanish transportation company Acotral, (Scania, 2018b).

one of the main impacts of 5G technology is to support numerous IoT device connections with each other, eliminating the limits of spectrum capacity in previous mobile communication technologies[410].

With the use of portable internet connected devices, firms can monitor the location and condition of cargo items throughout the supply chain process near real time basis.

This capability is a very important one for these firms taking into account the fact that, supply chain of any logistics firm in many cases covers long distances and different change locations. Embedded devices in all parts of the supply chain (i.e., warehouse, shipping, final delivery etc.) can transmit information to the cloud from which more detailed analysis can be made to determine inefficient points in the whole chain. Such an ecosystem consists of technological components (e.g., platform, connectivity, cloud etc.) and shareholders (e.g., suppliers, port facilities etc.) connected with each other, (Ngmn, 2016, pp. 14-15).

Besides this, 5G enable AR applications to become more efficient and widespread in several areas of logistics. Among them, logistics firms increasingly use 'vision picking' to select items from inventory to carry out an order more efficiently, (Clear Spider, 2018). In addition to order picking, assembly and repair process times reduced thanks to faster and more reliable data transfers to AR-enabled equipment. Maintenance personnel can use hands free AR glasses to get instructions while repairing any device, reducing training and labor costs, (DHL, 2019a).

Similar to other mobile high-tech applications, sophistication and contribution of vision picking systems are continually increasing in the form of new products and technologies developed by joint projects between sector players (i.e., logistics firm in transportation) and technology providers. As an illustration, a worldwide leading logistics firm DHL is expanding its augmented reality (AR) based "vision picking" system to other branches worldwide by using Google's smart glasses (Forde, 2019).

The executive officer (of this company) responsible for supply chain management declared that the feasibility of object recognition is providing many opportunities in

[410] Using shorter wavelengths, 5G will be able to connect 1000 more IoT per meter than 4G capability, resulting in ultrafast data to more users with low latency, (Fisher, 2021a).

industrial applications. He added that new generation of technology is optimized for use in intralogistics solutions[411] and even complex processes can be handled with this augmented reality application. More importantly and in parallel with the argument that digital transformation and realization of its benefits require adoption of different digital solutions ecosystem approach, DHL emphasizes importance of company-wide digitalization strategy. In addition to AR devices (glasses, wearables), this strategy consists of drones, robots, connected vehicles and other technologies-processes to advance warehouse and logistics management, (DHL, 2019b).

Drone and Robot Delivery Services: In an ideal digitalized work environment, IoT, AI and other technologies control whole supply chain process. Robots load cargos to autonomous vehicles in a warehouse. Then these vehicles get to another station to unload them. Here robots and AI again inspect, classify and load them on drones to deliver these goods to final customers. It is evident that digital technologies supported by new generation telecom networks increasingly used in many industries. Among them, especially robots and drones attract public attention more than other advances. However, their use in logistics sector is relatively new, compared to other practices in manufacturing industry. Industry experts state technology level as one of the main reasons for late adoption. Whereas robots in manufacturing perform same movements and processes, requirements of logistics sector are more complex and demand more sophistication and ability for robots. A logistics robot should have the ability to deal with dissimilar items in numerous combinations. In other words, they need to possess visual, movement capability and adaptability to work environment. Another related point is that advancement of this technology necessitates joint working of different science fields more than many other innovations. These fields range from engineering (e.g., electrical- mechanical), computer science to biology, mathematics and even to psychology, sociology. For these reasons, diffusion of robot technology in a widespread manner has taken relatively long time depending on the specificities of the sector. The advent of low-cost sensors, more efficient batteries, cloud computing, increasing microprocessor capacity, mobility and wireless networks are among the main enabling factors in electronics and computer science fields to recent

[411] Invata defines ‘Intralogistics’ as the art of optimizing, integrating, automating, and managing the logistical flow of information and material goods within the walls of a fulfillment or distribution center, (IAS, n.d.).

developments in logistics sector. Furthermore, it is important to highlight another factor behind the acceleration of recent advancements in these technologies. In today's technology development system, three actors significantly affect the environment by their funding to research and development activities. Governments (public agencies), start-ups (venture capital) and global technology firms (e.g., Google, Huawei etc.) are all involved in technology development race in accordance with their objectives. Similar to the development history of internet, USA defense related public organizations such as Defense Advanced Research Project Agency (DARPA) has supported robotics technology innovations through various ways including university grants and contests with prize money. Among global companies, Amazon bought a start-up robotics firm dealing with warehouse logistics. As another example, Google started acquisition of robotics startup firms especially dealing with logistics, (Bonkenburg, 2016).

Like robots, drone use is also providing new opportunities in the logistics industry. Transportation firms can use drones both in rural (difficult to reach) and urban (heavy traffic) areas. 5G technology support coordination of drone movements and enable safe transportation (to avoid buildings, other vehicles including drones etc.) due to real time and secure transmission capabilities. Some firms have already begun to use them in their certain operations and others are making trials before utilizing them in their businesses. Rwanda government in collaboration with a start-up from USA has developed an innovative service to convey blood units to people in need, (Sandoz, 2018). Ghana introduced similar service (again in cooperation with a start-up firm) to distribute medicines, vaccines and blood supplies to 2.000 medical centers in rural areas with nearly 600 daily drone flights, (Murray, 2019). With the growing significance of mobile network infrastructures in digital service provision, mobile telecom operators are entering in robot and drone applications (along with other vertical sector usages). For instance, NTT Docomo[412] is undertaking drone projects with several partners and planning to expand the variety of applications make possible by using 5G network (i.e., large capacity, high-speed, low latency) capabilities after 2020. This company recently announced a new type of drone that flies with ultrasonic

[412] NTT DOCOMO is the biggest mobile operator in Japan with over 80 million subscriptions, (NTT, n.d.). The company works on development of mobile telecommunications starting from 3G and 4G technologies. It is currently involving in 5G technology works.

vibrations instead of propellers or wings. This specific feature reduces injuries, accidents and make them suitable for indoor (e.g., concert halls etc.) usages, (NTT DOCOMO Press Release, 2017). Apart from being enabler to the provision of these services, 5G technology has also a vital role in the implementation of drone detection systems. Another global firm Vodafone has introduced a service using sensors and cameras working in the operator's IoT network.

This system identifies any intruder, its location and alarm user such as power plants and prisons, (Fildes, 2018b).

In the light of these developments, industry experts forecast that the trend of using robots and drones along with other digital technologies continue to increase in every segment of supply chain process. These segments cover distribution centers (autonomous transport, mobile item picking, automated inventory management and surveillance etc.), sorting centers (autonomous maneuvering, container loading and unloading, handling of dangerous cargo), finally last mile delivery in the form of service robot, use of drones and automated door to door shipments, (Bonkenburg, 2016). Here, one should emphasize critical importance of communication capabilities of these elements with each other and management center. 5G network provide real time communication capabilities between these segments and enable coordination of each element's movement to optimize work processes, (GSMA, 2018c).

Apart from technological issues, suitability of regulatory and legal framework is critical for the further adoption of these innovations. In almost every service from autonomous driving to drones, regulatory framework should be designed to incentivize adoption, taking into account the fact that every innovation is a complex process involving interactions of different actors in an ecosystem.

C.4- Healthcare

With the advent of mobile telecom technology, health sector applications are showing important development and change in several respects. In fact, experts from Institute of Electrical and Electronics Engineers (IEEE) state that healthcare sector is undergoing a paradigm change due to soaring adoption of devices with sensing equipment, IoT and telemedicine, all of which are using these networks. Furthermore, the number of use cases are continuously increasing in line with evolution of the technology.

These applications put complex requirements on the network such as latency, bandwidth, upload/download capacity and connectivity. Initial applications started with IoT devices in hospitals, increasing data requirements of IoT based applications lead to expansion of Massive-Machine Type Communication (mMTC) or Massive IoT. More advanced usages including robotic remote surgeries stimulate the need for Critical Machine Type Communication (cMTC) or Ultra Reliability and Low Latency Communications (URLLC), (Rao, n.d.).

That is to say, people are beginning to experience a new era in health services thanks to 5G enabled applications. In the near future, 5G networks can connect patients and doctors around the world for monitoring, decreasing the need for physical observation in many cases. Connecting more medical devices to IoT will allow doctors to monitor patients without the need for hospital care. Medical personnel can transmit and/or receive digital imaging to/from other health institutions. This will both reduce cost of obtaining second opinion and give benefits to people who reside in rural-more distant areas by enlarging the access to these services, (Karsten, 2016).

Wearable Health Devices (WHDs) such as fitness trackers assist people to follow their health conditions both at an individual level for self-health monitoring and at a medical level for giving detailed input to physicians with a potential for earlier diagnostic and if necessary further medical care direction, (Dias & Cunha, 2018). Furthermore, researchers can design specific treatments to each patient by analyzing data obtained from this technology, (Karsten, 2016).

In this context, 5G will be a key activator of the IoT by providing a platform for connecting multiple objects to the Internet. These networks will support sensors that require very low energy consumption by charging once every 15 years. This new paradigm will be very useful for medically connected devices such as body-worn sensors that measure blood pressure or insulin. Moreover, high reliability and security of 5G infrastructures ensure more privacy for end-users, healthcare professionals and eliminate piracy concerns around health data and services, together with other cyber security measures applied in networks.

When considering the new 5G capacities that reach the 1-millisecond target within a low latency, one can even consider applications in the area of organ transplantations (ICTA, 2019, p. 45).

Teece (2017) also asserts that 5G technology has a significant influence on both health care sector and other sectors that produce these services & devices. According to him, 5G -as an enabler of “personalized health care” era- lead to new business practices while disrupting some of the previous models due to the capability of connecting different devices together with high reliability and low latency characteristics of this technology.

Indeed, internet of medical things (IoMT) including clinical wearables and remote sensors together with other devices that monitor and electronically transmit medical data such as vital signs, physical activity, personal safety, and medication adherence forms the core of this health care ecosystem (West, 2016).

C.5- Smart Cities and Utilities

The concept of smart city is getting more popular and widely used in both practical implementations and from policy planning to scientific literature in recent decades. The main reason behind this trend is continuing expansion of cities all over the world. For the first time in history in 2008, the number of people, living in cities (3.3 billion) surpassed those living in rural areas (UN-HABITAT, 2011, p. 1). This growth rate has increased in recent years and will continue to enlarge in the coming decades.

In fact, World Bank predicts that nearly 5.1 billion people will live in the cities and almost all of the future growth of the world’s population will be concentrated in cities by the year 2030 (United Nations, 2015, p. 37).

Although this trend is creating many problems like concentration of poverty, social disruption and pollution, it seems unavoidable and policy makers should look for solutions to problems of urbanization.

In the positive side of this trend, urban centers become hubs for knowledge sharing and innovation since the beginning of first industrial revolution. High population density and location of diverse industries in these areas enable more interaction and communication between the people (entrepreneurs, scientists etc.). This in turn led to knowledge spillovers, innovative thinking, advancement of new ideas and projects. Marshall (1890) firstly introduced the concept of agglomeration economies related to a geographically defined area in which an ecosystem of firms, industries, infrastructure items and viable market structures coexist and sustain each other. According to him, this concept consists of localization and urbanization economies. Localization economies refer to knowledge interactions, research collaborations and easy accessibility of inputs for firms in the same industry and in a close proximity to each other.

These positive externalities in turn lead to cost savings and efficiency increases. Urbanization economies include big market size, infrastructure advantages, presence of other industries that give positive externalities (Cruz Villamil, 2010). In today's market conditions with the increasing importance of open innovation models, these external economies become even more decisive for science and technology policies. As a result, firms cluster to achieve these benefits (e.g., lower costs, availability of specialized inputs, knowledge interactions etc.) and establish vertical and horizontal connections with each other. Apart from infrastructure conditions and market size, efficiency of city clusters depends on many other factors including, historical path dependencies and public policy choices (UN-HABITAT, 2011)[413].

On the other side of the coin, as briefly mentioned before, increasing urbanization brings about many problems since cities become main consumers of resources leading to enormous amount of consumption, traffic congestions, air pollution, and waste disposal problems among others. Policy makers think that appropriate uses of digital technologies may help to solve these challenges. These new technologies applied in urban services extensively benefit from ICT, leading to what is called *smart cities*. People (experts, scientists and policy planners etc.) have begun to use this term since 1990s to emphasize pervasive influence of new technologies in the modern city

[413] For instance, Ankara region is becoming more important for the 5G works both in terms of domestic production efforts and as a testing location for service development. Some of new electronic communication equipment companies like ULAK and 5G test area established in the Ankara region. In this respect, it may be useful to evaluate the working of productivity enhancing mechanisms of clustering and agglomeration economies. It is stated in the literature that, firms benefit from knowledge spillovers and interactions, can buy or sell more specialized inputs due to the presence of related buyers/sellers, can produce different goods thanks to the demand generated by these factors.

infrastructure components and operations (Yin, et al., 2015). In line with technological advancements, scope of the concept has enlarged to address different needs. Moura et al. (2019) have analyzed evolution of the term by looking into smart city objectives like environmental protection, energy efficiency, security and increasing attractiveness to support city development.

Batty et al. (2012) elucidate this by emphasizing the main objective of the diffusion of ICT in urban areas should be improvement of every subsystem, in the end enhancing the quality of life and general well-being of residents.

Among many definitions, Gartner's description (Hughes L. , 2015) is also interesting for highlighting the role of ecosystem in urban areas.

The consulting firm sees intelligent exchanges of information that flow between its many different subsystems as foundations of a smart city. Furthermore, this continuous information exchange and big data (after processing and analyzing) are used in the social and commercial services of city life to make wider ecosystem more resource efficient, sustainable and more eco-friendly. Within, this background, some applications can be stated as follows.

Usage Cases of Smart City Concept: Smart city solutions in the first place require fast and reliable electronic communications infrastructure both in terms of widespread mobile network supported by new generation (fiber) fixed network coverage. With 4G technology, cities have begun to use wireless applications, but the usage ways and quality of these services will increase after the widespread adoption of 5G networks. As noted, 5G is the infrastructure designed to overcome the connection difficulties caused by multiple connected devices. These devices (IoT) are used in various areas such as vehicle and traffic monitoring and management, monitoring of transport system, waste and energy management.

Smart Traffic Management: This use case mainly deals with management of traffic lights and sending information to people like empty parking spaces by using sensor networks. It aims to reduce traffic congestions and air pollution levels by adjusting traffic flows in accordance with real time demand and giving priority to public transportation with a green wave system (Tomás, 2017). Like other smart city applications, traffic management services are increasingly used in cities all around the world. Notwithstanding to this, extent and service complications may differ between cities depending on network coverage, reliability and applications' complexities. To give few examples, Miami-Dade, Maryland and Copenhagen have adopted such systems. Miami-Dade city undertook a project involving 300 adaptive 'smart' signal traffic controllers, including supporting hardware and software to enlarge their traffic mobility management services. One pilot testing showed up to 10 minutes reduction in average travel time of drivers in the area. The system helps to keep traffic flow by altering timing according to traffic densities at intersections and give priority to public transportation (buses). City officials announce this project as a part of five-year plan to improve mobility in this area (Miami-Dade County News Release, 2017). Similarly, Maryland city officers invested nearly 50 million USD to install smart traffic signals to increase traffic management efficiency and reduce congestion for nearly 700,000 drivers per day on major corridors of the state roads. According to the public notice, smart traffic system processes real-time traffic situation and adjusts timing of traffic signals with artificial intelligence to prevent traffic congestions (Maryland State Press Release, 2017). Copenhagen also invested nearly 8 million EUR on a smart traffic system to avoid jams (EC, 2015). This system gives priority to buses and cycles in traffic. Vehicles can communicate their location, carried passenger numbers and other related traffic information. Besides, the application extends traffic light changes from eight to 30 seconds for public bus passes and they can adjust them to enable faster transportation after social events, matches and concerts. One of the distinct specialties is the ability to spot cyclist speed with the help of traffic cameras and arrange the lighting properly, (Tomás, 2017).

Connected Lighting: In simple terms, streetlights equipped with sensors that detect the movement of cars or people may turn on when there is movement in the area, otherwise they may go out. This will benefit energy saving and thus economy as a whole. Many cities acknowledge smart lighting as a beginning point of smart city solutions.

There are many direct benefits of such a system including improving energy efficiency and decreasing expenditures, maintenance costs and pollution. Furthermore, intelligent lighting can serve as a backbone for numerous other smart services such as public security, traffic management operations, parking assistance, environmental observation and extended wireless communications, (Woods, 2018).

Experts calculate up to 70% energy savings annually from the smart solutions together with LED based lighting. The initial investment costs may be high but durability of LED, energy efficiency and lower maintenance, diagnostic expenditures bring about these savings. However, it is argued that for this type of street lighting, extra revenues are necessary to offset the initial investments. Here, bundling with other applications in surveillance, reporting and coordination may provide additional revenue streams. One of the difficulties of this is that there is more than one player of the ecosystem. Telecom operators, lighting service providers, over the top services can all take part in the system and this may necessitate some kind of regulatory intervention (NGMN, 2016). In any case, the number of such projects are increasing in many cities. Navigant Research forecasts over 70 million connected streetlights installed globally by 2026 (EC, 2018b). For instance, Chicago has deployed over 200 thousand streetlights[414] with smart controlled LEDs, which reduce lighting costs by 10 million USD annually, in the four-year period (Chicago Department of Transportation, 2020). In another continent, Australia and New Zealand will spend near 800 million USD in the next decade. With this budget, they plan to switch 95% of streetlights to LED models before 2027 (Nhede, 2019) . European cities are also undertaking such projects and according to Eurelectric, they are planning to install 10 million smart streetlights by 2025, (Gordon, 2019).

Public Safety and Security: Developments in ICT (sensors, drones, processors etc.) together with high capacity and reliable communication networks provide new services and opportunities in the field of public safety.

Due to low latency and high data transmission capabilities of these telecom infrastructures, information obtained from several sources such as drones, sensors and cameras can be analyzed almost real time, reducing response time. For instance, a top security case such as bomb disposal operation with robots require very precise and low latency data capabilities. Connected camera systems installed on smart streetlights with gunshot detection sensors can also transmit data in real time so security personnel

[414] The Project planned to deploy (a total of) 270 thousand smart streetlights before completion in 2021.

will be able to respond in time (Infopulse, 2021).

At the same time, big telecom operators initiate open innovation models. Verizon (USA) launched a 5G lab as an innovation incubator. Entrepreneurs can access 5G technology to develop public safety services and applications in this facility. Senior Vice President responsible for strategy, innovation and product (in this company) announced that their 5G First Responder Lab would provide technology entrepreneurs the opportunity to innovate applications and vertical cases that make use of the unique capabilities of 5G, and to provide these applications to the market in a shorter period. Director of public sector product strategy for Verizon also emphasized the priority given to usage cases of this revolutionary technology beyond network deployment itself. He added that 5G would enable technology that no one has envisaged yet, and this facility would promote the advancement of life-saving innovations, (Verizon Communications, 2018).

Emergency Services: Closely related to public security services, emergency services deal with disasters (earthquake, flood etc.) and other critical situations like accidents, fires etc. Early warning systems are used to minimize causalities in these disasters and other emergencies. Here, occurrence detection prior to an event and sending of information to concerned organizations play vital roles and this process necessitates reliable communication capabilities. In emergency management, IoT and artificial intelligence are also important in monitoring, estimation and event detection. The reliability of networks and embedded systems performance are in fact more crucial after such events. These networks should perform by using very low energy and have the ability to send geo-fenced notifications. Emergency communications should provide real-time high priority voice, video, text conversation services and should be resilient to data and cyber security threats that could delay the reaction time of the emergency response (Markakis, et al., 2017). In this regard, 5G is a suitable technology for enabling real time usage of multimedia for enhanced situational perception and permanent connection capability to the first responders and emergency service personnel (mostly) due to its network-slicing feature[415], which dynamically adapts

[415] Sdx (2018b) defines 5G network slicing as the application of network virtualization to divide single network connections into multiple distinct virtual connections that allocate different amounts of

transmission speed, latency of networks and expands number of channels and uplink capacity.

Suiting these capabilities, coordination with response teams and use of sensors, robots & drones in research and rescue operations are among the many uses of emergency management, (Ngmn, 2016, p.23). 5G networks enable emergency service equipment traction and enhance response to emergency cases using IoT integration. As an example, ‘connected ambulance’ usage can reduce the death rate after the incidents. Ambulances can be operated as a connection hub for medical devices by using 5G networks.

Simultaneously, real time data can be sent to hospitals to gain precious time to save patients.

Within this context, UK public organizations have implemented projects to test connected ambulances equipped with live video streaming capability to give specialist advice to ambulance medical personnel, (WM5G, 2019). Coordination and control centers are essential parts of any emergency service management system. With 5G technology, control rooms are no longer dependent on fixed networks system elements and they can communicate with a lower latency and high transmission speeds. Although previous generations of the mobile technology, especially 4G, support these operations- like other smart city services- 5G undoubtedly upgrades these and increase the number of different solutions. TechUK (2019) compares the functioning of emergency control room operations utilized in these different generations. Previously, after the contact event recorded as digital evidence by using camera, mobile device and loaded to internal service. After 5G, emergency services associating with the incident will be able to record it in real time and transmit to the control center live. In the meantime, digital evidence automatically uploaded to internal service by the mobile equipment. To achieve these capabilities, UK government undertook a project to upgrade emergency services network communications system from which nearly 300 thousand personnel such as fire, rescue and ambulance services and nearly 50

resources to different types of traffic. Experts consider network slicing is a paradigm changer in that 5G networks can adapt to the requirements of different needs, applications as opposed to previous setting in which different applications, users had to operate within a given network capacity, (GSMA, 2017, p.3).

thousand vehicles communicate with each other. Along with other projects, TechUK underline the fundamental role of network structure (i.e., sufficient to meet requirements and demand) and the need for continuous investment in emergency services. The agency also emphasizes development of standards and establishment of an information-sharing environment to stimulate innovation in this field, (TechUK, 2019, p.15).

