AN ASSESSMENT OF LOCALIZATION POLICIES IN TURKEY: THE CASE OF MOBILE TELECOMMUNICATION SECTOR

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ABSTRACT

AN ASSESSMENT OF LOCALIZATION POLICIES IN TURKEY: THE CASE OF MOBILE TELECOMMUNICATION SECTOR

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The primary purpose of this thesis is to evaluate Turkey's innovation policies in the mobile telecommunications sector. A limited number of global companies produce mobile telecommunication technologies. These companies dominate the infrastructure market. Policymakers in Turkey have set domestic production in the electronic communications sector as a target in many strategy documents. ULAK company was established, and HTK, which hosts approximately 150 companies, has formed for production in the industry. On the other hand, mobile operators are obliged to purchase domestic goods with concession and authorization documents.

This thesis defines an innovation system by consolidating the stated policies. What are the drivers and barriers in the system is the main research question of this thesis. For the research, semi-structured interviews, secondary data sources, and document analysis methods were preferred. The findings obtained as a result of the research were classified on a functional basis.

Finally, the policymakers underline the domestic production targets for both 5G and subsequent generations in many policy documents. This thesis proposes relevant policy instruments to overcome policy barriers based on the findings.

Keywords: Mobile Telecommunications Technologies, Localization, Technological Innovation System, Turkey

ÖZ

TÜRKİYE'DE YERELLEŞTİRME POLİTİKALARININ BİR DEĞERLENDİRMESİ: MOBİL TELEKOMÜNİKASYON SEKTÖRÜ ÖRNEĞİ

ACAR, Musa
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Bu tezin temel amacı, Türkiye'nin mobil telekomünikasyon sektöründeki inovasyon politikalarını değerlendirmektir. Sınırlı sayıda küresel şirket, mobil telekomünikasyon teknolojileri üretmektedir. Bu şirketler altyapı pazarına hâkim durumdadır. Türkiye'deki politika yapıcılar birçok strateji belgesinde elektronik haberleşme sektöründe yerli üretimi hedef olarak belirlemişlerdir. ULAK firması kurulmuş ve yaklaşık 150 firmaya ev sahipliği yapan HTK, sektörde üretim yapmak üzere oluşmuştur. Öte yandan, mobil operatörler imtiyaz ve yetki belgeleri ile yerli malı satın almakla yükümlüdür.

Bu tez, belirtilen politikaları konsolide ederek bir inovasyon sistemini tanımlar. Sistemdeki itici güçlerin ve engellerin neler olduğu bu tezin temel araştırma sorusudur. Araştırma için yarı yapılandırılmış görüşmeler, ikincil veri kaynakları ve doküman inceleme yöntemleri tercih edilmiştir. Araştırma sonucunda elde edilen bulgular işlevsel olarak sınıflandırılmıştır.

Son olarak, politika yapıcılar birçok politika belgesinde hem 5G hem de sonraki nesiller için yerli üretim hedeflerinin altını çiziyor. Bu tez, bulgulara dayalı olarak politika engellerinin üstesinden gelmek için ilgili politika araçlarını önermektedir.

Anahtar Kelimeler: Mobil Telekomünikasyon Teknolojileri, Yerelleştirme, Teknolojik İnovasyon Sistemi, Türkiye

To my family

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LIST OF ABBREVIATIONS

B2B: Business to Business

ETSI: European Telecommunications Standards Committee

EU: European Union

GDP: Gross Domestic Product

GPRS: General Packet Radio Service

GPS: Global Positioning System

GSM: Global Technologies for Mobile

GSMA: Global System for Mobile Communications

GTENT: Global Telekom ve Entegre Teknolojiler A.Ş

HTK: Communication Technologies Cluster

ICT: Information and Communication Technologies

ICTA: Information and Communication Technologies Authority

IoT: Internet of Things

ITU: International Telecommunication Union

KOSGEB: Small and Medium Enterprises Development Organization

LTE: Long-Term Evolution

M2M: Machine-to-Machine Communication

METU: Middle East Technical University

NIS: National Innovation System

NSTIS: The National Science, Technology, and Innovation Strategy

ONF: Open Network Foundation

PSTN: Public Switch Telephone Network

PTT: Post and Telegraph Administration

R&D: Research and Development

RIS: Regional Innovation System

SME: Small and Medium Enterprises

TD-SCDMA: Time Division Synchronous Code Division Multiple Access

TEYTEB: Technology and Innovation Support Programs Presidency

TIS: Technological Innovation System

TL: Turkish Lira

TOBB: Union of Chambers and Commodity Exchanges of Turkey

TRL: Technology Readiness Level

TUBITAK: Scientific and Technological Research Council of Turkey

TURKSTAT: Turkish Statistical Institute

TUSIAD: Turkish Industry & Business Association

ULAK: ULAK HABERLEŞME A.Ş.

UPS: Universal Service Project

US: United States

UUYM5G: End-to-End Domestic and National 5G Project

WIPO: World Intellectual Property Organization

YÖK: Higher Education Institution

CHAPTER 1

INTRODUCTION

1.1. Aim of the Study

Mobile telecommunications services serve more than 8 billion unique subscribers worldwide (World Bank, n.d.). This technology provides essential benefits in many fields, from production to consumption, from social relations to media and education, etc. Moreover, it has an extensive infrastructure network worldwide; there is no country in the world that does not have a mobile telecommunication technology infrastructure. Although it is such a widespread technology, only a limited number of global manufacturers can produce infrastructure products and services which are categorized as high technology. Throughout the history of telecommunications, the leading suppliers have been a few European-based and Chinese companies that have made a breakthrough in the last few decades and have taken a large part of the market share in the mobile telecommunications infrastructure market.