Smart Homes: Although it is not directly related to smart city concept, it can be said that cities (of course) consist of mainly residences. Other areas like businesses, public entities and recreational places form other main parts of any city. In fact, it may not be wrong to state that connectedness levels between smart city subsystems and smart homes are going to increase in the near future, as well.

In general, the concept can be seen as a system that uses telecommunication networks to link main devices, services in a house while permitting remote access, observation and control both from inside and outside of the building. There are three components in the system; network (fixed, mobile, cable), intelligent control (gateway to manage the system) and home automation (UK Dept. of Trade and Industry, 2003).

This IoT management platform enable several applications connected through a smart home gateway system. They include connected household appliances (e.g., a refrigerator ordering food or beverage), image monitoring (e.g., monitoring of images on the internet with cameras placed in the house, sending alarms by detecting some movements such as smoke, carbon monoxide gases) and remote automation (e.g., light, TV and PC, recorders can be switched on and off). Moreover, smart home systems can be used in energy management (e.g., adjustment of light and temperature) and remote measurement (e.g., reading gas or electricity meters), among other applications.

In a similar fashion, Downes has argued that 5G technology is not only the case of refrigerators or other home devices that monitors the usage patterns and orders food but also providing home security, energy use control & optimization and home entertainment to name a few of them. More importantly, this technology can assist sick and/or aging people to connect to telehealth services from their homes to monitor their health (Downes, 2018). In fact, this last example supports the above argument that smart city, smart home and other so-called smart applications like telehealth etc. will form an interconnected digital world, where people use these services in their daily lives.

C.6- Media, Entertainment and Retail Services

Media and entertainment sector is undergoing radical transformations due to new technologies and changing consumer demands in recent years. Indeed, these interactions are multidirectional and opens up new opportunities for companies and even to end users (previously passive actors in the market).

Owing to recent technological developments such as big data and analytics, companies can deliver each consumer what she/he wants in the right time and from any selected platform. Furthermore, they can more effectively address advertisements to target consumers. In terms of their performance evaluations, media companies can also use big data analysis and adjust their marketing strategies accordingly, (Thusoo, n.d.).

Deloitte (2019a) has indicated the fact that media usage of consumers has transformed considerably since the last decade, leading to both risks and opportunities for traditional broadcasters, media & entertainment companies, latecomer digital service providers and actors. Young people are spending more time in the internet than watching TV and demand for streaming services are increasing continuously. In USA, millennials prefer to watch streaming content from internet instead of sitting in front of traditional TV broadcasting and 20% of them routinely use mobile devices for looking video content. In fact, demand for streaming services such as Netflix continue to thrive, reaching nearly 60% percent subscription rates in this country (Deloitte, 2019). Similarly, younger viewers (between 16 and 34) lead the related transformation in UK, by spending more time on non-broadcast content. More specifically, this age group devoted nearly two and a half hours to this media as opposed to slightly above two hours to broadcast content in 2017 and this discrepancy is expected to widen more in the coming years, (Ofcom, 2018).

As the above examples show, apart from decreasing demand for traditional media sources, new services and applications are attracting more popularity in countries especially where there exist communication networks to support these provisions. Among them, media companies are prioritizing virtual and augmented reality services and are starting to make investments in these areas. For instance, Sony, Warner and Comcast invested in the NextVR startup, a VR platform providing live broadcasts such as music events in 2018 (O'Neil, 2018) and new alliances, start-ups have been entering the related market segments at an increasing rate. More recently, Apple has bought NextVR for nearly 100 million USD in 2020 to enter this market segment, (Leswing, 2020).

Notwithstanding to this, these new services necessitate considerable amount of investment for media companies and even these are not enough since upgrades on other parts of the system such as telecom networks are also necessary for increasing mass-market adoption. O'Neill (2018) has indicated the fact that 360-degree video together with VR applications provide more video content with higher resolution requirements. Accordingly, media companies need to have bigger and reliable transmission capabilities to deal with enormous data traffic.

In parallel with technological innovations, market actors are also diversifying their contents by launching new services. In VR-AR segment, 'job training' and 'ask the expert' services give growing revenue opportunities for these companies. Similarly, demand for voice enabled digital assistants are increasing in this market, (Deloitte, 2019, p.3). Another opportunity come from multiplayer game competitions (e-sports). Market revenues has reached to 1.1 billion USD in 2019 and expected to be around 1.8 billion USD around 2022, (Russ, 2019).

In turn, these developments are affecting the market structures of every country continuously, though differently depending on country specific factors. This is especially evident in USA market where media & entertainment companies have been increasingly undertaking merger and acquisition activities. In fact, it is normal to expect continuing consolidation trend all over the world taking into account convergence between different networks and technologies[416]. In line with this, telecom operators aim to develop and provide their own multimedia content, value added

[416] Although convergence is not a new concept, it is accelerating more rapidly as existing networks upgraded or new technologies developed to offer different telecom and media services. As an example, cable television providers are now providing voice, internet access, and broadcast services over the same network as one bundled package of services, and for one monthly price. Likewise, a mobile service provider are able to offer data and video, as well as voice services, and digital television (DTV) providers are giving interactive services to consumers.

applications as revenue streams from conventional services like voice calls are diminishing to a considerable extent, if not disappearing completely. For instance, Verizon Communications established partnerships with Apple and Google for the provision of 5G wireless service, starting with four major cities in USA at the end of 2018, (Moritz, 2018). As another (vertical) merger case, AT&T made an acquisition of Time Warner including HBO, Warner Bros. and Turner Cable networks to become content producer in addition to its original role of content distributor, (Gold, 2019). This trend is also similar in Europe and other parts of the world. For instance, Vodafone acquired German cable operator (Unitymedia) for 22 billion USD in 2019, (Reuters, 2019c).

It is clear that telecom operators are enlarging their business portfolios in media like pay-tv to increase consumer loyalty (lock-in) and their ARPU (average revenue per user) levels.

On the other hand, while both market actors and consumers are facing with tremendous changes in terms of their media & entertainment experiences, several risks and problems are starting to appear for these market actors. Among them, one of the most controversial is privacy and data protection in ever-increasing digital and data driven media industry. Indeed, this issue covers almost every 5G related usage case in different sectors. With the growing role of data in digital environment, privacy concerns spread to different dimensions as never before experienced. Previously, (data) privacy related to traditional identifiers such as demographic information such as name, address and gender collected through various means.

While digital technologies penetrate in every dimension of personal and social life, innovations reshape the notion of privacy from personal communication, location and space, behavior and actions, biological data, images and even feelings of individuals, (Deloitte, 2019b).

In the light of these developments, both users and government agencies are increasingly giving more attention to data protection issues. As a case in point, one of the leading (worldwide) social media giant ‘Facebook’ is facing with personnel data privacy investigations in several countries. For instance, Federal Trade Commission of USA (FTC) imposed 5 billion USD fine, making it the largest fine ever given to a company on data privacy issues (Nuñez, 2019). This is also relevant for EU member states after the implementation of new general data protection regulation (GDPR) as of May 2018[417]. Similarly, Ireland's Data Protection Commission (DPC) has started to investigate Facebook's WhatsApp and Twitter over possible violation of EU data privacy rules. In the end, DPC fined the company around 550 thousand USD for failing to comply with GDPR (Lomas, 2020). Apart from EU, Türkiye's Personal Data Protection Board (KVKK) fined this company two times (approximately 282.000 and 270.000 USD) for exposing personal info and non-public photos without user consent and/or approval (Reuters, 2019d).

C.7- Summary of Usage Cases Evaluation

This part gives a brief examination of usage cases mentioned above. Here, Table C.3 indicates main areas in terms of problems & trends and role of mobile communications in this context.

Table C.3- Major Sectoral Problems, Trends and Role of Mobile Communications (Technology and Operators)

Industry	Problems& Trends	Mobile Communications
Agriculture	Aging and growing population Widespread presence of chronic diseases Changing needs and demand Increasing costs of inputs Digital innovation and transformation Cyber Security and Regulatory developments Need for qualified personnel	More efficient & faster information sharing in ecosystems Reduction of input costs (e.g., efficient use of fertilizer, water etc.) In sum, improvement of agricultural productivity overall (e.g., more crop productivity)
Automotive	Traffic problem especially in urban areas Increasing number of traffic accidents and losses Weather pollution Increasing (both owning and operational) costs of vehicles Cyber Security and Regulatory developments	Decrease in traffic congestion, accidents and environmental pollution due to smarter management of vehicles Moreover, 5G will facilitate completely new functions in the vehicle and beyond. Foundations for future mobility and automated driving, as well

[417] Briefly, this new regulation gives more control to end users on the storage and usage of personnel data by companies. Among other things, consumers can access where their data is stored and how they are used. Moreover, they can demand deletion of personal data and block transferring them to other parties. Besides, end users are also able to transfer their data to other operators, (GDPR Summary, n.d.).

Industry	Problems& Trends	Mobile Communications
	Electric powered- Autonomous & connected vehicles Increase in shared vehicles (also yearly updated) Safety & infotainment Transformation of value chain, importance of user-oriented innovations, software applications (relatedly increase in R&D spending in this category) New players in the sector / a new ecosystem where standard car makers team up with major actors in the ICT sector, including public organizations	as more enhanced infotainment functions in vehicles. Different requirements for various usage cases. Higher bandwidths of up to 10 Gbit/s and an estimated latency in data transmission of less than 1 millisecond needed in critical application like fully autonomous driving.
Logistics	Supply chain risks Global crises such as wars, pandemics etc. Increase in (fuel) costs and environmental problems On time delivery pressures (Same as automotive related problems stated above)	Same as above category such as reduction of pollution, congestions etc. More specifically, increase in productivity of sector through mobile tech. applications and processes like vehicle tracking, real time information, flexible delivery and warehouse management etc.
Healthcare	Aging and growing population Widespread presence of chronic diseases Changing needs and demand Increasing costs of health system Digital innovation and transformation Cyber Security and Regulatory developments Need for qualified personnel	More efficient & faster information sharing in ecosystems. Remote monitoring of patients and elderly people, reducing number of hospital visits. Reduction of more serious health problems in patients thanks to online monitoring and control.
Smart Cities	Similar to above-mentioned ones related to logistics, transportation and automotive sectors. Notably, overcrowded cities leading to many problems such as pollution, crime, inefficient use of natural resources etc.	Enabling real time management of public services and resources such as electricity and water consumption. Contribution to solution of pollution, traffic and security problems thanks to dense IoT supporting network.
Media	Convergence: Differences between published and digital media, mobile and fixed Internet access, pay-tv and OTT, and social and traditional media are becoming less distinct. Social media companies are	Enabling production of more content. Supporting higher audio-visual quality from a wider variety of connected devices.

Industry	Problems& Trends	Mobile Communications
	entering video content services and end users are also starting to enter in this market by using these platforms. OTT, virtual reality and internet advertising services constitute important revenue segments in the medium term. Increasing importance of streaming and mobile video, decreasing demand for traditional pay TV. Changing content strategies. Investments in AR/VR technology and services like job training, expert consultancy and voice enabled digital assistants. Growing popularity-demand for multiplayer gaming competitions.	Increasing probability of reach to target audience. Enabling gaming services that include AR/VR applications.
Manufacturing[418]	IoT and predictive analytics-maintenance increasingly important Shift from B2B to B2B2C Simplifying supply chain management and ERP Big Data- Cloud Computing VR-AR / 3D Printing Reshoring- bringing operations Need for qualified personnel (knowledge of digital technology)	More flexible work environment Enabling real time communication and information sharing between machines and work force in factories. Increasing productivity through better management of inputs. Reduction of accidents and improvement of safety.

Source: Compiled from above mentioned topics.

As selected cases show, digital applications supported by up-to-date mobile telecom networks will increasingly play roles (indeed they are already) in solution of several problems encountered in different sectors. In essence, these networks will enable all other sectoral usages by enabling efficient working of IoT devices with low latency and reliable data transfer capabilities.

Here, provision of a reliable network (at the same time having widespread coverage) can be seen as a prerequisite for efficient functioning of millions of devices connected via this infrastructure. Before finishing this part, it is worth reiterating the importance

418 Only few applications for manufacturing sector are given in this table without going into details in the main part. The reason for this is that digital technologies have been firstly utilized in this sector and other sectors have been adopting them later. In other words, the usage cases in other sectors like agriculture are more illuminating in showing potential of these technologies for the near future.

of several risks in digital era. Very briefly, these risks can be grouped in two broad categories. First category covers digital divide problem and it is examined in the study.

Other part includes many other issues that are related to use of these technologies. They cover wide-ranging topics from cyber security to internet addiction.

These technologies also lead to labor saving outcomes and people believe unemployment problem will become more serious in the near future along with expanding adoption of usage cases in different sectors. In any case, these issues are not discussed in the study.

Notwithstanding to them, it is certain that digitalization trend is unavoidable part of people lives in the coming decades.

In this regard, public policy has a crucial role to play in both dissemination of digital technologies and safeguarding risks occurred from living in this environment.

D. A DIGRESSION ON THE CURRENT SITUATION OF ERICSSON

After experiencing financial difficulties especially after the telecom bubble, it is seen from the annual report (Ericsson, 2022) that the company has managed to increase its growth rate and net sales figures. More specifically, net sales realized as 210.8 billion SEK in 2018, 227.2 billion SEK in 2019, 232.4 billion SEK in 2020, 232.3billion SEK in 2021 and finally 271.5 billion SEK in 2022[419]. It has nearly hundred thousand employees[420], more than 60 thousand patents and 100 licensing agreements in 2023. Ericsson has been making increasing number of commercial agreements with service operators, sales of 4G and 5G related equipment surged along with the increasing R&D investments, especially in the field of IoT to meet new business opportunities and increasing demand for 5G usage cases. Starting from 2019, among the important operations, the firm announced the launch of first large scale 5G network matching the requirements of 5G smartphones in Europe. It has begun the establishment of 5G smart factory in USA to respond increasing 5G infrastructure deployments in this region.

Furthermore, it acquired another firm's business line (Kathrein) whose expertise lie in antenna and filter products to extend its capabilities in advanced radio network area.

CEO of the company has pointed out the growing demand for digital applications and the platform role of 5G for these services. He expected near 2.6 billion 5G subscriptions in the six-year period with a corresponding expansion of this ecosystem. What is more important is the real transformative effect of 5G in M2M communications and in this segment the number of IoT connections expected to reach 5 billion by the year 2025. In this context, being a scarce resource, spectrum availability considered as one of the most crucial policy issues by the company. Here, low bands (below 1 GHz) have been traditionally used for all generations of mobile communications with relatively more (wide) coverage, moderate capacity and low latency. These bands provide similar capabilities (in terms of latency and capacity) to

[419] Average exchange rates of SEK in terms of USD are 8,5430 for 2017, 8,6945 for 2018, 9,4604 for 2019, 9,2167 for 2020, 8,5812 for 2021 and 10,1177 for 2022 (FED, 2023).
[420] The figure is more stable fluctuating between 97.8 thousand in 2018 and 101.7 thousand in 2022.

usage applications whether the underlying technology is 4G or 5G. The situation is not much different in mid bands (between 1 and 6 GHz) though larger bandwidths offer more indoor coverage. The real capabilities of 5G realizes its potential in high band frequencies between 24 and 40 GHz with large bandwidths (100 MHz or higher) giving ultra- low latency, more capacity but at the same time limited coverage.

Ericsson thinks that spectrum used by 4G will be transferred to 5G smoothly in the near future. However, they criticize the EU policy of becoming late in spectrum allocation for 5G. It is pointed out that several countries such as USA, Japan, Korea and China have made available high band frequencies for 5G usage whereas nearly half of EU countries have given related licences relatively late as compared to those countries. Here, although one can argue that Ericsson is defending its interests and trying to lobby for this end, history of mobile communications technology evolution shows the benefits of early adoption and market formation in domestic markets as well.

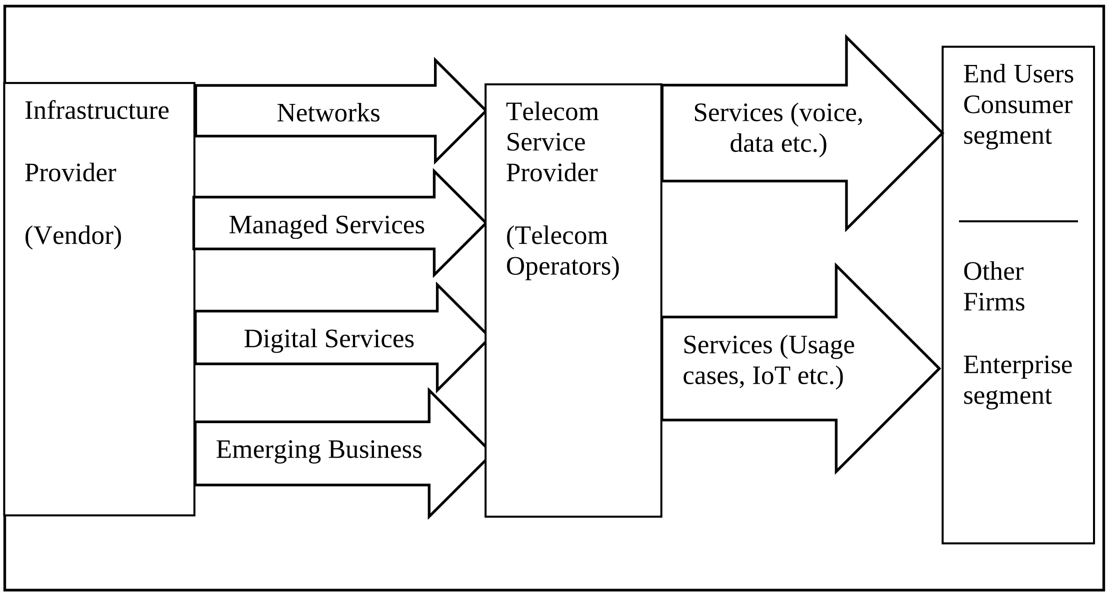

Figure D.1- Revenue Channels (of main actors)

Source: Ericsson Annual Report 2019

Within this background, the company's strategy built on increasing R&D investments for technology and cost leadership among other competitors. In other words, Ericsson aims to achieve technology leadership, cost efficiency and prioritize product-led solutions in a global scale. As indicated, the company sees huge potential in 5G and expects additional revenue stream of 700 billion USD owing to expansion of usage cases mainly in automotive, manufacturing and healthcare, among others. To capture from these revenue opportunities, the company try to meet main customer (i.e., telecom service providers) requirements, by dividing their operations into different segments as shown in Figure-D.1. Network segment consist of hardware inputs necessary for the construction of mobile networks. Digital services are mainly composed of software-oriented support functions provided to operators like business and operational support systems, cloud communication and infrastructure. Managed services include artificial intelligence, network design, optimization and IT operations. More recently, the company combined digital and managed services into cloud software and services to benefit from software and services convergence.

Lastly, the firm is continuously monitoring new opportunities in collaboration with customers via its emerging business segment. Here, the company has focused more on media and broadcasting sectors like enabling platform for broadcasters and content providers as well as other potential usage cases in the scope of Industry 4.0.

Ericsson prioritize a cluster-based deployment strategy emphasising customer experience on a continuous basis. In this context, a project undertaken by SK Telecom given as an example for such a strategy. It is reported that this service provider has selected areas that have large potential (demand) for 5G services. The aim is to establish 5G network and then make possible for providing value added services from this network. Selected cluster areas include densely populated business areas, e-sport stadiums, and shopping districts. Business segment is also addressed in other clusters such as mobile game development clusters.

In current terms, 5G selected areas include 5G League of Legends Park service cluster, ten commercial areas in the country, summer cluster (beaches and water parks) and business to business cluster including manufacturing, smart city, smart office and smart hospital.

For instance, SK Telecom provides social VR service for the consumers to feel that they are actually in the social events like movies physically. The cluster numbers have reached to 70 in 2019 and planned to be increased further to address new business opportunities.

It can be seen that Ericsson has historically given priority to R&D activities for the long-term competitiveness in terms of both technology and cost leadership. R&D expenses increased from 37.887 billion SEK in 2017, to 47,3 billion in 2022. This figure amounted to 17% of net sales (271.5 billion SEK) in the last year[421]. The number of personnel working in this department amount to quarter of the total employees (nearly 29.5 thousand). While the research activities have a long- term orientation, development part aim to make right investment decisions that are crucial for the last stage, i.e., mass production and commercialization. As it is observed, the company makes extensive collaborations with industry forums and universities throughout the world with a focus on emerging and disruptive technologies. Current research portfolio includes edge computing, artificial intelligence, virtual and augmented reality and zero touch as main topics. Moreover, the company is starting preliminary exploration of 6G mobile communications technology. After R&D, 'supply chain management' occupies one of the most crucial operations of the firm.

By looking into manufacturing sites, service delivery and R&D centres, one can observe the firm strategy of worldwide presence and being near to main customers throughout the globe[422].

To gain some further understanding of the sectoral trends, it may be beneficial to observe the risks identified by this global vendor. Apart from some other risks related to financial problems, uncertainties in the context of industry are more relevant for our purposes. At most, the continuing growth of Ericsson is dependent on (increasing) demand for mobile communication services.

In other words, if telecom operators' investments in the mobile networks may decrease due to insufficient demand, regulatory or institutional delay or global socio-economic crises, it is certain that all of the vendors' businesses in equipment production adversely affected to a certain extent. Global and/or country level crises comprise all kinds of political unrest, uncertainty and trade disputes occurring between

[421] 1SEK= approximately 0,10 USD.
[422] More specifically, it has manufacturing sites in Brazil, China, Estonia, India, Mexico, Poland and USA, service delivery centres in China, India, Mexico and Romania and R&D centres in 15 countries. These are Brazil, Canada, China, Finland, France, Germany, Hungary, India, Ireland, Italy, Poland, South Korea, Spain, Sweden and USA. One thing noticed by the author is the fact that Ericsson has a R&D centre in Türkiye as well but this is not stated in the annual reports of the company.

countries. As a case in point, global health problems like Covid-19 pandemic, disputes between two global powers (i.e., USA vs. China) and the situation of UK exit from EU (Brexit) in terms of both demand and supply considerations may disrupt supply chain relations, R&D operations on a global scale. For institutional risks, spectrum availability or spectrum licensing delays are regarded as the most important uncertainties in this category. R&D works (efforts) are inherently risky themselves. Company executives state the fact that if their investments in development of technologies, equipment, system solutions will not meet the sector requirements and will not be adopted (demanded) by operators then competitive position of the firm may suffer in the future. Here, it is essential that any firm (in this market segment) should timely introduce its products and should not lag behind other competitors' solutions in both price and quality considerations.