On the other hand, Turkey carries out specific policies in order to be a producer in the mobile telecommunications sector, considering many factors such as cyber security and economic concerns. The primary purposes of these policies are to establish an innovation ecosystem and to create a product portfolio. This thesis aims to reveal the strengths and shortcomings of the Turkish approach by analyzing the relevant policies and structure (i.e., actors, institutions, interactions, and infrastructure). Analysis for the thesis will be conducted within the scope of the Functional - Structural Analysis Framework of Wieczorek and Hekkert (2012). This analysis targets the policy recommendations for further innovation policies in the telecommunication sector.

1.2. Backround of the Study

Telecommunication is generally considered a component of information and communication technologies (ICT). International Telecommunication Union (ITU) defines telecommunication as transmitting, disseminating, or receiving any sign, signal, text, image, sound, or intelligence over wired and wireless systems (ITU, 2012). The concept corresponds to the infrastructure part of the ICT. This infrastructure increases the circulation of information and reduces communication and transaction costs. Advances in satellite, optical fiber and mobile technology, the Internet, and the World Wide Web have greatly improved the concept of communication (Lam and Shiu, 2010). The increased accessibility of information and data and their faster dissemination by the infrastructure have created the idea of the information society. In short, the concept of telecommunication has been indispensable for centuries.

In the course of history, countries have invested heavily in telecommunication infrastructure. These investments, which started with postal and telegraph services in the past, also changed with the advancement of technology. Public Switch Telephone Network (PSTN), Broadband, and Fiber technologies have emerged as breakthrough technologies. For the last few decades, telecommunication infrastructures have concentrated on mobile communication technologies. Mobile communications use wireless and cellular technology that eliminate fixed points for communication. Currently, mobile technology allows sharing of voice, data, and applications (mobile applications) with internet-enabled devices such as smartphones, tablets, and watches (IBM, n.d.).

Along with these advancements, mobile technology is also used in many areas such as production, distribution, and marketing. According to the World Bank's data, mobile cellular subscriber penetration in the world is at 109% as of 2019 (World Bank, n.d.). This widespread use of mobile communications globally summarizes the trend in the telecommunications industry in general.

Moreover, Turkey has followed the global trend, making these tendencies in the telecommunication and mobile communications industry the sector's main drivers. The mobile subscription penetration rate in Turkey is around 98%, according to the report published by the public institution of Information and Communication Technologies Authority (ICTA) which regulates the telecommunications sector. This penetration rate is slightly below the world average. However, according to data from the World Bank, the penetration rate of mobile subscribers in Turkey has been increasing.

The network and infrastructure investments in mobile telecommunication technologies turn the industry into a vast production ecosystem. High-tech mobile communication equipment for telecommunication infrastructure; including cable, fiber, and batteries, creates a considerable product portfolio in this area and, consequently, a production ecosystem. A fundamental issue is whether a country's industry is sufficient to meet this wide range of product ecosystems. Moreover, telecommunications investments yield much more profit than the production ecosystem created only for its products and services (Markova, 2009). The investments create externalities and new sectors, and promote existing ones.

Therefore, Turkey has made a substantial investment in the sector, providing services for the whole population in the country. As of 2021, Turkey's total investment in mobile telecommunications infrastructure is more than 10 billion TL[1]. A large part of the production for the mobile communication sector in the country is driven by international companies such as Huawei, Ericsson, and Nokia. Turkey has provided the necessary products and services to the telecommunications sector through international suppliers and imports due to the absence of local production in the industry.

The product portfolio for mobile communication technologies is categorized as high technology products such as software and hardware. Therefore, Turkey has laid out specific plans and implemented certain policies to develop an innovative ecosystem and diminish import rates in the sector. The National Science, Technology, and

[1] https://www.btk.gov.tr/uploads/pages/pazar-verileri/2021-4-pazar-verileri-raporu.pdf

Innovation Strategy (NSTIS) 2011-2016 by the Supreme Council for Science and Technology includes meaningful action to prepare a strategy document in ICT and software areas. In this sense, research, development, the realization of systems to be used in 4G Mobile Communication infrastructure, and transferring technology to the manufacturing industry are other essential issues for the program. With the TUBITAK TEYDEB 1511 Program, it was decided that projects related to the development of 4G system components in the field of Mobile Communication Technologies would be supported.[2]

ULAK HABERLEŞME A.Ş. (ULAK) was established in 2017 to carry out R&D and engineering activities for mobile and broadband communication systems used by commercial operators[3]. Moreover, OSTİM is an Organized Industrial Zone that has initiated the collaboration of the stakeholders in the communication technologies sector. ICTA also supports this collaboration as a public institution. This technology-based collaboration has been managed as Communication Technologies Cluster (HTK) since 2017. HTK aims to establish, collaborate, reinforce, and contribute to domestic and national development in the economy and industry. The primary goals are to meet the needs of the sector, to compete in international markets, to commercialize the knowledge developed by universities in this regard, to meet the needs of operators providing services in the industry with hardware, software, and material manufacturers, and to bring together the stakeholders in the communication technologies sector.[4] ULAK and HTK are essential elements of national innovation policies to enhance innovative activities and commercialize these activities in Turkey. Although ULAK and HTK are separate legal entities, they are involved in publicly supported projects in infrastructure works for the mobile telecommunications sector. The mobile operators and the mobile telecommunication infrastructure market consumers have specific investment obligations to support these policies. Mobile operators must make at least 45% of in-scope purchases (including high-technological productions) from domestic productions. 10% percent of in-scope purchases must be