The executive officers (of the company) consider related markets highly competitive and expect increasing one in terms of price, quality, service functionality and timely introduction of new products. Although, there are not many competitors, existing ones have very strong technological and financial resources and aggressive marketing (commercial) strategies internationally. Moreover, market consolidation trends (if it continues) considered as potential threats because of the reason that competitor vendors may gain larger scale economies and resources, capabilities. In addition to this, new market actors may enter in some segments of the sector in line with the technological developments.

On the other side of the coin, telecom operators have large buyer powers and competitive bidding processes, which include conditions such as future price reductions that force all vendors to operate on tight margins.

Another concern is the intellectual property rights that are invaluable for the company. Here, the company sees challenges in protecting the patents due to many reasons including limited protection of these rights in different countries.

Moreover, Ericsson regards other country attempts to establish and/or protect their national industries may negatively influence its market share and sales growth. In regulatory risk category, unforeseen institutional changes may lead to extra costs (e.g., compliance to new regulations etc.) for the global vendors. Apart from licencing policies of countries, specific regulations are undoubtedly influencing the investment plans of telecom operators, affecting the business of these vendors in turn. As a specific illustration, the conditions of instalment procedures (approval process, location requirements etc.) related to base stations has an effect on the network rollouts of telecom operators.

Although above-mentioned risks are crucial in the first place, numerous other factors affect the working of the company ranging from financial issues (debt composition etc.) to environmental concerns. Among them, cyber security threats may cause severe problems for the company.

In this regard, Ericsson has undertaken a test for evaluation of its (cybersecurity) defence capability and has decided to strengthen this by making additional investments in 2019. The upshot of these risk analysis is that sustainability or protection of competitive position not taken for granted even for a multinational company in the long term and the firm has undertaken several policies to protect this position in the global arena. In basic terms, these policies consist of continuing high level of R&D activities, strengthening capabilities by making acquisitions and observing technology, market trends to match competitors' strategies. On this global level competition, these big players have also used some social and environmental projects to gain popularity and to reduce adverse views of people in using mobile technologies. For instance, Ericsson has actively participated in various programs for increasing digital inclusion. As addressed before, digital divide is a serious problem throughout the world even in different parts of the more advanced countries. In this context, one can argue that the company tries to achieve more than one objective: serving needs of people (legitimization of new technology), increasing adoption and usage (market formation) and in turn raising these markets' potential for long- term growth. In this context, it should be beneficial to stress another main risk perceived by the company, since they also have an influence on our market as well. Ericsson considers localization (i.e., national and domestic production policies) attempts as a serious threat to its business potential. It gives security concerns, protectionism and economic motivations (reduction of foreign trade deficit, increasing employment etc.) for the reasons of these policies. Here, the company thinks possible violations of these regulations may further impose reputational and/or material costs as well.

E. INTERVIEW GUIDE (IN TURKISH & IN ENGLISH)

Çalışma kapsamında, sektör uzmanlarıyla önceden belirlenen sorular çerçevesinde bir mülakat yapılması planlanmaktadır. Bununla birlikte, mülakat esnasında ilgili uzmanın vurgulamak istediği hususlar ön plana çıkarılabilecektir. Ayrıca, uzmanın (mülakat yapılanın) temsil ettiği kuruma göre de bazı sorular kapsam dışında tutulacaktır. Örneğin, hizmet bazında çalışan bir firmayı temsil eden kişiye doğrudan donanım üretimiyle ilgili sorular yöneltilmeyecektir. Ancak isterse/ uygun görürse cevaplamasında da bir sakınca bulunmamaktadır.

A- Genel Hususlar

1. Sektörü hizmet sunumu ve donanım üretimi olarak iki ana başlığa ayırabilir miyiz? Bu sınıflandırma hakkında herhangi bir yorumunuz var mı?

2. Firmanızın ana faaliyet alanlarını kısaca belirtebilir misiniz? / Firmanızı sektörde nerede konumlandırabilirsiniz?

3. Sizce önem arz eden sektördeki & değer zincirindeki ana aktörleri ve sektördeki politika yapımından sorumlu (sektörde) kamu kuruluşlarını sayabilir misiniz?

4. Sektörde hangi araştırma kurumları var? / Sektörde faaliyet gösteren eğitim kurumları, köprü kuruluşlar var mı?

5. (Sektörde) en aktif sivil toplum kuruluşları hangileridir?

6. İş birlikleri ve Etkileşimler: Diğer sektör aktörleri, yani eğitim, köprü ve/veya diğer değer zinciri ortakları ile herhangi bir iş birliğiniz var mı?

7. Kurumsal Etki ve Değişim: Son dönemde şirketinizi/sektörünüzü etkileyen politika (kurumsal) değişiklikleri var mı? / Bunlar arasında temel işlevlerinizi (operasyonlarınızı) etkileyen en önemlilerini belirtebilir misiniz?

8. Türkiye telekomünikasyon sektörüne baktığımızda sizce en önemli sorunlar nelerdir? (Detay bağlamda tartışılacağı için genel olarak belirtebilirsiniz).

B- Girişimcilik ve Üretim/ Faaliyet Olanakları

9. Sizce sektörde yeterli sayıda ticari aktör (firması) var mı? İşletme türleri ve ürünleri nelerdir? Bu aktörlerin inovasyon yetenekleri var mı? (Yeterince) yenilik ve büyük ölçekli üretim yapıyorlar mı?

10. Sektöre giriş/çıkış konusunda düşünceleriniz nelerdir? Gözlemlerinize göre yaklaşık kaç firma sisteme giriyor (yeni gelenler) ve sistemden çıkıyor? / Sektöre girmek zor mu ve bu süreçte engeller var mı (yüksek yatırım ve/veya bürokratik maliyetler vb.)?

11. Altyapı-pazara giriş mekanizmalarının yeterliliği: Pazara giriş için destek mekanizmaları girişimcilerin ihtiyaçları için yeterli mi? / Ne tür fonlar (sübvansiyonlar, hibeler, vergi teşvikleri vb.), teknik ve eğitimsel destekler mevcut? / Başka araçlar da öneriyor musunuz?

12. Firmaların (girişimcilerin) mevcut üretimleri sektörün gelişmesi için bir tür engel teşkil ediyor mu?

13. Sektördeki iş birlikleri hakkında ne düşünüyorsunuz? Yeni gelenler ve/veya yerleşik firmalar için faydalılar mı? Firmalar arasındaki iş birliği faaliyetlerini desteklemek (teşvik etmek) için herhangi bir mekanizma var mı?

14. (HTK) Kümelenmesine İlişkin: Bu kümede olmanın faydaları nelerdir? Kümelenme yardımı, üye firma ilişkileri vb. nedenlerle pazardaki varlığınızı artırdınız mı? Sektörün rekabet gücünü (etkinliğini) artırmaya yönelik ek yenileme ve/veya benzeri projeler yapılabilir mi?

C-Bilgi (Kapasite-Yeterlilik) Üretimi & Geliştirilmesi

15. Sektörde bilgi üreten kuruluşlar hangileridir? Bu ortamda ek aktörlerin de aktif olması gerektiğini düşünüyor musunuz? (Eğer öyleyse lütfen bazılarını adlandırın).

16. Daha sık üretilen bilgi türü (yani temel veya uygulamalı) nedir?

17. Altyapı unsurları bilgi geliştirme/üretim için yeterli mi? (Laboratuvarların varlığı, test alanları, eğitim sistemi vb.)

18. Sistemin /sektörün) geliştirilmesi için yeterli miktarda ve kalitede bilgi üretimi var mı? (Yeterli proje, araştırma, patent ve yayın var mı?)

19. Araştırma ve geliştirmede kullanıcı-üretici etkileşimleri ve diğer farklı aktörler arasında iş birlikleri var mı?

20. Bilgi (araştırma ve geliştirme) öncelikleri nasıl belirlenir? / Bu önceliklerin başarı düzeyini takip edecek mekanizmalar var mı?

21. Mevcut yapı sektörün gereksinimlerini (ihtiyaçlarını) karşılıyor mu? / Araştırma sistemi küresel eğilimleri, koşulları, faktörleri takip ediyor mu?

22. Sektöre özgü AR-GE, kamu teknoloji planlarında-programlarında (yeterli) önceliği alıyor mu?

23. Bu AR-GE faaliyetleri ve diğer bilgi kaynaklarını kimler kullanıyor? Bu sayı yeterli mi?

24. Hem nitelik hem de nicelik açısından mevcut yapı (AR-GE düzeyi, bilgi stoğu vb.) sektörün (daha fazla) gelişmesi için bir engel teşkil ediyor mu?

D- Bilginin (Yeteneklerin) Yayılması ve Değişimi

25. Bilim ve endüstri arasındaki / kullanıcılar ve endüstri arasındaki / diğer kuruluşlar ve endüstri arasındaki bilgi alışverişi düzeyi hakkında ne düşünüyorsunuz?

26. Firmanız sergi, kongre, konferans vb. etkinliklere katılıyor mu (katılımcı gönderiyor mu)?

27. Firmanız (işle ilgili operasyonel) performansı artırmak için dış taraflardan (örneğin tedarikçiler, müşteriler, rakipler) gelen bilgileri/yetenekleri kullanıyor mu? / *Firmanız müşteri-tedarikçi ortaklıklarından faydalanıyor (öğreniyor) mu? /* Firmanız çalışanları dış kuruluşlara (Örneğin, üniversiteler) gönderiyor mu?

28. Firmanızın dış aktörlerden bilgi/bilgi elde etme stratejisi var mı?

29. Firmanız danışmanlardan tavsiye (know-how vb.) alıyor mu?

30. Firmanız ortak girişimlerden / Ar-Ge anlaşmalarından / ortak geliştirme projelerinden öğreniyor (faydalanıyor) mu?

31. Firmanız herhangi bir lisans) patent satın aldı mı /alıyor mu?

32. Bu bilgi alışverişi (seviyeleri) tatmin edici midir, değilse sıkıntılı kısımlar ve sorunlar nelerdir?

33. Bilgi alışverişi süreçlerinde yaşanan aksaklıklar sektörün gelişimi için bir engel oluşturuyor mu? Çözüm önerileriniz var mı?

E- Araştırmanın Yönlendirilmesi (Rehberlik)

34. Sektörün (daha fazla) pazar büyümesi, teknolojik ilerleme dahil olmak üzere gelecekteki gelişimi için net bir vizyonu var mı?

35. Sektörün güvenilir, gözlemlenebilir ve ulaşılabilir politika hedefleri var mı?

36. Sektör ve teknoloji alanından beklentileriniz nelerdir? (Mevcut yapı, gelişmeler vb.) / Beklentileriniz ile politika belgeleriniz, vizyon beyanlarınız ve mevcut mevzuatlar (yani revizyonlara ihtiyaç var) arasında bir uyum olduğunu düşünüyor musunuz? / Değilse, bunun eksikliğinin sektörün ilerlemesine engel teşkil ettiğini düşünüyor musunuz?

F- Piyasanın Oluşumu (Gelişimi)

37. Pazarın mevcut ve gelecekteki büyüklüğü hakkında ne düşünüyorsunuz? / Gelecek için fırsatlar ve tehditler (riskler) görüyor musunuz?

38. Hizmet pazarlarını haneler (konutlar) ve işletmeler (son kullanıcı profili açısından) olarak ayırabilir miyiz? / İşletmelerde/hanelerde kullanımın artırılması sürecinde destekleyici ve engelleyici hususlara ilişkin görüşleriniz nelerdir?

39. Sektörde farklı pazar segmentleri var mı? Geleneksel (olgun, standartlaştırılmış ürünler) ve niş (gelişen teknoloji ile ilgili ürünler) pazarlarından bahsedebilir miyiz? / Firmanız (veya kümeniz) niş segmentlere daha kolay girebiliyor mu?

40. Mevcut durum tatmin edici mi (potansiyel, pozitif trend vb.) ve gelecekteki büyüme hakkında işaretler veriyor mu? Değilse (ayrıca) sektörün gelişimi için bir engel mi oluşturuyor?

G- Kaynak Mobilizasyonu (Yeterliği)

41. Sektörün sürdürülebilir büyümesi için kaynakları (insan-finansal-fiziksel) yeterli buluyor musunuz? (Yeterli ve erişilebilir finansman, risk sermayesi ve kullanım alanları vb.) / KOBİ'ler (mevcut) kaynaklara kolayca erişebiliyor mu? /

Politika yapıcılar bu pazarın gelişimine öncelik veriyor mu? /Politika hedeflerine ulaşmak için ayrılan kaynaklar yeterli mi?

42. (Cevap negatifse)- Değilse, bu yetersizlikler sektör için ne gibi engeller/ problemler oluşturuyor? / Çözüm önerileriniz olur mu?

H- Değişime/ Yeni teknolojiye/ (Sektörün Gelişimine Negatif Yaklaşım-Engelleyici Durum)

43. İzin, onay işlemleri vb. şeklinde pazarın (sektörün) gelişimine / yeni teknolojiye (gibi) karşı bir çeşit direnç gözlemlediniz mi?

44. Bu faktörler herhangi bir projenin tamamlanma süresini (uzunluğunu) etkiliyor ve engel teşkil ediyor mu?

45. Nispeten daha büyük ve daha küçük firmalar arasında bir çıkar çatışması var mı? Kendi çıkarlarını sürdürmek için ayrı dernekleri vs. var mı?

46. Sizce sektör aktörlerinin gündem belirleme / yönlendirme / çıkarların korunması hususlarında ne kadar gücü (etkisi) var?

47. Kentsel alanlarda yeni teknoloji yatırımları (baz istasyonu kurulumları gibi) için olumsuz bir kamuoyu olduğunu düşünüyor musunuz? / Bu önemli bir sorun oluşturabilir mi? Tedbirler (yani düzenlemeler, güvenlik protokolleri ve kamuyu aydınlatma araçlarının mevcudiyeti) bu endişeleri hafifletmek için (sizce) yeterli mi?

I- Genel Değerlendirme

48. Sizce ülkemizde telekomünikasyon sektörü politikasının amaçları neler olmalıdır?

49. Kurumların ve kamu kuruluşlarının yapısı, verimliliği konularında ne düşünüyorsunuz?

50. Politika yapıcı bir konumda olsaydınız, önerileriniz neler olurdu?

Mülakat Eki-2 / Sektöre Özgü Problemlerin Detaylı Analizi

Düzenleyici Çerçeve

1. Ülkede nispeten başarısız bir telekomünikasyon liberalizasyon / deregülasyon süreci olduğunu (tecrübesi) kabul edebilir miyiz? Basit bir evet/hayır yanıtı yoksa, genel anlamda bu deneyimin önemli başarıları ve başarısızlıkları hakkında ne düşünüyorsunuz? Ayrıca, bu deneyimin (sonucunun) ülkedeki yeni nesil mobil telekom hizmetleri (yani 5G) pazarına etkileri neler olabilir?

2. Düzenleyici konular açısından, evrensel hizmet, yetkilendirme prosedürleri, pazara erişim ve geçiş haklarında revizyon ihtiyacına ilişkin AB komisyonunun gözlemlerine katılıyor musunuz? Sektörel performansı artırmak için revize edilmesi gereken diğer düzenlemeleri de ekleyebilir misiniz?

3. Yatırım maliyetlerinin aşırı olduğunu düşünüyor musunuz (belediye ücretleri vb. altyapı ile ilgili maliyetler dahil) ve bu sorunları çözmek için yapılabilecek bir şey var mı?

4. Son olarak, yönetmeliklerin çıkarılması ve/veya gerekli revizyonların yapılması dışında, bunların uygulama etkinliği konusunda herhangi bir sorun var mı?

Kurumsal Hususlar

5. Kamu kurumları arasında etkin bir iş paylaşımı olduğunu düşünüyor musunuz?

6. Hayır ise, bu etkinsizlikler ve/veya örtüşen işlevler sektör aktörleri için sorun (darboğaz) oluşturuyor mu?

7. Bu soruna herhangi bir çözüm veya iyileştirme önerebilir misiniz?

8. Düzenleyici kuruluşların eski yerleşik operatörden ve diğer devlet kontrolündeki firmalardan tamamen bağımsız olduğunu düşünüyor musunuz?

9. Düzenleyici otoritenin bağımsızlığı endişelerine ilişkin AB Komisyonu bulgularına katılıyor musunuz? Evet ise bu durum sektörün performansını nasıl etkiliyor? (Bu, sektörün gelişimi için mutlaka olumsuz bir olgu (darboğaz) mıdır?) Ortaya çıkan sorunlar nelerdir ve bu soruna herhangi bir çözüm önerir misiniz?

Politika Belgeleri

10. Sektörel politika belgelerinin (örneğin, strateji, eylem planları vb.) sayısının aşırı olduğunu düşünüyor musunuz? Evet ise, bunlar sektör için herhangi bir sorun oluşturuyor mu?

11. Politika belgelerinin son (nihai-uygulama dönemi sonrası) değerlendirmelerini ne ölçüde gördünüz? Cevabınız olumsuz ise (nadiren vb.), bu konuda iyileştirici öneriler sunabilir misiniz?

12. Kamu politikalarının ve kurumlarının değerlendirilmesi için düzenleyici etki analizinin gerekli olduğunu düşünüyor musunuz? Ayrıca devlet kurumları tarafından yapılan kamuya açık etki analizinin sayısı ve niteliği konularında düşüncelerinizi öğrenebilir miyiz?

Sektörel Dernek ve Organizasyonların Rolü

13. Sektörde dernekler etkin bir şekilde rol alıyorlar mı? Uygulamada sorunlar var mı? (Örneğin herhangi bir konuda yeni düzenlemeye ihtiyaç olup olmadığı ve/veya mevcut düzenlemelerin uygulamada etkin bir şekilde uygulanıp uygulanmadığı gibi konular görüşülüyor mu?) Çözüm önerileriniz nelerdir?

Düzenleme Yaklaşımları

14. Coğrafi bazlı düzenleme kavramının bugüne kadar çeşitli politika belgelerinde yer aldığını ancak fiili bir uygulama olmadığını gördük. Sizce bunun sebepleri neler olabilir?

15. Bu düzenleyici yaklaşımın uygulanması piyasa rekabeti, kullanıcı memnuniyeti vb. için faydalı olabilir mi?

16. Evrensel hizmet yönetmeliği ve uygulaması hakkında ne düşünüyorsunuz?

17. Mevzuat ve/veya uygulama eksiklikleri var mı? Evrensel hizmet fonlarının kullanımının şeffaf olmadığı ifadesine katılıyor musunuz?

18. Bu konuda iyileştirme önerileriniz var mı?

19. Kablo-TV ağının durumu (sizin için) tatmin edici mi? Hayır ise, bu düşük performansın nedenleri nelerdir?

20. Kısa/orta vadede, geniş bant (kullanım) yaygınlığını ve pazar rekabetini artırmak için bu ağın (şebekenin) daha etkin bir şekilde kullanımı sağlanabilir mi?

<u>5G ye Geçiş ve Piyasa Oluşumu</u>

21. Sektördeki nispeten başarısız fiber yatırım/ kapsama performansının nedenleri nelerdir? Sizce önceki denemeler neden çok başarılı olmadı?

22. Ülkedeki fiber altyapı kapsamını artırmak için neler yapılabilir?

23. 5G ağlarının çok daha fazla fiber kapasitesi gerektirdiği ve ülkenin bu ağı daha etkin (ve yaygın) kullanabilmesi için daha fazla fiber altyapısına sahip olması gerektiği ifadesine katılıyor musunuz?

24. Sektör aktörleri için yol haritalarının belirlenmesi bağlamında bir 5G eylem planının (detay bazda) faydalı olacağını düşünüyor musunuz?

25. 5G hizmetlerindeki aktör sayısında bir değişiklik bekliyor musunuz? Mevcut üç işletmecide herhangi bir değişiklik bekliyor musunuz? (Mülkiyet yapısı, sermaye grubu değişikliği vb.)

26. Bu hizmetlere son kullanıcılardan yeterli talep var mı (Örneğin. ARPU seviyeleri, daha hızlı mobil internet talebi vb.) / Buna göre 5G lisans ihaleleri için gerçekçi/optimum tarih hakkında ne düşünüyorsunuz? / Bu ihalelerin talebini ve başarısını belirleyen faktörler nelerdir?

27. 5G hizmetlerinin başlamasından sektör için yeni fırsatlar bekleyebilir miyiz?

28. Sektörün gelişimi için lisans koşulları vb. kullanabilir miyiz? Yani bundan sonraki ihalelerde 5G lisanslarında neler yer almalı?

<u>Donanım Üretimi ve İlgili Piyasa</u>

29. Bir mobil telekom ağının tüm bileşenlerini üretmenin mümkün olduğunu düşünüyor musunuz? Bunun yerine, bazı belirli bileşenlere öncelik vermeli miyiz?

30. Önceliklendirme önerirseniz: Desteklenebilecek ve/veya (potansiyel olarak) rekabet avantajı sağlayabilecek bu segmentleri/ürünleri adlandırabilir misiniz?

31. Yerli üretimi desteklemek için finansman mekanizmalarının yeterli olduğunu düşünüyor musunuz? Değilse, iyileştirme amaçlı önerileriniz olur mu?

32. Geçmiş ihaleleri göz önünde bulundurduğunuzda, 5G ihalelerinin sektörün yerli üretim kabiliyetlerini desteklemek için kullanılabileceğini düşünüyor musunuz?

33. Cevabınız evet ise, lisanslara ne tür önlemler/maddeler eklenebilir?

34. Yerli üretim mevzuatının uygulanmasını şeffaf bir şekilde takip edebiliyor musunuz?

35. Değilse, bu süreçte revizyonlar/değişiklikler önerebilir misiniz?

36. Sektördeki yabancı küresel aktörlerin (Huawei gibi) varlığına ilişkin görüşleriniz nelerdir (pozitif – negatif etki)?

<u>Benzer Kurum Analizi</u>

37. İki benzer organizasyonun (ULAK ve HTK- GTENT) varlığının etkinsizliklere neden olduğunu ve gereksiz maliyetlere yol açtığını düşünüyor musunuz?

38. Bu konuda farklı/alternatif önerileriniz olur mu?

<u>Kamu Alımları ve Benzer Yöntemler</u>

39. Kamu alımlarının ve dikey kullanım hizmetlerinin (kamu kuruluşları tarafından) erken benimsenmesinin (kullanılmasının) sektörün gelişimi için faydalı olduğunu düşünüyor musunuz?

40. Cevabınız evet ise, bu mekanizmaları yeterli buluyor musunuz? Mevcut durumu iyileştirmek için farklı yöntemler/politikalar önerebilir misiniz?

Interview Guide (in English)

<u>A- Introduction & General</u>

1. Can we divide the sector into two main headings as service and equipment production? Do you have any comments about this classification?

2. Can you describe your firm's main activity areas? / Where can you position your firm in the sector?

3. Can you name main actors in the sector & value chain and public organizations in the sector that are also responsible for policy making (in the sector)?

4. Which research institutions are in the sector? / Are there any educational agencies, bridging organizations (that are operating in the sector)?

5. What are the most active non-governmental organizations (in the sector)?

6. Collaborations and Interactions: Do you have any type of collaboration with other sector actors, i.e., educational, bridging and/or other value chain partners?

7. Institutional Impact and Change: Can you mention institutions (regulations) that effect your essential functions (operations)? / Are there any policy (institutional) changes that have affected your company/industry lately?

8. When we look at the Turkish telecommunication sector, what do you think are the most important problems?

<u>B- Entrepreneurship and Production/Activity Opportunities</u>

9. Does the IS have adequate number of commercial actors (firms)? What are their types of businesses and products? / Do these actors have innovative capability? Are they making (enough) innovations and large-scale production?

10. How many firms enter (new comers) and leave the system? / Is it difficult to enter in the sector and are there any obstacles in this process (like high investment and/or bureaucratic costs etc.)?

11. Adequacy of infrastructure-market entry mechanisms: For market entry, are support mechanisms adequate for the needs of entrepreneurs? / What kind of funding (subsidies, grants, tax incentives etc.), technical and educational supports are available? / Do you propose other tools as well?

12. Are the production and/or experimentation of firms (entrepreneurs) constituting some kind of a barrier for the (further) development of the IS?

13. What do you think about collaborations in the sector? Are they beneficial for new comers and/or established firms? Is there any mechanism for supporting (incentivizing) collaborative activity between firms?

14. Relevance of CTC (HTK) Cluster: What are the benefits of being in this cluster? Have you increased your market presence due to cluster help, member firm relations etc.? Can there be revisions and/or similar projects made to increase competitiveness (efficiency) of the sector?

C-Knowledge (Capacity-Sufficiency) Production & Development

15. Which organizations are the producers of knowledge in the sector? Do you think that additional actors should also be active in this setting? (If so, please name some of them)

16. What is the type of knowledge (i.e., basic or applied) produced more often?

17. Are the infrastructure elements satisfactory (adequate) for knowledge development/production? (i.e., existence of labs, test fields, training system etc.)

18. Is there sufficient amount and quality of knowledge advancement for the improvement of the IS? (Are there enough projects, research, patents and publications?)

19. Do collaborations between different actors exist along with user-producer interactions in research and development?

20. How are knowledge (research and development) priorities established? / Is there any mechanism to follow the achievement level of these priorities?

21. Is this knowledge stock satisfying (matching) the requirements (needs) of the IS? / Does the research system follow global trends, conditions, factors?

22. Is this TIS getting (enough) attention-priority in public technology plans-programs?

23. Who are using this knowledge stock? Is this number enough?

24. Is this knowledge stock in terms of both quality and quantity setting a barrier for the (further) development of the IS?

D- Dissemination and Exchange of Knowledge (Capabilities)

25. What do you think about the knowledge exchange level between science and industry / between users and industry / between other organizations and industry?

26. Does your firm send employees and/or participate in exhibitions, congresses, conferences etc.?

27. Does your firm utilize information/knowledge from outside parties (e.g., suppliers, customers, competitors) to enhance (business-operational) performance? / Does your firm benefit (learn) from customer-supplier partnerships? / Does your firm send employees to outside organizations (e.g., universities)?

28. Does your firm has a strategy to gain information/knowledge from outside parties?

29. Does your firm obtain (hire) advice (know-how) from consultants?

30. Does your firm learn (benefit) from joint ventures / R&D agreements / joint development projects?

31. Does your firm obtain (purchase) any licence?

32. Are these knowledge exchange (levels) satisfactory and if not, what are the troublesome parts and problems?

33. Do disruptions in information exchange processes constitute an obstacle to the development of the sector? Do you have any suggestions to remove these obstacles?

E- Guidance of Search

34. Does the IS have a clear vision for future development including (further) market growth, technological advancement?

35. Does the IS have policy goals that are reliable, observable and attainable?

36. What is your expectations for this IS and technology field? (Current structure, developments etc.) / Do you think that there is a match between your expectations and policy papers, vision statements and current legislations (i.e., need revisions)? / If not, do you think that lack of this constitute an obstacle for the progress (of the IS)?

F- Formation (Development) of the Market

37. What do you think about the current and future size of the market? / Do you see opportunities and threats (risks) for future?

38. Can we divide services markets in households (residences) and businesses segments (in terms of end user profile)? / What are your views on supporting and hindering aspects of increasing adoption of use in businesses/households?

39. Does different market segments exist in the sector? Can we talk about traditional (mature, standardized products) and niche (developing technology related products) markets? / Can your firm (or cluster) enter niche segments more easily?

40. Is the present state satisfactory and giving indications about future growth? If not (furthermore) is it generating a barrier for the development of the IS?

G- Resource Mobilization

41. Do you consider the resource capabilities (human- financial- physical) adequate for the sustainable growth of the IS? (Sufficient- adequate and accessible funding, risk capital and usage areas) / Can SMEs access (available) resources easily? / If not, do these insufficiencies form any sort of barrier for the IS? / Do policy makers give priority to development of this market?

42. (If the answer is negative), what kind of obstacles/problems do these inadequacies create for the sector? / Do you have any solution suggestions?

H- Counteract Resistance to Change

43. Have you observed some kind of resistance to the new technology (like) in the form of permit, approval procedures etc.?

44. Are these factors affecting the completion time (length) of any project and forming an obstacle?

45. Is there a conflict of interest between relatively larger and smaller firms? Do they have separate associations etc. to pursue their own interests?

46. Do system actors have lobbying power? (Not only in terms of public opinion but also for self-interest)

47. Do you think that is there a negative public opinion for new technology deployments in urban areas (i.e., base station installations)? / Can this generate a considerable problem or not? Are the measures (i.e., regulations, safety protocols and availability of public disclosure tools) satisfactory enough to alleviate these concerns?

I- Concluding Remarks

48. What do you think should be the aims of the telecommunication sector policy in our country?

49. What is your opinion on the subjects of structure, efficiency of institutions and public organizations?

50. If you were in a policy-making position, what would be your recommendations?

Interview Supplement-2 / Detailed Analysis of Sector-Specific Problems

Regulatory Framework

1. Can we accept a relatively unsuccessful story of telecom liberalization/deregulation in the country (as compared to these objectives, i.e., liberalization and deregulation)? If there is no simple yes/no answer, what do you think about the important accomplishments and failures of this experience in general terms? Furthermore, what are the implications of this experience (outcome) for the next generation mobile telecom services (i.e., 5G) market in the country?

2. In terms of regulatory issues, do you agree with the EU commission observations on the need for revisions in the universal service, authorisation procedures, market access and rights of way? Can you add other regulations that needs to be revised to increase sectoral performance?

3. Do you think that financial costs are excessive (including infrastructure related costs like municipality fees etc.) and is there anything that can be done to solve these problems?

4. Lastly, apart from the enactment of regulations and/or making necessary revisions, is there any problem in effectively implementing these in practice?

Organizational Considerations

5. Do you think that there is an efficient work sharing between the public organizations?

6. If no, are these inefficiencies and/or overlapping functions creating problems (bottlenecks) for the sector actors?

7. Can you propose any solution or revision to this problem?

8. Do you think that the regulatory organizations are completely independent from former incumbent operator and other state-controlled firms?

9. Do you agree with the EU Commission findings regarding the concerns of the regulatory authority's independence? If yes, how is this situation affecting the performance of the sector? Is this necessarily a negative phenomenon (bottleneck) for the development of the sector? What are the resulting problems and do you recommend any solution to this issue?

Policy Documents

10. Do you think that the number of sectoral policy papers (e.g., strategy, action plans etc.) are excessive? If yes, are these causing any problems for the sector?

11. To what extent have you seen post evaluations of policy papers? If your answer is negative (i.e., rarely etc.), can you recommend some policies to increase the implementation of such practices?

12. Do you agree with the statement that there is very few or none publicly available impact analysis made by the public agencies? / Do you think that regulatory impact analysis is necessary for evaluation of public policies and institutions?

The Role of Sectoral Associations and Organizations

13. What are the main problems of sectoral associations in these interactions? / What are the sectoral bottlenecks (e.g., whether there is a need for new regulation in any subject and/or the current regulations are not implemented effectively in practice) that should be addressed together with this sectoral organizations to increase sectoral development?

Regulatory Approaches

14. We have seen that location-based regulation concept is found in various policy papers to this date but there is not any actual implementation. What do you think could be the reasons for this?

15. Can the implementation of this regulatory approach be useful for market competition, user satisfaction etc.?

16. What do think about the universal service regulation and implementation?

17. Are there any shortcomings of this? Do you agree with the statement that the use of universal service funds is not transparent?

18. Can you propose any suggestions for improvement in this regard?

19. Is the situation of Cable-TV network satisfactory (for you)? If no, what are the reasons for this underperformance?

20. For future developments, can we utilize this network more effectively to increase broadband adoption and market competition?

Transition to 5G and Market Formation

21. What are the reasons for relatively unsuccessful fiber deployment performance of the sector?

22. What can be done to increase the fiber infrastructure coverage in the country?

23. Do you agree with the statement that 5G networks require much more fiber capacity and the country should have more fiber infrastructure to use this network more efficiently?

24. Do you think that a specific 5G action plan is needed (beneficial) for indicating roadmaps for the sector actors?

25. Do you expect any change in the number of actors in the 5G services? Is there any change in the existing three operators in terms of ownership etc.?

26. Is there enough demand from end users for these services (e.g., ARPU levels, demand for faster mobile internet etc.)/ Accordingly, what do you think about the realistic/ optimum date for 5G License Auctions? / What are the factors that determine the demand and success of these auctions?

27. Can we expect new opportunities from introduction of 5G services?

28. Can we use licence conditions etc. to increase the sector performance? In other words, what should be included in 5G licences in the next auctions?

Hardware Production and Related Market

29. Do you think that it is feasible to produce all components of a mobile telecom network? Instead, should we prioritize some specific components?

30. If you recommend prioritization: Can you name these segments/products that can be supported and/or (potentially) can have a competitive advantage?

31. Do you think funding mechanisms are enough for supporting domestic production? If not, can you provide some revisions for this institution?

32. Having considered past auctions, do you think that 5G auctions can be used for supporting domestic production capabilities of the sector?

33. If yes, what kind of measures/clauses can be included in licences?

34. Could you follow the implementation of domestic production regulations in a transparent manner?

35. If not, can you recommend revisions/modifications to this process?

36. What are your views (positive – negative impact) on the presence of foreign global actors (such as Huawei) in the industry?

Analysis of Similar Organizations

37. Do you think existence of similar organizations (i.e., ULAK & HTK- GTENT) cause inefficiencies and lead to unnecessary costs?

38. Do you have any different/alternative suggestions on this subject?

Public Procurement and Similar Methods

39. Do you think that public procurement and early adoption of vertical usage cases (by public organizations) are beneficial for the development of the sector?

40. If yes, do you find these mechanisms satisfactory enough? Can you recommend different methods/ policies to improve the current situation?

F. EVALUATION OF POLICIES IN THE NBSAP

As mentioned in the Chapter 5.2.5, NBSAP had 25 policies that were stated in detailed terms. In what follows, these policies have been evaluated to show extensive coverage of the plan. Indeed, it's scope ranged from digital content to safer internet projects together with other technical regulation issues.

Facilitation of passive infrastructure establishment, revision (update) of rights of way and facility sharing legislation and facilitation of network investments: Even the brief assessment of historical development in the sector shows the emphasis yet (at the same time) relatively unsuccessful attempts of both policy makers and other actors in the infrastructure investment area. Similarly, this emphasis has been shown in the NBSAP by stating several policies to increase investment rates of the sector. From these, 'facilitation of passive infrastructure investment' and 'revision (update) of rights of way and facility sharing legislation' are tools for the operators to lower their investment costs.

Nowadays, many network operators in other sectors such as railways, electricity etc. have installed telecom networks like fiber both for their own use and for renting extra capacity to telecom service providers. This practice had been in place in the country but there was no regulation for these network companies. For this reason, the plan aimed to implement a regulation concerning the procedures of this usage to establish a uniform approach and make clarifications for the telecom operators in terms of non-discriminatory usage, price cap determinations etc. The end date of this action was set as 2019, but there is no information about the outcome and specific regulation has not been enacted as of this date, to the best of author's knowledge.

In a similar fashion, facility sharing and rights of way regulations help telecom operators to reduce costs by eliminating the need of duplicate investments and time-consuming processes. The same conclusion is also valid for this issue in that there is no outcome of this policy action in the form of a new regulation easing the problems encountered by telecom operators. On the other hand, a technical step involving the implementation of 'electronic communication infrastructure information system' has been finalized according to ICTA but there is no information available to the public like broadband maps to inform other users.

The last action that can be included in this category was the facilitation of (direct) investments by the operators along with other cost reducing support mechanisms (i.e., facility sharing). This issue is a very broad one due to the fact that investment decisions depend on many issues ranging from financial considerations to regulatory obligations like coverage of rural areas etc.

Without going into much detail, one of the most important topics in this setting was the installation procedures of base stations. The procedures to ease base station installations have been enacted by various Laws in recent years. In this respect, most recent one is the easing of the permission procedures of base station installments within the range of 10 meters on the buildings and 15 meters on (empty) lands[423].There are other legal procedures in zoning and municipal legislations that lead to difficulties for infrastructure investments. Another interesting phenomenon is the negative attitude of some people to these legislations (that are facilitating base station installations) in the context of 'reaction to change (counteracting to change)'. As an example of these concerns, a newspaper article has referred to a Member of Parliament comments that base stations that are harmful to human health during talks in the Plan and Budget Committee, (Toprak, 2020).

However, the technology (mobile telecom and base stations) is so widespread and permeated all aspects of daily life that these concerns do not reach to majority of the people and do not become a major blocking issue in the transition to 5G.

A financial support model for regions where broadband infrastructures is difficult to expand commercially: This policy has been related to the establishment of financial incentive mechanisms for the operators to invest in commercially non-profitable areas. Several organizations including Ministries[424], regulatory authority and operators included in this group under the responsibility of MTI. It included

[423] https://www.resmigazete.gov.tr/eskiler/2020/11/20201117-1.htm , Law No. 7256, Article 26.
[424] In this period, related organizations were Ministry of Finance, Ministry of Development, Ministry of EU and Undersecretariat of Treasury.

several steps to accomplish the main goal as indicated in the below Box-F.1.

Box-F.1: Financial Support Mechanism Steps

- Determination of cities suitable for direct or indirect financing
- Impact analysis of these financing methods
- Preparation of final financial support model/s
- Enactment of necessary regulations

Although, the policy has addressed an important topic in bridging digital divide, practical implementation is not clear for the author (or not known in detail by the public). In any case, either a financial support model has not been introduced to the public knowledge at this stage or this work has not been completed at all.

Expansion of cable TV network: Another topic, as discussed previously, is the importance of establishing an alternative network to increase broadband service availability (and competition) throughout the country. Related targets of this policy are given in the below Box-F.2.

Box-F.2: Cable TV Infrastructure Targets

Box-F.2: Cable TV Infrastructure Targets

- Establishing cable TV network in 32 city centers (previously not covered) until the end of 2020.
- Covering min. 25 % of all city centers' (i.e., 81 city centers) residences until 2023.
- Upgrading this network to enable (at least) capability of giving 100 Mbyte/sec.

This policy is different from the (most of) other ones in that, it had more clear-cut objectives (e.g., reaching 32 city centers in 2023) and at the same responsible organization is an actual network provider (although a state owned one). What is more interesting is the fact that, there were only two organizations (Turksat and MTI) in this category while it is certain that these investments required some financing and here financial organizations ought to have been included in this category.

Currently, the company has presence in 23 cities and there is no detailed knowledge about the coverage rates of each city center and the available internet speeds given from these networks. The actual investment performance indeed has depended (and will depend) on both the company's available funds (allocated for this purpose subject to approval of budgetary organizations) and other factors such as government support and regulatory incentives such as rights of way and facility sharing, among others. In this respect, different alternatives including privatization of the company might be considered (in fact previous policy papers advocated such measures) if a new plan will be implemented to expand the coverage and quality of this alternative infrastructure. Notwithstanding to this, sale of this firm to private investors seems difficult taking into account current economic conditions and relatively underperformance of the sector in terms of financial considerations.

Making indoor electronic communication infrastructure installation mandatory: It is known that, some operators could have difficulty in providing alternative internet access to existing residences due to lack of space, extra financial cost etc. In this regard, this regulation is beneficial by providing indoor infrastructure for the operators to make the necessary connections with their networks. One can consider this action plan as completed by checking the enactment of related regulations.

With the 'Indoor Electronic Communication Installation Technical Specifications' prepared by ICTA, fiber optic cable installation (during the construction phase) is required inside the building up to the flats, among other requirements to ease (facilitate) this process, (ICTA, 2017) .

Efficient and effective use of spectrum: As discussed previously, (availability of) spectrum is the most significant source by which mobile operators can give their services throughout the country.

For this very reason, every government (either ministries or regulators) aim to use these scarce resources effectively and to introduce different ways to allocate their usage.

Accordingly, this issue was also included in the NBSAP. Enabling spectrum trading was one of the important policy aims of this plan, but it is not introduced in any regulation as of this date. After the closure of the plan period, ICTA announced the preparation of 'Mobile Broadband Spectrum Strategy Paper' in the work plan of 2020 to be completed at the end of this year, although a summary of this has been published in 2022, in the end. With this strategy paper, ICTA aims to determine and to make publicly available the allocation times and number of different spectrum bands that will be introduced to the market actors, (ICTA, 2020a).

Expansion of broadband satellite services: Apart from more widespread (and conventional) infrastructures (i.e., copper, fiber, cable and mobile), satellite broadband access is rather limited across the world. The same situation is applicable in Türkiye as well, and (to this author's knowledge) there is no usage of consumer (retail level) broadband provision by the satellite operators. At the same time, it is getting more important medium in the operations of providers in the increasing world of mobile communications. The plan set out detailed policies to expand the adoption and use of these technologies, (Box-F.3).

Box-F.3: Expansion of satellite broadband services

- Revision of related legislation and financial obligations that create obstacles for related market growth
- Supporting R&D and domestic production activities in satellite communication and infrastructure services
- Implementation of scientific and institutional awareness raising activities to expand the use of these services

This policy group included MTI, MTF[425], Turksat, related satellite operators and civil society organizations under the responsibility of ICTA. There is not any (publicly available) information about these policy steps. Although satellite production is not in our sectoral analysis scope, the more recent establishment of Türkiye's Space Agency and declaration of 'National Space Program' may increase the efforts in this area.

Accordingly, these programs will have an effect on the satellite communication services segment in the medium term. In any case, Telkoder (2021) has made some policy recommendations in a recent report.

Briefly, the report recommends holding of a workshop to identify regulatory areas where revisions, amendments etc. are necessary for responding new technological developments in this sector. Secondly, they are recommending establishment of global collaborations and investments in satellite earth stations. Lastly, they suggest removing of domestic satellite earth station usage obligations in data transmissions

[425] Please note that at that time, the name of the organization was 'Ministry of Finance'.

(for existing satellite systems) as a short- term recommendation[426].

Decreasing tax and other financial liabilities: One of the most publicly discussed topics in the sector is the heavy tax burden imposed (mainly) on users. For this reason, this plan (and some others also) stated lowering tax rates as an objective to expand usage and adoption of telecom services. The work group included MTI, ICTA and other related public organizations[427] under the responsibility of MTF.

Box-F.4: Decreasing tax and other financial liabilities

- Analysis concerning planned tax reductions and other financial regulations to provide quantitative figures
- Gradual reduction in tax and other financial obligations (including removal of special electronic communications tax collected from the first subscription and gradual reduction and finally elimination of special communications tax (SCT) from fixed and mobile communication services
- Gradual reduction of tax and other fees on smart phones, tablets and similar devices
- Revision of Municipal Revenues Law (related to communications tax section)

Like other specific actions, there is no information available for the outcome of these policy steps (Box-F.4). However, it seems probable that there is some kind of blocking mechanism between MTF[428] and other actors in stating these objectives. Because, it is common to see financial obligation (cost) reduction objectives in policy papers of public organizations other than MTF, which is actually main decision maker in these issues and usually prioritized budget revenues.

In fact, apart from other objectives, MTF enacted only one financial regulation in this period and this apparently was not made in the context of this plan objectives.