[2] https://www.tubitak.gov.tr/sites/default/files/btyk28_gelismeler.pdf

[3] [1] https://www.ulakhaberlesme.com.tr/index.php/tr/hakkimizda/sirket-profili

[4] http://www.htk.org.tr/haberlesme-teknolojileri-kumelenmesi-icerik-7

made from SME productions. These obligations are regulated within the framework of the audits carried out by ICTA. There is also an indirect obligation imposed on global manufacturers through consumers. Mobile operators are obligated to make at least %40 percent of in-scope purchases from companies with R&D centers to establish and develop R&D projects in Turkey. These R&D centers have to employ at least 500 engineers and 250 researchers. This indirect obligation affects global vendors in the sector, such as Huawei, Ericsson, and Nokia. They must fulfill these obligations to carry out their commercial activities in Turkey.

In addition, localization policies are also being initiated for 5G. The creation of national technology initiatives and technology platforms are fostered to establish national consortia in order to strengthen participation in possible Horizon 2020 projects. [5] 5G TR Forum is one of the examples of those national initiatives. It aims to ensure the development of indigenous services and technologies that will take place in the infrastructure markets in 5G and beyond new generation communication systems.[6] Moreover, the "End-to-End Domestic and National 5G Network Project" was initiated by HTK with the support of ICTA, OSTİM and TÜBITAK (Şengül et al., 2020). The R&D process of fundamental infrastructure pieces of equipment of 5G networks, 5G new radio, core network, network management system, radio-link, etc., has been initiated by local firms. [7]The target is to reduce the dependency of 5G technology on global suppliers and to use domestic resources in mobile telecommunication infrastructures together with 5G. Therefore, the policies and obligations will be implemented in further telecommunications technologies in the sector.

1.3. Research Question

The innovation policies and sector obligations are the main instruments for the localization policies in Turkey. This thesis will discuss the innovation policies and

[5] https://era.gv.at/public/documents/4071/Turkish_National_Roadmap_on_European_Research_Area_May_2019.pdf

[6] https://5gtrforum.org.tr/hakkinda

[7] https://www.htk.org.tr/uctan-uca-yerli-ve-milli-5g-haberlesme-sebekesi-projesi-projesi-117

obligations in regards to the technology innovation system, which Carlsson and Stankiewicz define as *"network(s) of agents interacting in a particular technology area under a specific institutional infrastructure generate, diffuse, and utilize technology*." (Bergek, Hekkert, Jacobsson, 2008).

According to this system approach, this thesis describes a network for the mobile telecommunications industry. The actors in the sector's policy maker, manufacturers, and consumer roles are established. Norms, regulations, obligations, and policies in the mobile telecommunications sector are the other components of the system. The structure and the set of key processes called "functions" within the system will be identified. The critical contribution of this thesis to the literature is that it defines a system for the mobile telecommunication sector in Turkey and determines the components of this system.

Moreover, this thesis develops a mixed method to evaluate the system's functions. Semi-structured interviews are the primary data sources for collecting data. Secondary data and document analysis support this method. In addition, this thesis is based on the hypothesis that the production capability and capacity obtained as a result of innovation policies are insufficient to meet the needs of consumers. This hypothesis assumes that although the system has well-functioning policies, there are technical and commercially blocking mechanisms in providing domestic supply. In this sense, the hypothesis of the thesis will be tested with the developed method.

The content of the method is the policies and obligations in the sector, both mentioned in the previous section and explained in detail in the following chapters. The evaluation of the functions will also be carried out within the scope of the research question below;

What are the effective and deficit parts of localization policies for mobile telecommunication technologies in Turkey?

This thesis, based on this research question, consists of six chapters. In the first part, the purpose and basis of this study are given. In addition, the research question of this

study and its contribution to the literature are also briefly mentioned. The following part is a literature review on understanding the innovation system approach. This chapter includes a technological innovation system with a functional analysis. In the third part, telecommunication technologies and localization policies of different countries, both in the past and today, are discussed. This section details the policies implemented by Turkey. While the research methodology is included in another section, the findings obtained via this research constitute the fifth section of the thesis. In this section, the results are detailed according to a function-based distinction. Finally, the thesis concludes with a section on policy recommendations.

CHAPTER 2

LITERATURE REVIEW

Innovation and investments in technology are prerequisites for achieving competitiveness and progress and, through these, sustainable economic growth (Pece et al., 2015). Many empirical studies also prove this positive link between innovation and economic growth. For this reason, many countries carry out innovation policies to ensure economic development. The main goal of these policies is to reveal the most applicable structure and system for innovation.

Based on the subject mentioned above, this section will first discuss the definitions in the literature for the concept of innovation. Subsequently, it will explain the innovation system and its various iterations that are addressed. First, the geographical examination of national and regional innovation systems will be reviewed. Afterward, sectoral and technological innovation systems will be evaluated. This thesis examines the innovation systems on a functional basis. Briefly, the activities of the components in systems refer to functions (Bergek et al., 2008). It explains what happened in the system. There are six different functions subject to the function-based evaluation in question. In this chapter, these functions will be detailed. Afterwards, the assessment of the subject will be based on these functions.