In this respect, MTF started an investigation of GSM operators for manipulating tax differentials[429] between voice and internet services in the last quarter of 2017,

[426] In more detailed terms, ICTA has enacted an obligation for satellite service providers to use satellite earth stations located in the country borders for transmission of users' data traffics with the amendment of Authorization Ordinance and set the latest compliance date as June 2018. However, the report states that ICTA has extended the compliance date to Dec. 31, 2020. This date has also passed but there is no publicly available information about the current situation as of this date (March 2021).

[427] It is written exactly like this, without naming other organizations.

[428] Please note that at that time the name of the ministry was 'Ministry of Finance'. The current (name) abbreviation is used in the text to avoid confusion.

[429] At this time, voice communication services had 25% tax rate whereas internet services had 5%tax rate. It was alleged that these operators reduced the share of 25% taxable mobile phone calls and increased the share of internet services subject to 5% tax to minimize tax expenditures.

(Cumhuriyet, 2017). Connectedly, the ministry equalized these separate rates in 7,5% level at the end of this year. Afterwards, related tax rate further increased to 10% at the end of January 2021, in turn raising the end user costs, (Haberturk, 2021).

Taking measures regarding OTT services: The plan aimed to support development of domestic (national) based over-the-top service[430] providers and to align obligations of these with foreign companies. In fact, OTT related issues have been increasingly getting attention of policy makers throughout the world for financial (i.e., tax purposes) and data privacy concerns. Irrespective of this action plan, owing to increasing importance, policy makers have recently enacted a new legislation for regulating social media services[431]. Public authorities declared objective of the legislation as protection of users and provision of more effective measures against cybercrime, (Ünal & Şengül, 2020).

However, some critics argue that new rules have tightened government control over these platforms, (Euronews, 2020). On the other hand, domestic telecom providers are starting to introduce their platforms (like Turkcell's BİP and Turk Telekom's Yaay) in line with the increasing demand for these services. Furthermore, these three operators have signed a cooperation agreement in this topic and allowed their customers to use each other's platform without reducing their internet quotas, (Ahaber, 2021). Apart from these developments, there is not much information regarding the needs of the sector and/or how to support the development of the sector by public policy.

Facilitating the access of disabled, low-income and other disadvantaged groups: As a demand side policy, this action covered a very broad scope and different organizations had roles depending on the situation. In our context, ICTA has been working on facilitating the access of segments that need social support. The regulatory authority has enacted 'Procedures and principles on support mechanisms for socially disadvantaged groups' at the beginning of 2019. This legislation has enabled the provision of more affordable communication services (25% reduction in these bills)

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[430] BEREC defines OTT service as 'content, a service or an application that is provided to the end user over the public Internet'.

[431] Briefly, the related legislation requires the appointment of legal representatives of big social media providers (i.e., that are more than 1 million daily users) to deal with the requests of removing content violating privacy and personal rights. In addition to this group of obligations, these providers are required to store user-data in the country.

for the disabled and the widows, orphans of the war, duty martyrs and veterans.

Other provisions have provided preferential treatment for these groups in call center and other operator (subscription) service shops.

The other policy steps (in the NBSAP) included supply of ICT devices for free or with affordable costs and ensuring educational programs to these groups. Besides, this action plan aimed to make private firms' (operating in electronic communications, energy, banking that are subject to control of public organizations) web sites accessible and usable by disabled people. However, there is no publicly available information related to outcome of these works under this plan.

Determination of areas for the development of native language (Turkish) digital content and applications: As a demand side policy (according to the plan), this topic can be regarded as the broadest category compared to other actions. The fact that this group had more than thirteen organizations under the responsibility of MNE supports this observation. One can argue that, the number of actors in an action group does not mean anything by itself but it is certain that achieving coordination in a group as large as composing of five different Ministries[432] ranging from Health to Agriculture is difficult to achieve in practice.

As one of the actions, MNE was responsible for development of EBA platform. MTI had the duty of implementing projects related to the development of national and domestic e-mail, OTT application and internet search engine in this category.

With regard to these, there are no practical applications as an outcome of this plan. Having observed this (and some other topics as well), it can be said that preparation of more specific policy papers and more clear-cut determination of responsible actors may reduce coordination and inspection problems in implementation phase.

Increasing user confidence to the internet: Though it is not (directly) in our study scope, this topic is getting more and more important with the ever-present internet and

[432] Other than Ministry of National Education (MNE), Ministry of Foreign Affairs, Ministry of Family, Labour and Social Services, Ministry of Environment and Urbanisation, Ministry of Transportation and Infrastructure, Ministry of Youth and Sports, Ministry of Food, Agriculture and Livestock, Ministry of Health, Ministry of Forestry and Water Management and other organizations such as Universities were in the same working group.

digital services. While these are generating efficiencies and positive gains, at the same time affecting the lives of people and especially children through cyber security threats. As an example, European Commission (EC) stated the fact that 51% of EU citizens do not have adequate knowledge of cyber threats and 86% of them think that this threat is increasing in general terms. For this reason, EC started to implement safer internet action plans, especially targeting children education in the form of 'better internet for kids' projects, (EC, 2021b). In line with these developments, ICTA has also started educational programs and safer internet service applications (e.g., child and family applications). The action in the plan had other steps as well related to expansion of these programs and safer internet usage services. It had no quantitative target and it is seen from ICTA's annual reports that this is an ongoing activity with new revisions each year.

Expanding (Diffusion of) cloud computing: Cloud computing is among the critical areas of digital transformation and both mobile telecom operators and other ICT firms are actively involved in this market segment. As an example, EC considered cloud computing an essential component of an innovative economy and has prepared several action-strategy plans in this subject. Briefly, the Commission has divided these into two categories. One is related to supporting cloud and edge computing technologies by means of funds and other financial incentives.

The other category consists of regulatory activities such as protection of private data and safeguarding of competition, (EC, 2019c).

The NBSAP had similar policy steps in line with these two broad categories but it is probable that related organizations have devised their policies irrespective of this plan. It is observed that the Scientific and Technological Research Council of Türkiye (TÜBİTAK), Small and Medium Enterprises Development Organization of Türkiye (KOSGEB) and Ministry of Industry and Technology (MI&TECH) have provided grants to R&D works, software development and other type of projects.

On the other hand, the author has not found out any cooperation (that was stated in the action plan) platform between public organizations, private sector and universities in this subject. Furthermore, there is no specific regulation (found by the author) as an outcome of this plan like data protection and quality standards etc.

Expanding (Diffusion of) M2M, IoT and IoE services, applications: As emphasized, number and usage of M2M, IoT and IoE applications are increasing very rapidly with the development of mobile telecom technologies.

Indeed, the number of these connections will surpass human connections (in the meaning of internet usage) in the near future especially after 5G technology.

ICTA's works in this area have been concentrated more on the reduction of fees collected by the state. In this respect, policy makers have removed wireless license and usage fees from M2M subscriptions, (Anadolu Agency, 2017).

With these fee reductions and exemptions, they have aimed to raise the adoption (usage) of these applications that increase productivity in all sectors. The other set of policies (that employed by the regulator) have included legal obligations to use domestic applications and operators' networks in the country. For instance, ICTA has enacted an obligation for the use of domestic operators' SIM cards in smart car connections. This regulation aims to support the domestic companies in terms of both commercial and technology development purposes. Besides this, the regulator has also emphasized the importance of storing and transmitting data in the country borders by mandating this obligation, (Aksan, 2019).

On the other hand, MI&TECH has prepared another strategy paper called 'Industry and Technology Strategy' that covers these topics in the 'Data Communication and Open Data Reform', 'Cyber Security Standards and Infrastructure', 'Cloud Computing and Data Centers', 'National Block Chain Infrastructure' and 'Two Leverages of Industry: Energy and Logistics' categorizations. The strategy aims to achieve its objectives by the year 2023, further states the need of forming detailed action plans in each category (where necessary) and declares that the outcomes (i.e., performance report) are published in the internet site annually, (Ministry of Industry & Technology, 2019). It is evident that these performance (publicly available) follow-ups will be useful for assessing the achievement levels and for informing public about the outcomes of these plans.

Revision of wireless license and other related fees: There are various sector specific license fees (wireless license fee and usage fee etc.), apart from one-off license fees to get necessary authorizations in the telecom sector and it is no doubt that they have increased operating expenses of firms and eventually transferred to end users. The NBSAP aimed to reduce and/or remove some of these fees during the plan period. It was one of the more specific (and limited) action in terms of both scope and the number of related organizations (i.e., ICTA being the responsible organization along with MTI and MTF) involved in the process.

Establishment of (strong) internet exchange points (IEP)[433]: The number and capacity of domestic IEPs bring many benefits to the hosting countries and their ISPs[434]. Accordingly, establishment of these points have been stated as objectives in the five-year development plans.

Currently, some sources state the number of existing IEPs as four. Demircan (2020) gives the information that three (of them) belongs to DE-CIX and one of them belongs to TURK-IX.

In any case, this plan's main aim of establishing strong regional IEPs with the inclusion of all providers had not been achieved at the end of the plan period along with the preparation of related regulatory framework. Indeed, there is no change or progress observed in this action item, as of this date.

Data center supports: Along with IEPs, data centers (located in-home country) give many advantages to hosting country's firms and users.

Above all other reasons, presence and usage of domestic data centers can minimize data privacy breaches by keeping them in facilities located in the home country.In line with this, the NBSAP put forward several policies to promote data center investments in the country. These policies were (covered) enactment of necessary regulations (including the definition of data centers and data center management), provision of location, tax advantages, reduced electricity tariffs, attracting foreign investment and incentivizing usage of domestic hardware and software in these investments.

[433] IEP is defined as a critical technical infrastructure where different networks connect and exchange Internet traffic with each other.
[434] These benefits range from cost savings (due to less use of international traffic routes), lower latency and better user experience, local content generation, improved security and development of local cloud infrastructures, protection for global internet outages and similar kind of problems, attraction of international companies, (ITU, 2015b).

Irrespective of this plan, sectoral support came from ‘attraction centers program’[435] implemented by Development Bank of Türkiye[436]. The elements under the heading of data center investment and energy support package consisted of data center energy support, fiber infrastructure support, "investment location allocation support" and "interest-free investment loan support".

Increasing competition in the wholesale broadband market: This action had a timeframe of 2017-2018 period and focused mainly on market analysis procedures. In brief terms, regulators have made market analysis to identify markets where there is not desired level of competition and imposed some obligations to firms that have significant market share (power) in these markets. These obligations range from non-discrimination, transparency to certain kind of cost accounting requirements, to name a few. ICTA has made such kind of analysis since 2010s to increase market competition in different segments. However, apart from few operators that have made infrastructure investments, the other firms’ have not succeeded in capturing much market share at the expense of (mainly) Turk Telekom. There may be several reasons for this outcome. One is the fact that service-based competition has limits without infrastructure investments in the sector. Secondly, the policies of the regulator have not been much effective in influencing market developments. Thirdly, one can also say that both of these factors have an effect on the current market structure. Here, making regulatory impact analysis can be helpful to assess the impact of these institutions. Indeed, this policy had emphasized (as a separate action step) the importance of making impact analysis and establishing participatory working mechanisms by including market actors in these processes. In spite of this, there is no regulatory impact analysis made in this regard as of June 2023. In general terms, sector actors consider this kind of analysis as essential tools to see effectiveness of all kinds of regulations and want to see publicly available studies. Another contribution of increasing the number and availability of such studies is that, these findings, outcomes can be used as an input for newly prepared policy papers.

Transition to regulation on regional bases: Another action that has been included in various strategy papers is the implementation of regional regulations. Like most other

[435] “Cazibe merkezleri programı” in Turkish.
[436] https://www.resmigazete.gov.tr/eskiler/2016/11/20161122-2.htm

legislations in other sectors, electronic communications sector regulations are implemented in the whole country. In contrast to this, regulations based on regional characteristics take into account socio-economic differences. In other words, a regulatory body can give some exemptions to provider/s in some areas where competition exists or at the opposite, no infrastructure exists (in return for making investments in these locations). Likewise, this plan included determination of different regions (areas) in terms of various indicators such as the number of available operators, coverage of networks and usage characteristics. Then, depending on these determinations, it proposed preparation of market analysis to implement different regulatory approaches. Although the end date of this work set as 2018, there is no such an approach used by ICTA as of this date. This may be due to either inapplicability of different approaches or to the preference of the regulator (not to implement such kind of approach).

Development of smart cities program and development of smart transportation systems: One can include these actions in the category of vertical usages of broadband internet technologies. Irrespective of this plan, MEUCC [437] prepared a very comprehensive '2020-2023 National Smart Cities Strategy and Action Plan' to lay out the details of this policy. Its basic aim is to increase the capability of ecosystem to support transition to smart cities throughout the country. Likewise, MTI prepared 'National Intelligent Transportation Systems (ITS) Strategy Document and 2020-2023 Action Plan' in this context. Being another detailed policy paper, its main objective is the development of ITS infrastructure along with other complementary targets[438].

Domestic production and R&D support in the sector, R&D and standardization studies related to 5G and beyond technologies: These two (action) topics were closely related to the objective of national technology development and production. They included actions such as establishment of 5G Forum, support mechanisms for domestic production and inspection of R&D obligations of domestic operators[439].

[437] Please note that at that time, the name of the organization was 'Ministry of Environment and Urbanization.

[438] Other goals are 'Ensuring Sustainable Smart Mobility', 'Ensuring Road and Driving Safety', 'Generating a Liveable Environment and Conscious Society' and 'Ensuring Data Share and Security'.

[439] These are evaluated more comprehensively in the analysis of hardware production segment in chapter 5.5.

G. INTERVIEW LIST

Int (1): Private sector/ services - Engineer- 20 years of experience
Int (2): Private sector/ services-Economist-22 years of experience
Int (3): Private sector/ services- Engineer- 25 years of experience
Int (4) Private sector/ services- Social Science (economics)- 18 years of experience
Int (5): Private sector/ services- Engineer-21 years of experience
Int (6): Private sector/ hardware- Engineer-24 years of experience
Int (7): Private sector/ hardware- Engineer- 15 years of experience
Int (8): Private sector/ hardware- Engineer (computer prog)- 11 years of experience
Int (9): Private sector/ hardware- Engineer (computer prog.)- 8 years of experience
Int (10): Private sector/ hardware- Engineer- 16 years of experience
Int (11): Private sector/ hardware- Engineer (computer prog.)- 20 years of experience
Int (12): Private sector/ hardware- Social Science (management)- 19 years of experience
Int (13): Private sector/ hardware- Engineer -25 years of experience
Int (14): Private sector/ hardware- Engineer (computer prog.)- 9 years of experience
Int (15): Retired government officer- Engineer- 33 years of experience
Int (16): Retired government officer- Engineer- 35 years of experience
Int (17): Government officer- Engineer- 15 years of experience
Int (18): Government officer- Social science (management)- 13 years of experience
Int (19): Government officer- Engineer - 26 years of experience
Int (20): Government officer- Social science (economist)- 22 years of experience
Int (21): Sector expert (advisor, journalist)- Social science (management)- 14 years of experience
Int (22): Sector expert (university)- Engineer-11 years of experience
Int (23): Sector expert (university)- Social science (economics)-17 years of experience

H. APPROVAL OF METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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04 AĞUSTOS 2022

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Erkan ERDİL

Danışmanlığını yürüttüğünüz Ayhan TÖZER'in "Dijital Dönüşüm ve 5G Teknolojisinin Rolü; Türkiye Telekomünikasyon Sektörü Ekosisteminin Analizi (Araştırma 5G geçiş sürecinde Türkiye Mobil Telekomünikasyon Hizmet ve Donanım Ekosisteminin Analizini amaçlamaktadır. Kapsam değişikliği olmamakla birlikte, başlıkta yazılımsal değişiklik yapılabilir)" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **0398-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

Bilgilerinize saygılarımla sunarım.

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I. SUMMARY FORM OF INTERVIEW NOTES (REGULATORY TOPICS)

Abbreviation of Assertions	Response Type	Most used words, phrases (Coding)
A1-Problems in regulatory framework / General Evaluation	Total:23/ Agree:13/ Disagree:3- Some moderate success /No comment: 4 / Not having enough knowledge:3 Respondents consider current situation unsatisfactory. There is a consensus that current regulatory structure is one of the main reasons for this outcome.	‘Unsatisfactory growth rates’, ‘Liberalization and privatization failures’, ‘Competition problems’, ‘High tax rates both for firms and for end users’, ‘Lower service quality in some areas’, ‘Lower average internet access speeds’
A1.1-Presence of similar organizations	Total:23/ Agree:13/ Disagree:4- while accepting a problem, they consider more clear-cut role definition etc. can reduce this problem /No comment:3/ Not having enough knowledge:3 Respondents consider current situation unsatisfactory/unproductive, negative response- agree with the assertion- 57%, acceptance of a problem- 75%	‘Overlapping responsibilities’, ‘Confusion’, ‘Power maximization’, ’Risk Shifting’, ‘Time delays’, ‘Unnecessary waste of time’
A1.2-Independence of regulatory authority	Total:23/ Agree:15/ No comment:5/ Not having enough knowledge:3 Respondents give unsatisfactory/ unproductive, negative response- agree with the assertion- 65%	‘Conflict of interest’, ‘Dominance of bigger operators’, ‘Untransparent implementations’, ‘Biased practices’
A2-Existence of multiple policy papers	Total:23/ Agree:7/ Disagree:13 Not having enough knowledge:3 Respondents consider this topic as problematic but find the main issue in implementation phase (responsibilities, follow ups etc.)	‘Unclear responsibilities’, ‘Follow up problems’, ‘Coordination difficulties’, ‘Lack of interest’

Abbreviation of Assertions	Response Type	Most used words, phrases (Coding)
	- Not agree with the assertion- 30%	
A3-Impact Analysis	Total:23/ Agree:21/ Not having enough knowledge:2 Respondents consider the current outcome as totally unsatisfactory/unproductive, negative response- agree with the assertion- 91%	'Not available', 'Not exist', 'Better to see', 'Certainly beneficial to have'
A4-Interactions between public actors and associations	Total:23/ Agree:8/ Disagree:7 No comment:5/ Not having enough knowledge:3 There is not a dominant opinion/ answer in this category. It appears that smaller firms have difficulties in this regard. But taking into account the position of bigger firms and government officials, that attended these interviews, it can be said that the problem is worth considering for policy makers.	'Having difficulties in reaching', 'Communication problems', 'No need for lobbying for bigger firms', 'bigger firms are state owned' versus 'do not observe such difficulty', '
A5-Implementation of location-based regulation	Total:23/ Agree:5/ Disagree:9 No comment:2/ Not having enough knowledge:7 There is not a dominant opinion/ answer in this category. It appears that this regulatory tool has lost its place in the agenda of experts. Actors seem to prefer implementation of existing (nationwide) regulations in a transparent manner.	'Long overdue', 'Not critical now', 'just implement existing regulations well' versus 'can be implemented in certain regions', 'can give incentives'
A6-Universal Service Fund	Total:23/ Agree:14/ No comment:4/ Not having enough knowledge:3	'Lack of transparency, accountability', 'don't know how it's used', 'should be used more effectively and for the real purpose'

Abbreviation of Assertions	Response Type	Most used words, phrases (Coding)
	Respondents give unsatisfactory/unproductive, agree with the assertion- 60%	
A7-Cable TV Network	Total:23/ Agree:18/ No comment:2/ Not having enough knowledge:3 Although respondents regard this network as an important alternative, they think that valuable time has been lost to increase presence of this infrastructure. Agree with the assertion- 80%	'Important access tool', 'Alternative for consumers', 'Long overdue', 'Should be used more effectively', 'Regulation failure', 'Unsatisfactory growth rate and coverage', 'Not successful for providing competition'
A8-Fiber coverage	Total:23/ Agree:18/ No comment:2/ Not having enough knowledge:3 Respondents consider outcome as unsatisfactory/unproductive, agree with the assertion- 80%	'Totally inadequate', 'Block effectiveness of 5G', 'Joint infrastructure company', 'incentives for investments', 'tax reliefs, subsidies'
A9-Number of (nationwide) operators in 5G	Total:23/ Agree:21/ No comment:2/ Respondents agree that there will be no change in the number of nationwide operators- agree with the assertion- 91%	'No change', 'remain the same', 'three but who will own them', 'sunk costs', 'having fourth one a lost opportunity a long time ago'
A9.1-Market opportunities in 5G	Total:23/ Agree:20/ No comment:3/ Respondents totally agree about potential market opportunities with the condition that regulatory framework should support these in practice.	'New opportunities', 'MVNO', 'New spectrum types', 'Vertical usages', 'Depends on regulatory policy and implementation'
A10-License auctions, Domestic production capabilities	Total:23/ Agree:18/ No comment:2/ Not having enough knowledge:3 Here, also there is a consensus between market actors on the importance of license conditions	'Licenses are important for this policy', 'Should be continued for this purpose', 'necessary to have commitment to

Abbreviation of Assertions	Response Type	Most used words, phrases (Coding)
	and implementation of them after market formation.	this objective by the authority’
A10.1-Implementation mechanism	Total:23/ Agree:18/ No comment:2/ Not having enough knowledge:3 As a continuation of above assertion, it is fairly obvious that market actors expect more commitment from (especially) regulatory authority in inspection, control and coordination phases.	‘Problems in implementation’, ‘Not transparent’, ‘Could not follow’, ‘Product lists’, ‘Domestic goods certificate’, ‘Inadequate inspections controls’
A11-Prioritization of segments	Total:23/ Agree:13/ No comment:6/ Not having enough knowledge:4 Participants agree that there should be a prioritization but in a well-planned manner and with a long-term perspective.	‘Not feasible to produce all’, ‘Prioritization of software-based products’, ‘Need to achieve scope economies’, ‘Lack of long- term planning and strategy’
A12-Use of public procurement	Total:23/ Agree:17/ No comment:3/ Not having enough knowledge:3 There is no objection for the use of this policy tool at all, but the real expectations lie in the implementation aspects such as procurement of only domestic products.	‘Important policy tool’, ‘Not full commitment observed in practice’, ‘Should be used only for domestic products’, ‘Lack of long-term planning’
A13-Coexistence of similar organizations under different ownerships	Total:23/ Agree:8/ Disagree: 6 No comment:4/ Not having enough knowledge:5 Respondents do not have a common opinion. Some consider presence of state owned and operator owned companies lead to competition problems. While most of them agree on the	‘Competition problems’, ‘Use of same support funds’, ‘Similar treatments of SMEs and other well-funded companies’ <u>versus</u> ‘Importance of a lead firm’, ‘Financial capabilities’

Abbreviation of Assertions	Response Type	Most used words, phrases (Coding)
	necessity of different treatment of SMEs in support programs	

J. TURKISH SUMMARY

Bilgi ve iletişim teknolojilerinin giderek daha ilerlemesi ve yayılması sonucunda, ülkeler bilgiye dayanarak rekabet etmekte ve bilgiye ulaşmak, bunları kullanmak ve yaymak konusunda daha başarılı olanlar vatandaşlarının refah seviyesini artırabilmektedirler. 5G gibi mobil genişbant teknolojileri de bilgi ekonomisinin en önemli altyapılarından biri olarak kabul edilmektedir. Söz konusu teknolojiler hem sosyal hem de ekonomik açıdan çeşitli dönüşümlere yol açmakta ve tüm ülkeler rekabet avantajlarını sürdürmek için ilgili alanlarda yerli üretim yeteneklerini ve sürdürülebilir ekosistemlerini geliştirmeyi hedeflemektedirler.

Tezde bu çerçevede dijital dönüşüm sürecinde özellikle önem arz eden ve bu sürecin altyapısını oluşturan telekomünikasyon sektörü incelenmektedir. Bu noktada, özellikle mobil telekom teknolojilerinin gelişimi, gelinen nokta ve ülkemiz piyasasındaki durum üzerine odaklanılmıştır. Bu kapsamda çalışmanın ana bölümleri aşağıda özetlenmektedir.

Tezin ilk bölümünde bilgi ve iletişim teknolojilerinin (BİT) tüm dünyada ve hemen tüm sosyo-ekonomik alanlarda giderek artan önemi vurgulanmış ve bu noktada kesintisiz ve kapsayıcı bir internet erişiminin tüm bu teknolojilerden etkin bir şekilde yararlanmak için olmazsa olmaz bir ön koşul haline geldiği ifade edilmiştir. Bu süreçte, internetin dönüştürücü rolünü daha da ileriye taşıyan mobil telekomünikasyon teknolojilerinin gelişiminin dijital dönüşümü hızlandırıcı etkisine de değinilerek, çalışmanın ana konusunun bu teknolojileri (gelişim süreci, etkileri, çeşitli riskler vb.) içerdiği belirtilmiştir. Daha detaylı belirtecek olursak çalışma sektörel bir analizi kapsamakta olup, telekomünikasyon sektörünü inceleme konusu yapmaktadır.

Genel olarak, kablolu (sabit) ve kablosuz (mobil) olarak adlandırılabilecek telekomünikasyon teknolojileri artık diğer BİT'leriyle ile adeta bütünleşmiş ve kesin çizgilerle sektörel ayrım yapmak giderek zorlaşmaktadır. Yakınsama olarak da adlandırılan bu gelişme neticesinde özellikle telekomünikasyon, yayıncılık ve bilgisayar (ekipman ve yazılım) teknolojileri alanlarında faaliyet gösteren şirketler, daha önce ayrı olan bu pazarların hepsinde birden hizmet vermeye başlamışlardır. Örneğin, bir mobil telekomünikasyon hizmeti sağlayıcısı (operatörü) artık konvansiyonel telefon, yayıncılık, katma değerli hizmetler (bilgisayar oyunları, dijital eğlence vb.) ve diğer firmalara çeşitli BİT (bulut, siber güvenlik vb.) hizmetlerini sunabilmektedirler. Diğer taraftan, son kullanıcılarda örneğin bir cep telefonu vasıtasıyla telefon hizmetlerinin yanısıra, TV, video, oyun vb. birçok hizmetten yararlanabilmektedirler. Hatta cep telefonunu bir kredi kartı olarak kullanma da giderek görülen bir uygulama olarak karşımıza çıkmaktadır.

Tüm bu gelişmeler ışığında, çalışmanın kapsamı (bir analiz yapılabilmesi açısından) telekomünikasyon şebekeleri (ağları) üretim (cep telefonu hariç), şebeke kurulumu ve bunun üzerinden verilen hizmetler olarak belirlenmiştir. Bu noktada telekomünikasyon sektörünü genel olarak iki kısıma ayırmak mümkündür. Bunlar hizmet verilmesini mümkün kılan ekipman üretimi ve gerekli altyapı kurulduktan hizmet sunumu olarak verilebilir. Daha detay olarak ise altyapı işletilmesi ve (bu altyapılar üzerinden) çeşitli telekom hizmetleri sunumu olarak bir ayrıma da gidilebilmektedir.

Bu kapsamda, ekipman- şebeke üretim kısmında baz istasyonu, anten gibi şebeke ekipmanları ile son kullanıcıya yönelik telefonları sayabiliriz. Ancak, bu listeye bilgisayar ekipmanları ile burada kullanılan her türlü yazılımı da dahil edebiliriz. Tüm bu ekipmanların kullanılmasıyla kurulan şebekeler ise sabit (temel olarak bakır, fiber), mobil ve hibrid yapılar olarak karşımıza çıkmaktadır.

Bu şebekeler üzerinden (şebekelerin) sahipleri hizmet verebilirken, kiralama vb. yöntemlerle diğer işletmeciler hizmet verebilmektedirler. Bu hizmetler giderek çeşitlenmekte olup, örnek olarak ses, veri, video, medya ve bulut yönetim sistemlerini sayabiliriz. Tüm bu alt piyasalarda pazar yapısı ülke koşulları ve tarihsel gelişim süreçlerine göre farklılık gösterebilmektedir. Tarihsel olarak şebeke üreticileri önemli ölçek ekonomilerine ulaşmış olup, dünya çapında faaliyet göstermektedirler. Son dönemde teknolojinin gelişimine bağlı olarak daha çok yazılım tabanlı ürün/servis sağlayıcıların piyasaya girişi de hızlanmaktadır. Yine geleneksel olarak ülke çapında şebeke kurulumu maliyetli bir süreç olduğu için tekel ve (daha sonra) oligopolistik piyasa yapıları oluşmuştur. Burada özellikle hizmet sunumu konusunda rekabet seviyesinin artırılması amacıyla düzenlemeler yapılmaktadır.

Gelinen noktada özellikle telekomünikasyon alanında gelişmiş ülkelerde hizmet piyasalarında rekabet seviyeleri artmış durumdadır.

Dijital dönüşümün geldiği aşamada, artık tüm ülkeler bu sürecin altyapısını oluşturan telekom şebeke altyapılarını kurup, toplumun tüm kesimlerine hizmet götürülmesini amaçlamaktadırlar.

Bu noktada, gerekli altyapının o ülke kaynakları (yerli firma vb.) kullanılarak yapılması hem ülke ekonomisi açısından hem de giderek artan siber tehditlere karşı önem arz etmektedir.

Telekom şebeke kapsamının yaygınlaştırılması sayısal uçurum probleminin çözümünde de önemli bir rol oynamaktadır.

Söz konusu teknolojik gelişmeler, tarihsel olarak zaten önemli bir konumda bulunan haberleşme sektörünü daha da kritik bir noktaya getirmiştir.

Bilgi ve iletişim teknolojilerinin giderek daha ilerlemesi ve yayılması sonucunda, ülkeler bilgiye dayanarak rekabet etmekte ve bilgiye ulaşmak, bunları kullanmak ve yaymak konusunda daha başarılı olanlar vatandaşlarının refah seviyesini artırabilmektedirler.

Hemen hemen tüm bilgi teknolojileri hizmetleri kesintisiz ve etkin bir şekilde çalışabilen internet erişimini gerekli kılmakta ve bu erişimden yararlanamayanlar dezavantajlı bir konuma girmektedirler.

Bu noktada ‘sayısal uçurum’ denilen bazı toplum kesimlerinin internet hizmetine gereği gibi erişememesi önemli bir problem olarak görülmekte ve ülkeler bu problemi en aza indirebilmek için çeşitli politikalar geliştirip uygulamaktadırlar.

Mobil telekom teknolojilerinin geldiği son noktada diğer sektörlerinde bu şebekelere olan ihtiyacı giderek artmaktadır.

Çalışmada üzerinde durulduğu şekilde dikey sektör uygulamaları adı verilen bu hizmetlerin sayısı ve kapsamı her geçen gün çoğalmaktadır. Son dönemde yaşadığımız global düzeydeki hastalıklar ve doğal afetler de etkin bir şekilde faaliyet gösterebilecek telekomünikasyon hizmetlerinin hayati önemini bir üst seviyeye çıkarmıştır.

Son olarak, sosyo-ekonomik hayatın hemen hemen tüm unsurlarına nüfuz eden bu şebeke ve hizmetlerin, dış tehditlere karşı korunması da elzem hale gelmiştir. Siber güvenlik kavramı altında toplanılabilecek bu hususta en az telekom şebekelerinin varlığı kadar önem arz etmekte ve bu hizmetlerin geliştirilmesi ihtiyacı/ talebi ilgili pazarın da büyümesine yol açmaktadır.

Sektörün bu artan önemi ve rolü kapsamında, çalışma ülke telekomünikasyon sektörünü yenilik sistemleri yaklaşımı çerçevesinde incelemeyi amaçlamaktadır. Bu kapsamda, ülke telekomünikasyon sektörel yenilik sisteminin etkin işleyişini engelleyen temel sistemik, yapısal sorunların (varsa) neler olduğu ve daha spesifik olarak, düzenleyici çerçevenin bu sorunların çözümüne yardımcı olup olmadığı sorusu üzerinde durulmaktadır. İkinci olarak da ilgili ekosistemin telekom şebeke ekipmanları üretimi ve 5G Teknolojisi alanında üretim-inovasyon yeteneğinin araştırılarak bu yeteneklerin geliştirilmesine yönelik ne tür politika-programlar geliştirilebileceği incelenmektedir.

Genel bir girişi sunan (tez kapsamı, önemi ve problemler) ilk bölümün ardından, ikinci bölüm çalışmanın metodolojisi üzerinde durmaktadır. Tezde temel inceleme yöntemi olarak nitel araştırma yöntemi kullanılmıştır. Telekomünikasyon sektörüyle ilgili olarak hazırlanan politika belgeleri, raporlar ve kamuya açık diğer kaynaklar kullanılarak birtakım bulgular ve sorunlar tespit edilmiş ve bunları içeren sorular hazırlanmıştır. Politika belgeleri içerisinde özellikle beş yıllık kalkınma planları, genişbant internet teknolojilerini içeren strateji dokümanlarına (Ulusal Genişbant Stratejisi ve Eylem Planı gibi) öncelik verilmiştir. Bunu müteakip, sektörde çalışan uzman niteliğindeki kişilerle çeşitli mülakatlar düzenlenmiştir. Bu bölümde ayrıca yöntemle ilgili bilgilere yer verilmekte ve yapılan mülakatlara ilişkin genel bilgilere de kısaca yer verilmektedir. En son olarak da nitel araştırma yönteminin bu çalışmada kullanılmasının getirdiği çeşitli avantaj ve dezavantajlara da değinilmektedir. Yöntem ile ilgili vurgulanması gereken bir hususta çalışmanın istatistiki verilerle desteklendiğidir. Çalışmada uygun olduğu ölçüde istatistiki veri kullanılmaya çalışılmış ve bunlara destekleyici unsur olarak yer verilmiştir. Örneğin, internet abone sayıları erişim teknolojileri, hız ve kullanım miktarları bazında incelenmiş ve yıllık gelişimler üzerinde durulmuştur. Söz konusu kategorilerde uluslararası karşılaştırmalara yer verilmesi açısından özellikle OECD'nin yayınlamakta olduğu istatistiki veriler kullanılmış ve kıyaslamalara değinilmiştir.

Mobil telekomünikasyon teknolojilerinin gelişimi daha detaylı bir şekilde üçüncü bölümde sunulmaktadır. İlk olarak dijital dönüşümün önemi ve geldiği nokta vurgulanmıştır. İçinde bulunduğumuz ve dördüncü endüstriyel devrim olarak adlandırılan dönem tek bir teknoloji (örneğin buhar gücü ve birinci endüstriyel devrim) ile tanımlanmamakta ve pek çok BİT yeniliğinin (yapay zekâ, mobil telekom teknolojileri, otonom teknolojiler ve robotlar, 3 boyutlu yazıcılar, kuantum bilgisayar teknolojileri vb.) bir arada ve etkileşimli bir şekilde kullanılmasıyla elde edilebilen sinerji kazanımları ön plana çıkmaktadır.

Örneğin, sadece bir cihazı ele alırsak, cep telefonu abone sayısı 8 milyarı aşarken başta telefonlar olmak üzere mobil iletişim cihazları ve giderek artan akıllı telefonlar insanlık tarihinde en yaygın kullanılan cihazlar haline gelmektedir. Bu durumu mümkün hale getiren en önemli husus ise internet ile birlikte mobil telekom teknolojilerinin gelişimi olmuştur. 1. Nesil ya jenerasyon (1G) olarak da adlandırılan ilk aşamadan sonra gelinen noktada 5. Nesil (5G) teknolojisi ticarileşme aşamasına gelmiş ve ülkeler bu teknolojiyi kullanmaya başlamışlardır. Çeşitli ülkelerin 5G kullanım yaygınlıklarına Ek- B de yer verilmektedir. Kısaca, bu kısımdaki veriler ışığında ve Nisan 2023 tarihi itibariyle Güney Kore'nin hem yaygınlık seviyeleri hem de kapsama oranları açısından en geniş 5G kapsama alanına sahip olduğu görülmektedir. Örneğin bu ülkede AB ülkelerine kıyasla neredeyse altı kat daha fazla (100.000 kişi başına) 5G baz istasyonu bulunmaktadır.

Buradan, Güney Kore'nin bir bütün olarak AB'ye kıyasla çok daha iyi hizmet parametreleri kapsamına ve kalitesine (yani daha yüksek hızlar ve daha düşük gecikmeler) sahip olduğu görülmektedir. Bu kapsamda, söz konusu tarih itibariyle Güney Kore'yi Çin, ABD, Japonya ve AB üye ülkeleri takip etmektedir. Detay bazda Güney Kore'de 415 5G Baz istasyonu 100.000 kişi başına yaklaşık 50.000 5G abonesi vardır. Öte yandan Çin, devasa nüfusuna ve büyük ülke büyüklüğüne rağmen 163 5G Baz istasyonuna sahip ve 100.000 kişi başına yaklaşık 25.000 5G abonesi bulunmaktadır. ABD en büyük miktarda yüksek bant spektrumu tahsis ederken, 100.000 kişi başına 24.000'e yakın 5G abonesi olan 30 5G Baz istasyonuna sahiptir.

Tüm bu ülkelerdeki 5G teknolojisini ve erişimini yaygınlaştırma çabası, bu yeniliğin getirdiği üstünlüklerden kaynaklanmaktadır. Öyle ki 5G bir önceki teknoloji olan 4G ye nazaran önemli ölçüde hızlı internet erişimine imkân vermektedir. Söz konusu hızlardaki ve anlık iletişim kabiliyetlerindeki önemli artışlar (örneğin, iki jenerasyon arasındaki hız koşullara göre 10 ila 100 kat arasında farklılık gösterebilmektedir) mobil iletişim teknolojileri kanalıyla internet kullanan ve çok çeşitli sektörleri kapsayan dijital kullanım olanaklarını da beraberinde getirmiştir. Bu bölümde ve Ek- C de konuyla ilgili daha detaylı bilgi sunabilmek amacıyla dikey sektör uygulamaları olarak da adlandırılan bu teknolojilere yer verilmektedir. Gelinen aşamada söz konusu uygulamaların sayısı ve özellikleri her geçen gün artmakta olup, bu değerlendirmeler daha ziyade konunun önemini vurgulamak amacıyla sunulmaktadır. Örneğin, en geleneksel sektörlerden biri olan tarım alanında mobil internet teknolojilerini kullanarak daha verimli sonuçlar elde etmek mümkün olabilmektedir. Bu kapsamdaki bir iyileştirmeye yer verecek olursak, dijital tarım uygulamaları bir örnek teşkil edebilecektir. Dijital tarım, çeşitli kullanımlar için farklı türde veriler üretir. İlk olarak çiftçiler gübre ve su kullanımı gibi yerelleştirilmiş verileri üretir ve yönetir. Tahminler gibi dışarıdan aktarılan veriler ikinci kategoriyi oluşturur. Öte yandan hükümetler ve diğer paydaşlar da bu sistemden elde edilen verileri tarımsal analizler veya diğer politika amaçları için kullanabilmektedirler. Mobil iletişim teknolojileri destekli sensörler, nesnelerin interneti, bulut tabanlı bilgi işlem ve büyük veri analizinin tümü bu sürece katkıda bulunmaktadır. Sensörler ve Nesnelerin İnterneti, toprak kalitesinden verim tahminine, ürün tehditlerinin tespitine ve haritalanmasına kadar geniş kapsamlı veri toplama fonksiyonunu yerine getirebilir. Ekosistemden elde edilen veriler daha sonra detaylı analiz için belirlenen bulut platformlarına aktarılır. Büyük Veri platformları, internet üzerinden veri gönderen birbirine bağlı makinelerden üretilen çeşitli girdileri işlemek için gereklidir. İşte sadece bu örnek bile, mobil telekomünikasyon teknolojilerinin diğer BİT uygulamalarıyla birlikte kullanıldığında getirdiği etkinlik artışlarını göstermektedir.

Aynı şekilde giderek artan problemler yaşayan mega şehirlerde, diğer çözüm arayışlarının yanı sıra bu teknolojiler kanalıyla daha etkin (verimli) trafik, elektrik, su ve güvenlik yönetimi çözümleri verilebilmektedir.

Çalışmada detaylı bir şekilde ele alındığı üzere, dijital ve birbirine bağlı bir şekilde yönetilen trafik lambaları, şehir aydınlatması vb. uygulamalar trafik yoğunluğu ve elektrik maliyetlerinden tasarruf sağlamakta ve bu ekipmanlar ayrıca şehir güvenliği, acil durumlara erken müdahale (güvenlik kameraları, erken uyarı sistemleri vb.) gibi etkinlik kazanımlarını da beraberinde getirebilmektedir.

Sayısı giderek artan bu uygulamalar sosyo-ekonomik alanda pek çok değişime sebep olmakta ve bunlarda çeşitli fırsatların yanı sıra çeşitli risk ve tehditleri de ortaya çıkarabilmektedir.

Çalışmanın ana konusunu oluşturmamakla birlikte bu risklere karşı geliştirilmesi önem arz eden siber güvenlik politikalarının artan rolüne de değinilmektedir. Söz konusu dönüşüm aynı zamanda mobil telekom sektörünün yapısını da değiştirmekte ve mobil telekom operatörlerinin artan birleşme ve devralmalarla birlikte daha da büyümeleri sonucunu getirebilmektedir.

Söz konusu yeni iletişim teknolojilerinin riskleri kapsamında ele alınabilecek ve bu çalışmayı daha yakından ilgilendiren hususu ise teknoloji yatırımlarının artan maliyetleri ve diğer yatırım zorlukları oluşturmaktadır.

Bu konularla ilgili değerlendirmeyi müteakiben, ilgili teknolojinin sürekli gelişim gösteren özelliğini göstermek için bir sonra gelecek aşama olan 6G teknolojisi üzerinde durulmuştur.

Zira, bu konuda önde gelen ülkeler 6G konusunda da çalışmalara başlamış ve ilgili standartların oluşturulmasında söz sahibi olmak için rekabet etmektedirler. 5G teknolojisinde olduğu gibi, Çin, Güney Kore ve ABD gibi ülkeler bu konuda politika belgelerini ve destek mekanizmalarını oluşturmuş, bir yandan da ülke firmaları eliyle patent yarışında ön sıralarda olmak için faaliyet göstermektedirler.

Çalışmanın dördüncü bölümü analiz aşamasında da kullanılacak teorik çerçeveyi oluşturan yenilik sistemlerini kapsamaktadır. Liberal ekonomi anlayışına karşı gelişen ve ekonomide devletin rolü ve ilgili aktörlerin ilişkilerinin vurgulandığı bu anlayış, hemen tüm ülkeler tarafından benimsenmiş ve özellikle uluslararası kuruluşlar (OECD gibi) tarafından kullanılmaya başlanmıştır. Süreç içerisinde ulusal yenilik sistemleri ile başlayan farklı uygulama kapsamları daha sonra bölgesel, sektörel ve teknolojik (spesifik bir teknoloji kapsamı) bazda farklılaşmıştır. Hepsinin ortak özellikleri olmakla birlikte öne çıkardıkları farklılıklar olabilmektedir. Temel farklılıkların başında analiz edilmesi istenilen konu gelmekte olup, örneğin telekomünikasyon sektörünün incelenmesi belirli bir kapsam sınırlamasını gerekli kılmakta ve bu noktada sektörel, teknoloji odaklı yaklaşımlar öne çıkmaktadır.

Tüm bu hususların kısaca ele alınmasını müteakip, sektörel fonksiyonların vurgulandığı teknoloji bazlı yenilik sistemi çerçevesinde kaynak mobilizasyonu, girişimcilik faaliyetleri, bilgi üretilmesi gibi temel konseptler değerlendirilerek telekomünikasyon sektöründe uygulanması tartışılmaktadır.

Bu başlığın ikinci bölümü olarak görülebilecek kısımda, söz konusu yaklaşımları (nitel yöntemlerle birlikte) ön plana alan örnek çalışmalar incelenmektedir. Bu örnekler çeşitli ülkeleri içermekte olup, faklı yenilik sistemleri ve sektörlerin gelişimini incelemektedir. Tezde yedi çalışma incelenmiş olup, bunların hepsi telekomünikasyon sektörlerini içermekle birlikte; odak ve kapsamları bazı açılardan farklıdır. Aslında ilk etapta bu çeşitliliği göstermek için seçilmişlerdir ve temel olarak nitel analiz kullanılarak gerçekleştirilen çalışmalardır.