2.1. The Concept of Innovation

The concept of innovation has been described several times in the literature as something new in many different forms. Along with various dictionaries, academics associate the concept of innovation with something new and the commercialization of this new thing. The commercialization of the new product and its effects on the

economy constitutes the core of the discussions on the concept of innovation. For example, the straightforward definition defines it as *"…the implementation of changes in production (…) [or] the introduction of new types of commodities on the market"* (Suranyi Unger, 1982). Additionally, Schumpeter defines innovation as the critical dimension of economic change (Ziemnowicz, 1942). The definition made by the OECD/Eurostat (2018) on this subject is clear and instructive: *"An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)."*

On the other hand, Freeman (1998) explains it from a different perspective: *"…the word is used both to indicate the date of the first introduction of a new product or process and to describe the whole process of taking an invention or set of inventions to the point of commercial introduction".* This perspective not only defines the innovations in different modes but emphasizes the processes related to these innovations.

Regardless of the varying definitions of innovation in different modes or as a process, the literature underlines the innovation system concept. The idea of an innovation system indicates that innovations are produced through interaction between entities or actors/agents and that innovations do not occur as isolated, discrete phenomena (Edquist, 1997). The innovation system examines the behavior and interaction of the actors within the system to produce and adopt innovations. The ultimate goal is the generation, diffusion, and adaptation of innovation. Initially, The National Political Economy System, List's main work as an economist in 1841, initiated discussions about the innovation system. List describes a system of innovation at the national level, emphasizing the state's role as a coordinating tool in the systematic interaction between nation, research, technology, learning, and innovation within this system (Jun et al., 2016). Many definitions of the innovation system have been derived from the discussions of the concepts initiated by List's explanation for the innovation system.

Lundvall (2010) defines the innovation system within a comprehensive framework, including the interacting relationships and elements in producing, disseminating, and

using new and economically beneficial knowledge. He emphasizes that organizational structure and production structure are universal components in all innovation systems and underlines that specific definitions should be adjusted according to the processes examined (Andersson and Karlsson, 2004). According to Gregersen and Johnson's (1997) definition of the fundamental idea of systems of innovation, the overall innovation performance of an economy does not only depend on how specific organizations, such as firms and research institutes, perform. They also emphasize how components interact with each other and the government sector in producing and distributing knowledge. The interaction of actors and the government sector is included in the concept with a holistic understanding. Likewise, Christopher Freeman defines the innovation system as a network. Within this network are the activities and interactions of institutions in the public and private sectors that initiate, import, modify, and disseminate new technologies (Atkinson, 2014).

Other definitions of the innovation system in the literature contain elements similar to the explanations above. The innovation system can be briefly defined as a network that includes the activities and interaction of various actors for a specific purpose. In order to produce knowledge in innovation, an individual actor cannot perform the tasks alone. In the networks, there are many actors such as producers, consumers, universities, institutions, and organizations that provide economic resources, and public institutions that act as policymakers. In their pursuit of innovation, they interact with other organizations to gain, develop, and exchange various knowledge, information, and other resources (Edquist, 1997). This interaction can be established on a national, regional, and geographical basis, or it can be evaluated on a technological basis. Studies on innovation systems include the behavior of many actors in the network. The common ultimate goal of these networks is to ensure the production of innovation and its sustainability.

In this sense, the aforementioned holistic features and purpose of the systems approach are also compatible with the policies that are the subject of this thesis. Applied policies in the mobile telecommunication sector seem prone to occur within a system. The sector has particular actors, norms, regulations, and obligations. These components interact in accordance with the systems approach, and innovation processes are not

carried out in the sector in isolation. Moreover, performance analysis can be carried out for the policies implemented using the systems approach. In this sense, the systems approach can provide a set of guidelines, such as the importance of capacity building both in the business sector and in supporting research organizations, of encouraging inter-organizational links, and of encouraging continuous feedback between institutions engaged in research, development, engineering, and manufacturing (Dantas, 2008). Therefore, after the performance evaluation of the innovation policies in the sector, possible policy suggestions can be created by the system approach.

On the other hand, there are different innovation systems in the literature. The first of these is the National Innovation System (NIS), which includes institutions and organizations established or rooted in a nation-state. Many influential scholars have contributed to the modern literature on NIS. First of all, Freeman (1987) defines it as *"... the network of institutions in public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies".* Freeman defines the national innovation system concept in his examination of Japan's superiority in some industries and emphasizes the interaction between the activities that lead to advances in technology and the public and private institutions that make up the national system (Hsu & Chen, 2003). In addition, Lundvall (1992) introduced the concept of national innovation system as follows: *"...A system of innovation is constituted by the elements and relationships which interact in the production, diffusion, and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation-state"*. Ludvall's work on the concept emphasizes communication and interaction between actors. He states that this interaction between the actors in the system creates different kinds of "learning relationships" and that the feedback mechanism between the system content-actors is essential. On the other hand, Nelson made a study comparing the examples of many countries. In this context, the system is defined as *"...a set of institutions whose interactions determine the innovative performance...of national firms"* (Nelson, 1993).

Secondly, the regional innovation system (RIS) can be defined as a subcategory of NIS. Lasting competitive advantages in a global economy hinge on local things out of

reach of distant competitors (Porter, 2014). Thus, a wide range of literature has highlighted regionalization as at least part of resolving the regional economic development dilemma resulting from new competition in the globalizing economy and understanding of dynamic industrial development in some places (Pike and Tomanet, 1996). Lundvall and Borrás (1997) define the regions as the level at which innovation is produced through the cross-fertilization effects of regional networks of innovations, local clusters, and research institutions.

Unlike the two previous approaches, the sectoral innovation system bases its limitation on a sector or industry instead of a specific geographical area. Rather than focusing on interdependence within industry clusters, sectoral innovation systems are based on the idea that different sectors or industries operate under different technological regimes characterized by particular conditions of opportunity and availability, degrees of accumulation of technical knowledge, and certain combinations of features (Carlsson & Jacobsson, 2002).

Another approach that is also present in the literature is technological innovation systems (TIS). Briefly, this approach focuses on a particular technology around which system components are formed. This thesis focuses on a specific technology: mobile telecommunications technologies. It examines the innovation policies implemented in Turkey with this technology focus. Therefore, this thesis will analyze this TIS approach, and the details of this system will be discussed in the next chapter.

In conclusion, the literature associates the concept of innovation with the commercialization of a new thing or process in a different mode. The economic impact of innovation has encouraged many countries to pursue policies to increase their innovation capabilities and capacity. These policies include the interaction and behavior of different actors in a network and the innovation system. In the literature, innovation systems are examined territorially or technologically. The rest of the chapter will discuss TIS, and the functions within these systems will be examined.

2.1.1. Technological Innovation System

The systems of technological innovation approaches have received considerable attention in recent years for examining emerging technologies in sustainability transitions and beyond (Markard et al., 2015). Although it is similar to the sectoral innovation system, it differs in that it focuses on a specific technology rather than industry or sector. Moreover, “Technological Innovation Systems (TIS) are defined as 'dynamic networks of agents interacting […] under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology” (Carlsson and Stankiewicz, 1991: p. 111) and mobile telecommunications technologies, which are the subject of this thesis and aim to examine policy studies within an innovation system, are considered as a specific technology within the scope of TIS.

It focuses on understanding the dynamics of an innovation system with a particular technology (Markard et al., 2015). TIS approach aims to analyze and evaluate the development of a specific technological field in terms of structures and processes that support or hinder it (Hekkert et al., 2011). Many academics have emphasized these analyses as essential for policy design recommendations, and performance evaluation is a part of this system. First, after determining the technology to focus on, it is necessary to identify the system's structure formed by actors, rules, norms, and relations. Second, how the system works is analyzed using seven system functions derived from theory and empirically verified as indicators. The subject of research is how each of these functions works in the system and their interaction (Hekkert et al., 2011). The next step is determining at what stage the technology is currently at. In addition to this step, what works well in the system and which functions create blocks are analyzed. As a result of this step, policy recommendations are made over system errors. The diagram below also summarizes how the analyzes in the system are made.

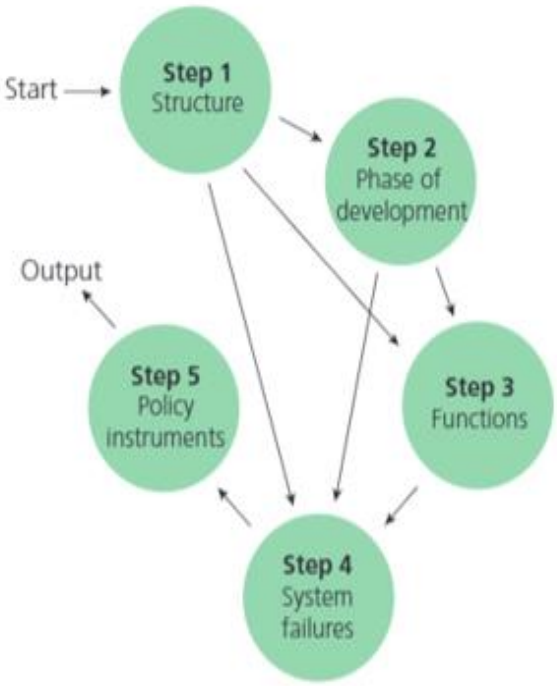


Figure-1: Schematic Representation of the 5 steps in analyzing a technological system for policy analysis.
Source: (Hekkert et al., 2011)

As a result, the innovation system approach includes geographically limited national and regional innovation systems that focus on a particular sector or technology. These systems include a structure and the essential elements. Evaluating the performance resulting from their interaction is critical in regard to the existing policies and possible amendments for policymakers. This thesis focuses on mobile telecommunications technologies, a specific technological field, and adopts the technological innovation system approach. The following chapters of the thesis will detail the elements and functions of this system. Moreover, a function-based evaluation will explain how it is implemented within innovation systems. The remainder of this chapter will consider this function-based assessment and its seven different functions.

2.2. Functional Analysis in Technological Innovation Systems

Analyzing TIS starts with identifying the structure of the system. There are three structural components; actors, networks, and institutions. Initially, the actors in the system are not only companies along the whole value chain (including those up and downstream), universities and research institutes, but also public bodies, influential interest organizations (e.g., industry associations and non-commercial organizations), venture capitalists, organizations deciding on standards, etc. (Bergek et al., 2008). The second element, networks, can be formed formally or informally. These networks can have many different characteristics, some organized to solve a specific task, such as standardization networks, technology platform consortia, public-private partnerships, or supplier groups with a typical customer (Bergek et al., 2008). The third element is the institutions that determine the rules of the game. This element includes the legal and regulatory aspects, norms, and cognitive rules that regulate interactions between actors, define the value base of various segments in society, influence firms' decisions, and structure learning processes (issue agendas, guiding principles, ways of doing business, etc.) (Bergek, Jacobsson, Hekkert, 2008).