Bu seçimin bir diğer nedeni ise bazı çalışmaların sektördeki tarihsel gelişmelerin, patika bağımlılıklarının ve kamu politikalarının rolünü analiz etmiş olmasıdır. Ayrıca bu vaka (sektörel) çalışmaları bağlamında telekomünikasyon sektöründeki özelleştirme ve serbestleşme gibi önemli olaylar ele alınarak çalışmada başka bölümlerde benzer konuların tekrarından kaçınılmıştır. Örneğin serbestleşme politikalarının açıklaması ve sektörün daha sonraki gelişmelerine etkileri bu bölümde özetlenerek bunlara (konulara) başka bir bölümde değinme gereği ortadan kaldırılmıştır.

Edquist (2004) tarafından yapılan sektörel analiz, özellikle internet ve diğer mobil telekom teknolojilerindeki ilerlemeyi (3G'ye kadar) ve sektörde sabit ve mobil internet hizmetleri gibi farklı alt pazarların oluşumunu ve internet servis sağlayıcıları ve mobil telekom operatörleri gibi farklı aktörleri gösterme açısından önem taşımaktadır.

Örneğin, İsveç telekomünikasyon sektörünü inceleyen çalışma tüm alt pazarları içermekte olup, geniş kapsamlı bir analizi içermektedir. Bu çalışmada görülen tarihsel gelişmeler, sektördeki patika bağımlılığı olgusunun önemine işaret etmektedir.

Çalışma ayrıca tarihsel gelişmelerin, daha sonraki Ar-Ge çalışmaları için hayati önem taşıyan teknolojik yetenekler, bilgi tabanı ve nitelikli insan kaynağının mevcudiyeti gibi çeşitli varlık ve deneyimleri oluşturarak mevcut pazar yapısını şekillendirebileceğini göstermektedir. Bu yeteneklerin var olması halinde sektörler ekonomik krizleri ve olası aksaklıkları atlatabilirler.

Bir diğer kritik konu ise telekomünikasyon sektörünün tarihinde yaşanabilecek yol bağımlılığı ve teknoloji kilitlenmeleridir. Burada vaka çalışmaları, araştırma portföylerinin çeşitlendirilmesinin ve sektördeki standart belirleme süreçlerine katılımın gerekliliğine işaret etmektedir.

Aslında, ikinci nesil mobil teknoloji standartlarının (GSM) oluşturulmasında AB düzeyindeki başarı, Ericsson ve Nokia gibi Avrupalı firmalara birçok avantaj sağlamış olup, buradaki başarı teknolojiyi ilk geliştirenler arasında olmanın yanısıra standart belirleme sürecinde etkin rol almanın önemini de göstermektedir.

Bu noktada, ana ülke pazarının büyüklüğü yeterli olamamakta ve daha küçük ülkelerden gelen firmaların faaliyetlerini sürdürebilmeleri için yurt dışı pazarda varlık göstermeleri gerekmektedir. Bu durum Güney Kore'den Samsung veya AB'nden Ericsson, Nokia için de benzerlik göstermektedir.

Aslında, daha büyük iç pazarlar Çinli firmalara ölçek avantajı sağlasa da onlar aynı zamanda denizaşırı pazarları ele geçirmek için agresif uluslararası pazarlama stratejileri de izlemektedir. Konuyla ilgili olarak, Çin menşeili bir firma bazında yapılan araştırma, global ölçekli firmaların stratejilerini vurgulamaktadır. Pasadilla ve Zhu (2016) tarafından yapılan analizden de görüldüğü gibi, bu satıcılar (en başta ZTE ve Huawei), diğer ülkelerde kurulu firmalarla ortaklık yapmak da dahil olmak üzere çeşitli politikalar kullanarak dış pazarları kazanmak için stratejik planlar uygulamaktadırlar. Anılan küresel satıcılar için en karlı gelir alanlarından biri, operatörlerle uzun vadeli iş anlaşmaları yapmaktır. Bu firmalar kurulduktan sonra neredeyse tüm altyapı bileşenlerini sağlayabilmekte ve bu ağların ömrü boyunca bakım hizmetlerine devam etmektedirler. Tabii ki bu, diğer gelişmekte olan ülkelerin teknolojiyi benimseyen statülerinin tek nedeni değildir, ancak daha zayıf teknoloji yeteneklerinin ortaya çıkmasında kesinlikle rol oynamaktadır.

Bu bağlamda, teknolojiyi benimseyen bir vakadan alınan örnek (örneğin, Nijerya telekom sektörü araştırması), bu (grup) ülkelerin daha ziyade telekomünikasyon şebekelerinin yaygınlaştırılması ve erişim hedeflerine vurgu yaptığını göstermektedir. Diğer bir deyişle, genellikle gelişmekte olan ülkeler vatandaşları için internet ve mobil telekom ağ erişiminin kullanılabilirliğini artırmaya odaklanmaktadır.

Dijitalleşmenin artan hızı ve datanın (veri) temel rolüyle birlikte, Cohen vd. (2014) yaptığı ABD ekipman sektörü vaka çalışmasında gösterildiği gibi telekomünikasyon sektörünün (ve hizmetlerinin) stratejik önemi, daha önceki düşüncelerin bile ötesine geçmiştir. Nitekim neredeyse tüm hizmet ve üretim süreçlerinin dijitalleştiği gerçeği göz önüne alındığında, veri iletim yollarının (yani ağlar ve ilgili bileşenlerin) kontrolü ve güvenliği, hemen tüm gelişmiş ülkelerin siyasi gündemlerini meşgul etmektedir. Bu bağlamda, (ABD pazarına ilişkin) örnek olay incelemesi, ülkede 5G geçişi sürecinde politika yapıcıların güvenlik kaygılarını açıkça göstermektedir.

Pazar hakimiyeti kaygılarıyla birleşen bu aktörler, mobil telekomünikasyon da dahil olmak üzere ilgili teknolojilerde teknoloji liderliği elde etmek için çeşitli politikalar (hatta Çin ürünlerinin kullanımını doğrudan yasaklamak dahil) ve destek mekanizmaları geliştirmektedirler. Bu hususların dışında çalışma, yeni teknolojilere odaklanılarak, yeni fırsat alanlarının bulunmasını da savunmaktadır. Bu önerilerin aynı zamanda gelişmekte olan ülkeler için pazara giriş noktaları bulma konusunda da faydalı olabileceği değerlendirilmektedir. Başka bir deyişle, 5G teknolojisindeki yazılımla ilgili bileşenler, konvansiyonel donanım segmentlerinde küresel satıcılarla rekabet edemeyen şirketler için alternatif pazar fırsatları sunabilir. Bununla birlikte, büyük Ar-Ge bütçelerine sahip küresel satıcıların da bu segmentlerde faaliyet gösterdiği gerçeğini dikkate almak gerekir. Nitekim yukarıda bahsi geçen örnek olaylar küresel şirketlerin yabancı ülke pazarlarında noktadan noktaya ağ kurulumu sağlamayı tercih ettiğini göstermektedir. Böylece uzun vadeli satış sonrası hizmetleri ve ekipmanlarına lojistik bağımlılığı olan bu pazarları bir anlamda ele geçirme stratejisi yürütmektedirler.

Telekomünikasyon sektörünün gelişiminin ve analiz çerçevesinin ele alındığı önceki bölümler ışığında, beşinci bölüm Türkiye telekomünikasyon sektörü inovasyon sistemini (IS), hizmetler ve ekipman üretimi başlıklı iki kısımda incelemektedir. Bu kısımda öncelikli olarak önemli aktörlerin belirlenmesi yapılmakta ve rolleri incelenmektedir. Sektörün hizmetler olarak tanımlanabilecek kısmında daha ziyade sektörün düzenleyici kurumu (BTK) tarafından faaliyet izni alan (gerekli izinler, yetkilendirmeler vb.) firmalar faaliyet göstermektedir. Sabit ve mobil ses hizmetleri, internet hizmetleri, altyapı işletmeciliği ve rehberlik hizmetleri gibi çeşitli hizmet türlerini içeren bu kısımda işletmeci sayısı dinamik olarak değişmekte olup, son rakamlara göre bu kategorilerde yaklaşık 450-500 civarı firma bulunmaktadır.

Ancak, çalışmada sektörel verilerle gösterildiği üzere ilgili piyasada daha ziyade oligopolistik bir yapı ortaya çıkmış ve alternatif işletmeciler önemli ölçüde pazar payı elde edememişlerdir.

Bu noktada gerek ulusal gerekse de uluslararası (OECD) veriler (örneğin genişbant internet kullanım oranları vb.) kullanılarak sektörel gelişim ve karşılaştırmalar verilmektedir.

Karşılaştırmalı istatistik analizleri de göstermektedir ki, ülkemiz internet hizmetleri alanında temel yaygınlık oranlarında belirli aşamalar kaydetmiş olmakla birlikte, günümüzde dijital dönüşümün (hayatın) geldiği noktada dikkate alınarak, artık erişimin daha kaliteli (örneğin hız, hizmet kalitesi vb.)

hale getirilmesinde iyileştirmeler yapılması ihtiyacı önem taşımaktadır. Diğer taraftan, bölümde ayrıca telekom ekipman üretim kapasitesinin artırılmasıyla ilgili politikalar ve bunlarla ilgili gelişmelere de yer verilmektedir.

Özellikle, yerli ve milli üretim düzenlemeleri incelenerek, uygulamadaki denetleme, takip ve şeffaflık gibi problemlerin üzerinde durulmaktadır.

Pazar yapısının mevcut durumunda önemli rol oynayan tarihsel gelişim süreçlerinin incelenmesini müteakip, sektörle ilgili önemli politika belgeleri detaylı bir şekilde araştırılmıştır. Burada özellikle beş yıllık kalkınma planları ile ilgili bakanlık (Ulaştırma ve Altyapı Bakanlığı) ile düzenleyici kurum (BTK) strateji belgeleri incelenerek, önem verilen hususlar, bunların ne ölçüde tekrar edildiği (vurgulandığı) ve sonraki dönemlerle ilgili hedeflerin ne ölçüde gerçekleştirebildiği gibi konuların analizi yapılmıştır.

Bu analizin asıl kullanıldığı alan da sektörle ilgili diğer kaynaklarla birlikte, bazı bulgu, tespit ve problem alanlarının ortaya çıkarılması olmuştur.

Altıncı bölüm daha ziyade sektör uzmanlarıyla önceden tespit edilmiş konulardaki derinlemesine mülakatların analizini içermektedir.

Söz konusu mülakatlar daha önce bahsedilen piyasa oluşumu, araştırmanın yönlendirilmesi, girişimcilik aktiviteleri, meşrulaştırma, kaynak mobilizasyonu ve bilgi üretimi, değişimi ana konuları altında belirlenen sorular kapsamında ilerlemiştir.

Mülakatlar esnasında katılımcıların kendi ilgi alanlarına göre görüşmeleri yönlendirebilmeleri sağlanarak önemli buldukları alanları vurgulamaları temin edilmiştir. Burada katılımcı görüşleri alınmış ve birtakım tespitlerde bulunulmuştur.

Sektörel politika belgelerinin incelenmesi ve katılımcıların sektörel inovasyon sistemi hakkındaki görüşlerinin değerlendirilmesi neticesinde sektörle ilgili pek çok sorunun ve darboğazın olduğu tespiti yapılmıştır. Her sektörde olduğu gibi, bunların bir kısmı daha genel ekonomik ve yasal koşullarla ilgiliyken, bir kısmı daha sektöre özgü olarak karşımıza çıkmaktadır.

Birinci kategoride yer alan hususlarla ilgili olarak mülakatlar neticesinde bazı konular ön plana çıkmıştır. Her ne kadar bunlar bu çalışmanın temel konusu olan düzenleyici çerçeve ile doğrudan ilgili olmasa bile, yine de sistemin etkin bir şekilde işleyişi için önem arz etmektedirler.

Bunlar arasında vergi ve benzeri mali yükler, özel sektörden katılımcıların çoğu tarafından en çok eleştirilen konuların başında gelmektedir. Sektör aktörleri tarafından, pazar gelirlerinin (reel olarak) azaldığına dikkat çekilmekte ve (ağır) mali yükümlülüklerin, makroekonomik koşulların yanı sıra, bu sonuçta önemli bir rol oynadığı düşünülmektedir. Firmalar açısından bakıldığında ağır bir vergi ve benzeri finansal yükümlülük içerisinde oldukları görülmekte ve yine özel sektör temsilcilerine göre devlet için ciddi bir vergi geliri kaynağı haline gelmişlerdir. Bu durum çerçevesinde hem ticari firmalar hem de son kullanıcılar üzerindeki vergi yükünü optimize etmenin gerekli olduğunu vurgulamaktadırlar. Daha fazla ayrıntıya girmeden, önemli görülen bir hususu belirtmek gerekirse, bu söz konusu noktalarda ana aktörün Ulaştırma ve Altyapı Bakanlığı veya BTK değil, Hazine ve Maliye Bakanlığı olduğu gözlemidir. Her ne kadar verilen basit bir ifade olarak değerlendirilebilirse de gerçekte birçok politika belgesinin bu aktöre kapsamlı bir şekilde danışılmadan hazırlandığı görülmektedir. Gerçekten de telekomünikasyon hizmetleriyle ilgili ve/veya telekom sektörü kısmı içeren politika belgelerinin çoğunda vergi yüklerinin azaltılmasına ilişkin hedefler bulunmaktayken (özellikle son kullanıcılara ilişkin, örneğin özel iletişim vergisi), ancak tam tersine bu vergilerin sürekli olarak artırıldığı görülmektedir.

Bu noktada (bir anlamda ironik olarak) Hazine ve Maliye Bakanlığı'nın görüşünü almak şartıyla cari plan döneminde artış olmayacağını belirtmenin daha doğru olacağı değerlendirilmektedir.

Diğer taraftan, bilgi üretimi ve kaynak maksimizasyonu gibi birden fazla fonksiyonla ilişkili insan kaynakları konusunun önemine paralel olarak katılımcılar bu geniş kapsamlı konuya ilişkin kaygılarını dile getirmişlerdir. Üstelik, katılımcılar nitelikli personel bulunması, üniversite eğitiminin kalitesinin düşmesi gibi pek çok konuyu dile getirmiş ve bu konulardaki sıkıntılarını ifade etmişlerdir.

Bu konuların daha çok Millî Eğitim Bakanlığı'ndan Yükseköğretim Kurulu'na, üniversitelere kadar eğitim sağlayıcı kuruluşları doğrudan ilgilendirdiği ortadadır. Nitekim, genel bir sonuç olarak, diğer ülke örnekleri de dikkate alınarak, ilgili kuruluşlar tarafından gerekli insan kaynağının nitelik ve niceliğini artırmaya yönelik politika ve girişimlere daha fazla öncelik verilmesi gerektiği açıktır. Sürekli eğitim, dijital okuryazarlık ve yaşam boyu öğrenmeye duyulan ihtiyaç çeşitli AB politika belgelerinde de vurgulanmıştır. Ayrıca 5G teknolojisine geçiş ve dijital uygulamaların yaygınlaşması, dikey kullanımlarla birlikte insanların farkındalığının artması (meşruluk ve güvenli kullanım) daha da önem kazanmaktadır.

Eğitim ve bilgi üretimini yakından ilgilendiren bir diğer konu ise sektördeki firmalara verilen patent politikası ve Ar-Ge destekleridir. İlgili verilere bakıldığında sektörel yenilik sisteminin küresel tedarikçi firmaları olan ülkelere karşı rekabetçi bir duruşunun olmadığı anlaşılmaktadır. Buna rağmen uzun vadeli bir perspektifle ülkenin sınırlı kaynaklarla yeteneklerini geliştirmeye devam etmesi gerektiği aşikardır. Bu politikaların her ikisinin de çok sektörlü bir yaklaşımı gerektirdiği değerlendirilmektedir. Mülakatlardan tespit edildiği gibi bazı katılımcılar üniversite öncesi eğitim konularını dahi kapsayan kapsamlı bir patent politikasının gerekli olduğuna işaret etmektedirler. Mali açıdan bakıldığında, orta ve uzun vadede bu rakamların artırılması için genel olarak patent çalışmaları ile Ar-Ge destekleri arasındaki ilişkilerin daha fazla vurgulanması gerektiği ileri sürülebilir.

Ar-Ge desteklerinde daha kısa vadeli konulara ilişkin olarak katılımcıların görüşleri ışığında bazı çıkarımlar ve buna ilişkin öneriler şu şekilde ifade edilebilir. Genel anlamda katılımcıların bu işlemlerde çoğunlukla çok fazla bürokrasiyi eleştirdikleri görülmektedir.

Daha zor görülebilecek iyileştirmelerin (özellikle mevcut makroekonomik koşullar göz önüne alındığında fon, destek miktarının arttırılması vb.) uygulama olasılıklarının daha düşük olduğu göz önüne alındığında, ilgili prosedürlerdeki bu basitleştirmenin kısa vadede uygulanması daha kolay görünmektedir. Diğer bir deyişle, ilgili prosedürlerdeki sadeleştirmelerin (örneğin, finansman elde etmek için sürelerin kısaltılması ve belgeleme prosedürleri vb.) kısa vadede uygulanmasının en azından politika etkinliklerini artırıcı bir sonuç getirebileceği düşünülmektedir. Ayrıca, katılımcıların üretim kısmında yer alan büyük bölümü detaylara girmeden ürünlerin ticarileştirilmesi aşamasına daha fazla önem verilmesi gerektiğine de dikkat çekmişlerdir. Her halükârda bu önerilerin kapsamlı bir Ar-Ge destek politikası revizyonu bağlamında değerlendirilmesi ve ilgili aktörlerle katılımcı bir ortamda tartışılması gerekmektedir.

Çok sektörü kapsayan (koordinasyon, temel sorumlu kurumun farklı sektörde olması vb.) konular olarak adlandırılabilecek bazı hususları gözlemledikten sonra, sektör uzmanlarının gözünde merkezi rol oynayan daha sektöre özgü konulara odaklanılmıştır. Bunların sıralaması yapılacak olursa, çalışma sonuçlarına göre 'düzenleyici çerçevenin mevcut yapısı' ilk sırada yer almaktadır. Düzenleyici çerçevenin çeşitli etkinsizliklere (rol çakışması, zaman kaybı vb.) yol açtığı görüşü kapsamında katılımcıların hemen hepsi kamu kurumlarında üst düzey görevlerde bulunan kişilerin aynı zamanda sektördeki büyük şirketlerde benzer konumlarda olmasını en önemli gösterge olarak sunmaktadırlar. Elbette bu ilgili pozisyonlardaki kişilere yönelik bir eleştiri olmayıp, sektör uzmanları (katılımcılar) teorik açıdan bunun düzenleyici çerçevenin en önemli ilkelerinden biriyle uyumsuz olduğunu ifade etmişlerdir. Ayrıca, mülakat sonuçlarına göre düzenleyici çerçevedeki aksaklıklar, detay bazda yapılan düzenlemelerin uygulama aşamalarında da birtakım problemlere yol açabilmektedir.

Bu kapsamda, tartışmanın ikinci bölümünde benzer görevlere sahip kamu kuruluşlarının varlığının sektörde verimsizliklere yol açtığı değerlendirmesi de ortak bir görüş olarak karşımıza çıkmaktadır. Bu tespitin kanıtı olarak katılımcılar, ilgili kuruluşların yöneticileri arasında bazen güç mücadelesini, bazen de riskten kaçınma davranışlarını gözlemlediklerini belirtmektedirler. Söz konusu nedenle bazı düzenleyici çalışmalar (projeler, sorunlar vb.) zamanında tamamlanamamakta, hatta hiç tamamlanamamakta ya da çözülmemektedir. Bu argümanlar tezin başka bir bulgusuna götürmektedir; benzer politika belgelerinin varlığı bir tür etkinsizliğe yol açmış ve (çoğu zaman) uygulama sonrası analiz eksikliği bu belgelerden beklenen faydaları azaltmıştır.

Genel anlamda, katılımcılar benzer politika belgelerinin varlığını büyük bir sorun olarak görmemekle birlikte uygulama safhasında, ilgili kurumların üstlerine düşen konuları tam olarak takip etmemesi ve uygulama dönemlerinden sonra gerekli değerlendirmelerin (genellikle) yapılmadığı konusunda çoğunlukla benzer görüşler belirtmişlerdir. Bununla yakından bağlantılı olarak katılımcılar, düzenleyici etki analizinin faydalı olduğunu düşünmekte ve bu tür değerlendirme çalışmalarının daha kapsamlı kullanımını görmek istediklerini ifade etmektedirler. Buna göre, düzenlemelerin olası maliyet ve faydalarını değerlendirmek için kamuya açık düzenleyici etki analizlerinin sayısının ve kapsamının artırılması gerektiği mütalaa edilmektedir.

Bu bağlamda ilgili bir diğer konu da küçük oyuncuların (firmaların) kamu yetkililerine ulaşmakta zorluk yaşadıklarının gözlemlenmesidir. Nitekim katılımcılar (özellikle hizmet segmentinde), özellikle son yıllarda düzenleyici otoriteyle toplantılar veya yazılı belgeler yoluyla etkili bir şekilde iletişim kuramadıkları hususunu vurgulayarak, bu konularda iyileştirmenin, tüm sektör açısından fayda sağlayacağını dile getirmişlerdir. Büyük işletmecilerin çoğunun devletin kontrolünde olduğu dikkate alındığında bu sorun gerçekte daha da önem kazanmaktadır. Tüm bu gözlem ve açıklamaların mantıksal bir uzantısı olarak uzmanların büyük bölümü, daha katılımcı bir kurumsal çerçevenin oluşturulabilmesi için kamu kurumları ile sektörel dernekler, sivil toplum kuruluşları arasındaki etkileşimlerin artırılması gerektiği önerisini desteklemektedir.