Generally, TIS structures do not vary easily. However, actors' activities, interactions, and rules differ with the effect of the norms on this interaction. Many scholars focus on these interactions while analyzing the performance of TIS. All exchanges and activities in the system contribute to innovation development, diffusion, and exploitation as system functions (Bergek, 2002). The primary purposes of the interaction of these actors, as in all innovation systems, are the development, diffusion, and adaptation of technology.

Moreover, the processes created by the interaction carried out for this purpose are considered as functions in the literature. In other words, planned or unplanned functions tell us what is happening in the system. The concept of “functions in the technological innovation system” refers to the contributions (positive or negative) of one or more system components (components) to the overall “purpose” of developing, disseminating, and using innovations in a particular technological field (Bergek, 2002).

Some scholars have introduced system functions to the TIS approach for analyzing the processes integral to the development of a technological innovation system (Edsand, 2019). Seven different functions are used to analyze the functional pattern in the literature. The performance of TIS will be examined by evaluating these functions in the system. In this way, drivers and barriers in the system can be understood, and necessary optimizations can be determined.

2.2.1. Knowledge development and diffusion (F1)

Knowledge development, emphasized in the modern economy, is the primary purpose of innovation systems. It forms the basis of innovation activities in a particular technology. Although some academics have considered the distribution of knowledge a different function, this thesis is evaluated within the same function as the production of knowledge. It is assumed that the processing of the information produced in the system by different actors is vital for the system's functionality. For this reason, the development and distribution of knowledge are considered other elements of the same function.

There are different resources for knowledge development, which have various types, such as scientific, technological (e.g., system integration), production, logistics, application-specific, and design. In the literature, the source of knowledge development has been interpreted differently. Hekkert and other scholars (2007) emphasized learning by research and by doing within the scope of this function. Different academics have evaluated R&D, learning from new applications, and imitation among the sources of knowledge development (Bergek et al., 2008). R&D projects, patents, investments in R&D, bibliometrics, workshops, and conferences are the leading indicators of this function. While these indicators map the effort put into knowledge development, it is possible to map the increase in technological performance through learning curves (Hekkert et al., 2007).

2.2.2. Influence on the Direction of Search (F2)

If a TIS is to be developed, several firms and other organizations must perceive and enter the entrepreneurial opportunities in the new system (Bergek, Jacobsson, Hekkert, 2008). There must be sufficient incentive or pressure for these actors to enter the system and fulfill their duties (Bergek, Jacobsson, Hekkert, 2008). The primary concern of this function is how a technology system has been selected and the main factors that direct the studies within this technology system.

In the literature, policies implemented by governments, leading customers, and market actors are often addressed as functions. Multiple factors and activities have an impact on the formation of functions. These impacts are often an interactive and cumulative exchange of ideas between technology manufacturers, technology users, and many other actors, in which technology and opportunities are dynamic (Bergek, Jacobsson, Hekkert, 2008).

Some qualitative factors were suggested in the literature to measure the performance of the functions. The mobile telecommunication sector is being selected as a subject in this thesis. By combining the chosen sector and qualitative factors, first, the question of beliefs in growth potential is posed in interviews. Then, the incentive mechanism such as taxes or prices in the sector and the extent of regulatory pressure will be analyzed. Lastly, the effects of leading customers in the sector will be discussed.

2.2.3. Market Formation (F3)

The innovative output may not be formed yet; the customers' demands are not particular, or they may not have the competencies to express their demands (Bergek et al., 2008). Moreover, there may be question marks about pricing and performance. However, many scholars in the innovation field emphasize the importance of the market, citing the well-funded critical demand of a developed market as a driving force for innovation.

Mobile telecommunications technologies, the subject of this thesis, are a developed market in Turkey. Consumers in the market are experienced and express their demands well. For this reason, although the market studies in the past studies include the commercialization and market creation of a newly emerging technology, these criteria are not valid for the subject of this thesis.

However, innovation policies include actors defined as producers. Research into this function is vital to determine how actors will play a role in a developed and saturated market. The challenges of the actors will be discussed in this thesis. In this regard, specific topics for this function in the mobile telecommunication sector such as producers and consumers in the market, the market's size and character, the reflections of the international market, the relations between the actors, etc. will be explained. Moreover, the main question that must be answered is defining the barriers to entry into the market. The policies implemented by a new actor to overcome these barriers will be examined.

2.2.4. Entrepreneurial Experimentation (F4)

Entrepreneurial experimentation is a system-wide function that enables the creation, selection, and growth (commercial use) of new technologies and innovations (Lindholm-Dahlstrand et al., 2019). Different actors within the system interact in the search, creation, discovery, and exploitation of opportunities and new ideas. The main point is that this interaction between other actors is holistic and harmonious within the system. Moreover, the primary source of reducing uncertainty is the entrepreneurial experience which implies a search for new technologies and applications; this is where many will fail, some will succeed, and a social learning process will emerge (Bergek et al., 2008).

This function, which many essential economists emphasize for economic growth, focuses on questions such as the number of new companies entering the system and the diversity of these companies, the number of different application types, the breadth of technologies used, and the character of complementary technologies used. In this

thesis, the participants will be asked in the interviews whether there is an increase in the companies producing mobile telecommunication technologies, and whether the current policies cause an interest in technology and an increase in the manufacturer portfolio.

2.2.5. Legitimation (F5)

Legitimacy is a matter of social acceptance and alignment with relevant institutions: it is defined as a new technology whoseproponents must be seen as appropriate and desirable by relevant actors in different parts of the TIS to gain political power (Bergek et al., 2008). Moreover, it also includes the beliefs and recognition of other actors within the system for the specified technology. Socially, it is crucial to support the actions taken in this system together with this function.

Different actors regarding technology will be asked questions about their recognition of the specified technology. The attitudes of various stakeholders towards mobile telecommunication technologies and whether these stakeholders have extra lobbying activities are also crucial for this function. It will also be examined whether this technology is the subject of political discussions and how it is discussed in the media. The primary purpose here is to explore the evaluations of all stakeholders for the specified technology and whether the political support given to this technology has gained legitimacy.

2.2.6. Resource Mobilization (F6)

Human capital and its competencies, and financial capital are essential components in an innovation system. Literature defines these functions as how these capitals can be directed towards a particular technology and what kind of infrastructure and opportunity it provides for this orientation.

This thesis primarily investigates human resources by this function. It will be analyzed how the human resources are directed to the mobile telecommunications sector and what policies are implemented to increase competencies. In addition, whether the experiences gained by the human resources in international manufacturers are transferred to domestic production in the policies implemented will also be among the interview questions. The current performance evaluation will be made with interview questions on these issues. In addition, research will be conducted on the financial support given to the companies producing in this field and the economic capital obtained by the companies that can grow in this field. It will be questioned whether financial supports are a policy tool for domestic manufacturers in the mobile telecommunication sector to continue their production activities against their global competitors.

2.3. Conclusion

The concept of innovation is generally associated with the commercialization of something new in the literature. Moreover, its importance for economic growth and sustainability has been proven by empirical studies. Due to the economic impact, countries establish policies to increase their innovation capabilities and capacities. An essential part of these policies is creating a well-functioning innovation system. In the literature, the innovation system is mainly defined as a general framework, and it includes the interactions of many different actors and components for knowledge production, dissemination, and adaptation. In this sense, many other innovation systems are also discussed by academics.

The first discussions in the literature started with the national innovation system, which is an inclusive system that incorporates actors at the national level. Subsequently, the regional innovation system, a sub-category of NIS and associated with the economic impact of local policies, is discussed. Unlike these two systems, which have geographical focal points, there is a sectoral innovation system focused on a sector or industry and a technological innovation system focused on a specific technology. This thesis focuses on mobile telecommunication technologies and will deal with the

innovation policies carried out for certain technologies in Turkey within the framework of TIS.

The literature defines a specific structure consisting of actors, networks, and institutions regarding technological innovation systems. The activities and interactions of the components in this structure are defined as functions. The literature has different functions to measure a system's performance and identify well-functioning and block mechanisms. As shown in the figure below, function-based analysis for the system is used to determine critical policies and make the necessary adjustments.

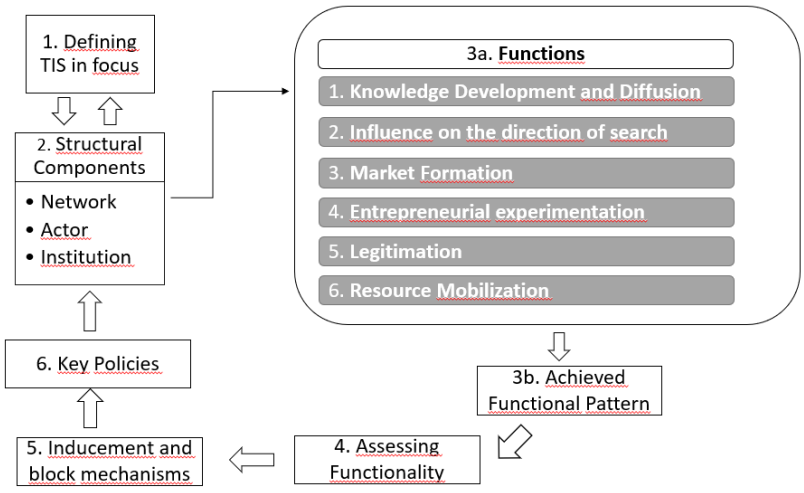


Figure-2: The Technological Innovation Systems framework of analysis
Source: (Gosens et al., 2015)

This thesis aims to analyze the policies implemented in regard to mobile telecommunication technologies in Turkey by considering a functional pattern. In the next part of the thesis, the historical development and current situation of telecommunication technologies in the world and in Turkey will be explained separately. Then, the countries with policies on mobile telecommunication technologies around the world will be discussed. Finally, this thesis will define the system and the actors for mobile telecommunication technologies in Turkey. The explanations will be made regarding the current policies.

CHAPTER 3

TELECOMMUNICATION TECHNOLOGIES AND LOCALIZATION POLICIES

This section primarily describes the historical development of telecommunication technologies in the world and in Turkey. Telecommunications technologies are discussed in this chapter, starting with the invention of the telegraph. The adaptation of the telegraph took place quickly in a short time, and the investments made enabled the rapid development of technology. Mobile telecommunication is the latest technology, with billions of unique subscribers globally. The story of the newest technology takes place over generations. With each generation, the services offered by technology have changed and developed. This situation caused it to become widespread quickly, and its rapid spread led to increased investment in technology. Although 4G is the most common generation globally, 5G has been deployed in several countries, and it is expected to increase its market share in the sector. The evolution of mobile telecommunication technologies up to 5G is also explained in this chapter.