Daha spesifik (düzenleyici) araçlara gelince, politika belgelerinden tespit edilen bir diğer bulgu lokal bazlı düzenlemelerin (yani bölgesel bazda düzenlemelerin), farklı bölgesel ihtiyaç ve gereksinimlere göre uyarlanmış hizmetler sağlayarak pazar rekabetini ve tüketici refahını artırabileceğini belirtmektedir. Ancak bu öneri katılımcılardan çok destek bulmamıştır. Sadece bazı katılımcılar, ilgili mevzuatın açık bir şekilde hazırlanması ve buna göre uygulanması durumunda bunun faydalı olabileceğini düşünmektedir.

Konuyu tartışanların büyük çoğunluğu bu farklılaştırmanın gerekli olmadığını, düzenlemeler şeffaf ve tarafsız bir şekilde uygulandığı sürece bu düzenleme aracına ihtiyaç olmadığını değerlendirmişlerdir. Sonuç olarak hem katılımcılar hem de diğer sektör uzmanları tarafından bu düzenlemeye yönelik önemli oranda destek ve/veya talebin olmadığı gibi diğer röportajlarda, dergi makalelerinde vb. konuyla ilgili bir beyanın bulunmadığı da tespit edilmiştir.

Ancak her durumda, politika yapıcılar, bu aracın neden çeşitli strateji belgelerinde (örneğin, Ulusal Genişbant Strateji Eylem Planı) yer aldığı ve sonuçta uygulanmamasının nedeni hakkında kamuoyunu bilgilendirmelidir.

Öte yandan, tezde vurgulanan diğer bir konuyu oluşturan dijital uçurumun kapatılmasına (azaltılmasına) yönelik metinde tartışılan bir diğer spesifik ancak önemli konu da evrensel hizmet politikalarının kullanılmasıdır. Hatta (telekomünikasyon erişim ve yaygınlığı) alanında gelişmiş ülkelerin bile bu politikaları (özellikle) evrensel hizmet fonlarından yararlanarak yaygın biçimde uyguladıkları müşahede edilmiştir. Türkiye'de bu tür politikaları benimsemiştir ancak asıl sorun, ilgili fonun nispeten şeffaf olmayan kullanımı ve uygulama kapsamına ilişkin ayrıntılı bilginin (mevcut) olmamasıdır. Bu bağlamda katılımcıların çoğunluğu bu fonun daha şeffaf kullanımının ve kapsamın genişletilmesinin ülkedeki daha iyi evrensel hizmet politikaları için kritik olduğunu düşünmektedir.

Yenilik sistemleri yaklaşımı çerçevesinde çeşitliliğin (alternatiflerin) önemli olduğu varsayımına benzer şekilde, telekomünikasyon pazarlarında da farklı erişim teknolojilerinin varlığının rekabetin artması ve dolayısıyla tüketici refahı açısından faydalı olduğu kabul edilmektedir.

Çalışmada yapılan incelemeler kapsamında, alternatif erişim ağlarının ülkede yaygın kapsama alanına sahip olmadığı ve ancak 4.5G'nin devreye girmesiyle mobil ağların daha yeterli (hala fiber erişime göre çok düşük) veri hızları sunmaya başladığı görülmektedir.

Bu arka plan çerçevesinde, politika yapıcılar ülkedeki Kablo TV ağının hem erişimini (yani kapsama alanını) hem de kalitesini (hız, teknolojik yenileme vb.) artırmaya çalışmışlardır. Çalışmada politika hedefleri ve sektörel birliklerin bu konudaki önerileri de dahil olmak üzere bazı temel konular analiz edilmektedir. Tüm bu çabalara rağmen sonuç tatmin edici olmayıp, bu ağ şu anda ülkenin sabit telekom ağına önemli bir alternatif oluşturmamaktadır. Buna göre katılımcılar, bu ağı genişletmeye yönelik düzenlemelerin (örneğin, alternatif özelleştirme yöntemleri, erişim düzenlemeleri vb.) uygulanmamasının, piyasa rekabeti ve erişim kapsamındaki yetersiz gelişmenin nedenleri arasında görülebileceğini değerlendirmektedir. Yapısal sorunların (çıkar çatışması, bağımsızlık, organizasyonel verimsizlikler vb.) yanı sıra, 'fiber şebekenin yetersiz kapsama alanı' katılımcılar tarafından en çok tartışılan (sektörün) sorunlarından biridir. Ankete katılanların büyük çoğunluğu, pozisyonları ne olursa olsun sorunu kabul etmiş ve 5G teknolojisine geçmeden önce yatırım oranının ciddi oranda arttırılması gerektiğini düşünmektedir.

Bu çerçevede, fibere dönüşüm oranı (hızı) artırılmadığı sürece internet erişim kalitesinde ciddi bir gelişme olmayacağı ve teknik açıdan 5G'den beklenen faydaların (istenilen ölçüde) elde edilemeyeceği de anlaşılmaktadır.

Uluslararası karşılaştırmalar ve diğer çok sayıda kaynak (örneğin, operatörlerin CEO'ları ile yapılan röportajlar ve dergi makaleleri) ile birleştirildiğinde, yetersiz fiber kapsama alanının (altyapı) hız, gecikme ve kullanıcı deneyimi açısından iletişim hizmetlerinin performansını engelleyen büyük bir sorun teşkil ettiği görülmektedir.

Ayrıca katılımcılar, mobil ağların (etkinliğinin) özellikle omurga kısmında yüksek fiber kapasitesine bağlı olması nedeniyle, 5G'nin uygulamaya geçmesine kadar herhangi bir ilerleme kaydedilmemesi durumunda sorunun daha kritik hale geleceğini belirtmektedir.

5G'ye geçiş koşullarıyla ilgili bazı konuları ele aldıktan sonra teknolojinin pazara tanıtım aşamasına geçmek uygun olabilir. Bu noktada katılımcılar, sektördeki mobil operatör sayısında herhangi bir değişiklik olmayacağı konusunda hemfikir olmuşlardır.

Bununla birlikte, yeni teknolojinin devreye girmesinden sonra yeni fırsatlar (pazara giriş alternatifleri anlamında) olduğu da ifade edilmektedir.

Ancak, söz konusu alternatiflerin (girişimcilik faaliyetleri) gerçekleştirilebilmesi için kamu otoritelerinin (özellikle BTK) lisanslama sürecinden itibaren daha etkin düzenlemeleri hayata geçirmesi ve bunların uygulamadaki süreçlerini takip etmesi gerektiği, tarihsel gelişimden de görüleceği üzere, değerlendirilmesi de yapılmaktadır.

Sektörün diğer tarafına (yüzüne) bakıldığında, tez çalışmasında detaylı olarak incelendiği gibi özellikle gelişmiş ülkelerin telekomünikasyon ağ ekipmanı üretme çabalarını artırdıkları veya en azından daha güvenilir ortak ülkeleri kullanmaya çalıştıkları (çalışmada) anlaşılmaktadır. Ayrıca, 5G teknolojisiyle birlikte kullanım alanları giderek artan dikey sektör uygulamaları güvenilir ekipman kullanımının, siber güvenliğin ve dijital tehditlere karşı önlemlerin kritik pozisyonunu daha da ön plana çıkarmaktadır.

Bu ekonomik ve güvenlik hususları (siber güvenlik vb.), ülkemiz telekomünikasyon sektöründe de vurgulanmaya başlanmış ve kamu otoritesi (politika yapıcılar) özellikle 3G teknolojisinin kullanım sürecinden itibaren Ar-Ge ve yerli-milli üretim kapasitesinin artırılması amacıyla çeşitli politikaları geliştirip, uygulamaya koymuşlardır.

Anılan tarihten bu yana söz konusu hususlarda bir miktar ilerleme kaydedilse de araştırma sonuçlarına göre gelinen nokta tatmin edici olmaktan uzaktır ve denetimden yerli malı temini prosedürüne kadar uygulama detaylarında çeşitli problemler, sorunlar yaşanmaktadır.

Bununla birlikte, konuyla ilgili soruları yanıtlayan görüşmecilerin tamamının, önümüzdeki 5G spektrum ihalelerinde yerli mal alım yükümlülüklerinin daha sıkı koşullarla devam etmesini istediği anlaşılmaktadır.

Ayrıca bu düzenlemenin şeffaf bir şekilde uygulanmasının ve kamuoyunun bilgilendirilmesinin gerekliliği (şeffaflık, takip edilebilirlik, bilgilendirme) konusunda hemfikirdirler.

Kaynakların kıt olduğu, yeteneklerin sınırlı olduğu dünyada, bir diğer soru da ilgili ekipmanların milli ve yerli üretiminin kapsamıdır. Çalışma, küresel tedarikçiler ile yerli firmalar arasındaki mevcut kaynaklar ve teknolojik yetenekler (ör. Ar-Ge bütçeleri, patent sayıları vb.) arasındaki farkı göstermektedir. Buna göre tüm segmentlerde rekabet hedeflerini belirlemek gerçekçi olmayabilir. Bunu takiben katılımcılar, 5G ağının tüm bileşenlerini üretmeyi hedeflemek yerine önceliklendirmeyi ve belirli ürün gruplarına odaklanmayı tercih etmektedirler.

Çalışmada önceliklendirmeden kastedilen, kamu desteğinin yönlendirilmesi, yani araştırmaya rehberlik edilmesi ve kamu fonlarının seçici kullanılmasıdır.

Benzer bir konu da (yerli üretim desteği kapsamında) kamu alım politikalarının kullanılması ve proje desteklerinde KOBİ'lere ayrıcalıklı davranılmasıdır. Tüm

BİT sektöründe öncü kullanıcı olarak devletin rolü, ulusal firmaların ürünlerinin ticarileşmesine yardımcı olmak, ürün geliştirmede deneyim kazanmak vb. gibi çeşitli yönlerden desteklemek açısından kuşkusuz kritik öneme sahiptir. Katılımcılar ayrıca, bazı çekincelerle birlikte, yerli üretim yeteneklerinin artırılması için kamu alımlarına ve yerli firmalar tarafından geliştirilen kullanım senaryolarının benimsenmesine öncelik verilmesi gerektiği bulgusuna da katılmaktadırlar. Bu politika aracı aslında çoğu politik belgelerinde olmasına ve politika yapıcıları tarafından kullanılmasına rağmen, uygulama aşamasında bu vurgu her zaman görülememektedir. Diğer bir deyişle, ilgili politika araçları (özellikle kamu alımları) uzun süredir politika yapıcıların gündeminde olmasına rağmen hem katılımcıların hem de sektör uzmanlarının uygulamada tespit ettikleri sorunlar, problemler bulunmaktadır. Aslında bu sorunları tüm bilişim sektörüne de genellemek mümkündür. Örnek olarak TÜBİTAK tarafından milli bir işletim sistemi (Pardus) geliştirmekle birlikte, bunun kullanımı kamu kurumlarında dahi oldukça sınırlı kalmıştır ve bu tip örnekleri artırmak mümkündür. Aynı eleştiriler, küresel bir satıcının ürünlerinin yanı sıra diğer yerli ürünlerin daha düşük miktarlarda satın alındığı evrensel hizmet fonundan temel telekom ekipmanlarının temin edilmesine yöneltilebilecektir. Bu noktada, kamu alım politikalarının etkinliğinin artırılması isteniyorsa, buradan tamamen yerli-milli ürün ve üreticilerin desteklenmesinin sağlanması gerektiği değerlendirilmektedir.

Son olarak, bazı katılımcılardan ve diğer yazılı kaynaklardan, sektörde farklı türde firmaların bulunmasının kıt kaynakların verimsiz kullanılmasına yol açtığı yönünde bazı eleştirilerin olduğu gözlemlenmiştir. Daha detay bir ifadeyle, KOBİ temsilcileri (kamu mülkiyetinin olduğu) ULAK ve sektördeki operatör bağlantılı teknoloji firmalarının da aynı kategoride (özellikle proje destek finansmanında) ele alınmasından şikayetçidirler. Bunun dışında bazı katılımcılar, ULAK'ın özellikle büyük projelerde öncü rol oynadığına dikkat çekerek, sektörel yeteneklerin geliştirilmesinde bunun faydalı olduğunu değerlendirmişlerdir. Buna göre, benzer ancak mülkiyet açısından farklı kuruluşların (örneğin. KOBİ'ler, büyük operatör bağlantılı ve savunma sanayi-kamu sermayeli firma) bir arada bulunmasının sektörde bazı sorunlara yol açtığı yönündeki ifadeye tüm açılardan destek verilmemektedir. Ancak, tekrar etmek gerekirse, politika yapıcılarının özellikle destekleme (finansal vb.) süreçlerinde küçük ölçekli firmaları ayrı bir kategoride ele almasının sektörel gelişim için daha etkin sonuçları mümkün kılabileceği mütalaa edilmektedir.

Söz konusu değerlendirmeler son bölümde bazı politika önerileriyle birlikte verilmiştir. Bunlara kısaca değinmek gerekirse, varılan sonuçlar kapsamında ülkemizde nispeten başarısız bir telekomünikasyon liberalizasyon-deregülasyon süreci olduğu tespiti yapılmaktadır. Gelinen aşamada düzenleyici kurumun sektördeki işletmecilerin tümüne karşı tarafsız kalması önünde engeller olduğu ve bu durumla birlikte diğer iyi yönetişim ilkelerine daha fazla vurgu yapılmasının sektörel politikaların istenilen sonuçlara ulaşabilmesi için gerekli olduğu sonucuna varılmıştır. Diğer bir deyişle, düzenleyici politikaların oluşturulması ve yürütülmesi aşamasında şeffaflık, hesap verilebilirlik ve katılımcılık gibi hususlara daha fazla önem verilmesi ihtiyacı üzerinde durulmuştur.

Söz konusu hususlara bağlı olarak, düzenleyici politikaların daha etkin bir şekilde yürütülemediği de görülmektedir. Örneğin, bir strateji belgesinde yer alan politika önerisinin belirlenen zaman içerisinde gerçekleştirilmediği, bunun bir açıklaması, gerekçesi ortaya konulamadan başka bir belgede daha bu konuya yer verildiği ama yine hayata geçirilemediği de görülmektedir. Bu noktada, strateji dokümanları ve benzer belgelerin faaliyet dönemlerinde kamuya açık bir şekilde izlenmesi ve dönem sonunda gerçekleştirme, performans değerlendirmelerinin de kamuoyuna açık bir şekilde verilmesi önem taşımaktadır. Aynı durum, düzenleyici etki analizleri içinde geçerlidir.

Öte yandan, yenilik sisteminde benzer görevleri paylaşan farklı kurumların bulunduğu bunun da çeşitli etkinsizliklere yol açabildiği (örneğin zaman kayıpları, muhatap bulamama vb.) mülakatlar sonucunda gözlemlenen hususlardan diğerini oluşturmaktadır.

Söz konusu gözlemler ışığında, çalışma alternatif organizasyonel yapılandırma önerilerinde bulunmaktadır. Ancak, tüm bu hususlar ötesinde tüm düzenleme çalışmalarında (yukarıda belirtildiği gibi) şeffaflık, izlenebilirlik, hesap verilebilirlik ve katılımcı karar alma mekanizmalarının daha fazla ön plana çıkarılmasının gerekli olduğu değerlendirilmektedir.

Bu temel hususların yanısıra, daha spesifik sektörel sorunlar ve düzenlemelerde karşılaşılan zorluklarla ilgili de analizler yapılmıştır. Öncelikle sektördeki rekabetin yeterince gelişmediği ve bununda tüketici refahı üzerinde olumsuz etkileri olduğu tespiti yapılmaktadır. Sektörde rekabeti artırıcı politikaların etkin bir şekilde yürütülemediği de bazı örnekler ışığında genel kabul görmektedir.

Örneğin, internet erişim hizmetlerinde bir alternatif oluşturabilecek ve dolayısıyla rekabeti artırarak, tüketici refahı üzerinde olumlu etkiler getirebilecek kablo TV şebekesinin geliştirilmesi yönteminin yeterince etkin bir şekilde kullanılamadığı ve kapsama alanının oldukça kısıtlı kaldığı görülmektedir. Gelinen aşamada gecikilen zamanı (maliyet unsuru) da dikkate aldığımızda, bu konunun sektör aktörleri nezdinde birinci derecede önemini kaybettiği anlaşılmaktadır. Bu bağlamda diğer bazı konulara da yer verilerek, çeşitli politika önerilerine yer verilmektedir. Bunlar içerisinde en önemlilerden birini fiber telekomünikasyon şebekesinin kapsama alanı yetersizliği sorunu oluşturmaktadır. Konu tarihsel gelişim süreci içerisinde ele alındığında ortak altyapı şirketi kurulumu dahil birçok politika tedbiri ve projenin ele alındığı ama bunların etkin bir şekilde yürütülemediği de anlaşılmaktadır. Ancak, 5G ye geçiş arifesinde fiber bağlantılara olan ihtiyaç göz önüne alınarak benzer projelerin daha katılımcı ve gerekli taahhütlerin yapılarak tekrar değerlendirilmesi önem arz etmektedir. Aynı şekilde katılımcılar tarafından sektör aktörlerinin yatırım sürecinde karşılaştıkları zorlukların bir kısmının devam ettiği ifade edilmektedir.

Bu tip benzer sorunların ilgili bakanlık ve düzenleyici kurum tarafından öncelikli olarak ele alınarak, kalıcı çözümlerin oluşturulması, yatırım etkinliğini artırıcı fayda sağlayacaktır.

Konunun diğer tarafını oluşturmakla birlikte, benzer şekilde, aynı ihtiyaç telekom ekipman üretim kısmında da gözlemlenmektedir. Sektörün üretim kapasitesinin artırılması amacıyla yürütülen politikalar belirli bir aşamaya gelmiş olsa da 5G ye geçiş öncesinde bu yetkinlik ve ölçek ekonomilerinin geliştirilmesi ihtiyacı devam etmektedir.

Bu çerçevede, diğer düzenleyici çalışmaların yanısıra, özellikle fiber şebeke kapsamının genişletilmesi, altyapı yatırım süreçlerinin iyileştirilmesi ve diğer tarafta üretim kabiliyetlerinin geliştirilebilmesi için 5G ye geçiş için ‘bir geçiş sürecine’ ihtiyaç olduğu değerlendirilmektedir. Ancak bu sürecin etkin bir şekilde değerlendirilmesi, vakit kaybedilmeden ve şeffaf bir şekilde yürütülmesi gerekmektedir. Aksi takdirde gerekli düzenlemeler (geçiş için) belirli bir süre olsa bile yapılamadığı için 5G teknolojisinden beklenen faydalar tam olarak elde edilemeyecek ve üstelik mevcut sektörel sorunlar bu aşamaya da taşınmış olacaktır.

Bu hazırlık aşamasını müteakiben, 5G ye geçiş aşamasında en önemli konuyu oluşturan lisans ihaleleri hususu da çalışma kapsamında değerlendirilmiştir. Bu ihaleler kapsamında, 5G teknolojisinin getireceği fırsatların ele alınması gerekmektedir. Düzenleyici kurum zaten diğer ihaleler kapsamında edindiği tecrübeleri bu ihaleye de yansıtacak ve gerekli kapsama, hizmet kalitesi gibi unsurlara yer verecektir. Bu noktada 5G teknolojisinin daha etkin hale getirebileceği alternatif hizmetlerin küçük işletmecilerce verilebilmesini temin edici hususlara yer verilebileceği mütalaa edilmektedir.

Ayrıca, bu yeni teknolojiyle birlikte daha etkin spektrum kullanımı yöntemleri söz konusu olabilmektedir. Örneğin, spektrumun ortak kullanımı, spektrum ticaretinin mümkün hale getirilmesi ve özellikle sektörel bazdaki uygulamalar için spektrum tahsisi gibi yenilikçi uygulamaların politika yapıcılar tarafından kullanılması uygun olacaktır.

Bu şekilde bir yaklaşım, ilgili piyasada çeşitlilik ve alternatiflerin artmasına yardımcı olabilecek ve belirli bir dinamizm de getirebilecektir.

Son olarak üzerinde durulması önem taşıyan diğer bir hususu da evrensel hizmet konusu oluşturmaktadır. Çalışmada yer verildiği üzere, birçok ülkede bu tür politikalar kullanılarak ilgili hizmetlere erişim ve kullanım güçlüğü çeken kesimlerin ihtiyaçlarının giderilmesi üzerinde durulmaktadır.

Sayısal uçurum adı verilen bu eşitsizliklerin en aza indirilmesi ve dijital dönüşümün büyük boyutlara ulaştığı günümüz dünyasında bu politikaların kapsamının daha da genişletilerek uygulanması gerekmektedir.

Benzer politikalar ülkemizde de olmakla birlikte, kullanım alanı kısıtlı kalmış ve yürütme aşamasında gerekli şeffaflığın sağlanamadığı gözlemleri yapılmıştır.

Bu çerçevede, yeni ortaya çıkan ve teknolojinin gelişimi ile birlikte değişen kullanıcı ihtiyaçları çerçevesinde söz konusu politikaların revize edilmesi ve ilgili fonun kullanımının daha fazla gözlemlenebilir bir şekilde yapılmasının fayda sağlayacağı değerlendirilmektedir.

Diğer taraftan, söz konusu fon kullanılarak yapılan/yapılacak ekipman alımlarında da yerli ürün kullanımına azami önem verilmesinin, yerli üreticilere olan desteği artırıcı bir etki yapacağı görülmektedir.

Benzer şekilde, 5G ile söz konusu olabilecek dikey sektör uygulamalarında azami ölçüde yerli kaynakların kullanımı hem güvenlik endişelerini en aza indirebilecek hem de yerli üreticiye ürünlerini ticarileştirme ve gerekli referansları elde edebilmesi açılarından destek sağlayacaktır.

Son olarak, tekrar belirtmek gerekirse, politika yapıcıların 5G ihaleleri öncesi gerekli hazırlıkları tamamlamaları elzemdir. Bunun aynı zamanda sektör aktörlerine, daha katılımcı ve şeffaf bir düzenleyici ortamın oluşturulması koşuluyla, piyasanın sürdürülebilir gelişimi engelleyen sorunların çoğunu çözme ve/veya en aza indirme fırsatını da vereceği değerlendirilmektedir.

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