Moreover, the billions of mobile subscribers require enormous investments in the sector to sustain the services. Every year, trillions of dollars are invested in mobile telecommunications, hardware, and software. The infrastructure market is so prominent around the world and this has encouraged many countries to invest in this market, with limited suppliers. Turkey is one of these countries. Countries investing in this sector implement innovation policies to realize technology in their own countries. This chapter also discusses these policies around the world and in Turkey. The procedures in Turkey and how they yield results in the current situation are analyzed in detail.

3.1. History of Telecommunication

Today, telecommunication refers to advanced networks and infrastructure, smartphones, satellites, and high-speed internet. ITU defines the concept as wired and wireless systems for transmitting and disseminating information. However, the communication and exchange of data have been the essential basic needs of humanity throughout history. In the early phase of history, people might have needed to communicate with others to warn them of potential danger or to detect another person's location. These needs may be very primitive compared to what people expect from telecommunication technologies today. Still, it is safe to assume that the methods are not related to the concept of telecommunications. As these methods serve the function of communication, this concept has constantly evolved with technological developments. A piece of technology regarded as one of the essential elements of this concept today may become obsolete in ten years. In this context, the idea of telecommunication is as old as human history and constantly evolving with developing technology.

Before the invention of modern telecommunication devices and the establishment of comprehensive and international networks, people used basic methods with limited capacity for communication. Smoke signals, drums, and pigeon posts were the first methods used in human history regarding telecommunication. For example, many famous civilizations in history (Greeks, Persians, Romans) used smoke and fire signals to convey information about specified singular situations (Huurdeman, 2003). The history of telecommunications begins with the history of humankind due to the basic need for communication. However, methods such as smoke signals, drums, and pigeons, which are associated with the concept of telecommunication, have limited capabilities and capacities. Today, although our communication needs evolve with the developing technology, the basis of human communication with each other, sending messages to and exchanging information with people at a distance remains the same. In this context, it is necessary to describe the methods that people used for thousands of years before the invention of the telegraph and still exist today under the telecommunication concept despite their limited capacities and applications. For this

reason, the general concept of telecommunication today, especially as the definition of ITU, will be called the modern telecommunication concept in this thesis.

The first developments in telecommunication technologies defined under the concept of modern telecommunication started with the invention of the telegraph in the 18th century. The first version of the telegraph was invented simultaneously in Sweden and France towards the end of the 18th century as an optical telegraph. The Swedish optical telegraph was the brainchild of Abraham N. Edelcrantz; in France, the inventor was Claude Chappe (Cantoni & Danowski, 2015). Although the optical telegraph is found simultaneously in two countries, it has made better progress in France. An optical telegraph is a semaphore system that uses several stations, typically towers, to transmit textual information via visual signals. Optical telegraphy developed mainly in France. The first infrastructure works for the system starting from the revolutionary years were made by Chappel. The communication system covered not much distance between the cities of Paris and Lille in 1798. The optical telegram had incrementally developed a line of communication of more than 3000 miles in approximately 40 years. The main factor in this development was the Revolutionary Era and the wars of the Napoleonic Empire, which persuaded governments to lavish resources on fast communication (Odlyzko, 2000). Moreover, due to the speed and possibilities in terms of communication, infrastructure for this technology has been established in many parts of Europe (Winston, 2002).

On the other hand, the electrical telegraph is the first electrical telecommunication network element hailed as a significant technical breakthrough. After Samuel Soemmering invented a crude telegraph in Bavaria in 1809, technological advances in the telegraph continued for 20-30 years. In this sense, the electrical telegraph created a virtual space for information flows that did not need physical presence and movement, thus freeing communication from many of its former limitations (Wenzlhuemer, 2007). In 1837, British physicists William Cooke and Charles Wheatstone patented the telegraph using the same principle of electromagnetism; Samuel Morse invented a telegraph system that was a practical and commercial success (Bellis, 2019). The electric telegraph, which started to spread quickly after its famous commercial introduction around 1845, reached an extensive infrastructure in

the United States and England (Calvert, 2008). The first attempt at intercontinental communication was made by establishing the trans-oceanic telegraph infrastructure. In 1951, the first submarine cable passed the Canal, and in the following years, lines extended from Egypt to India and from there to China and Australia. In the 1880s, threads reached South America and Africa one by one; in World War II, cables crossed all oceans and connected every continent and almost every country (Smelser et al., 2001).

In this sense, the telegraph was a dramatic innovation that provided a faster communication method than transportation for the first time throughout human history. Although the technological developments in the telegraph started relatively slow, it was an initial step towards instantaneous communication with the world (Odlyzko, 2000). The significant advantage of the telegraph increased the attractiveness of the technology. Therefore, countries have invested in telegraph infrastructure, from within their borders to international and trans-oceanic regions. The increase in investments in the telegraph has encouraged more widespread use and thus, technology adaptation has been realized in telecommunication.

The considerable change started with the telegraph. In communication, infrastructures have been consolidated with the invention of the telephone (the concept of "the telephone" refers to fixed telephone services). The telephone, an idea that has been a part of our lives since the second half of the 19th century, is widely used today. Telegraph technology had been operating as the most effective telecommunications infrastructure in the world for nearly 30 years when Graham Bell reached the most concrete development for the telephone in 1876. However, the main problem with telegraph technology was that it used Morse code to send and receive one message at a time. On the other hand, Bell invented the telephone by researching the possibility of transmitting multiple messages along the same cable (Morris, n.d.). The simultaneous transmission of messages provided a significant advantage over the inferior telegraph technology. Therefore, user preferences in telecommunication technology have shifted to telephone technology. According to a report published by AT&T, one of the largest global telecommunications companies, there were

approximately 10 million telephone subscriptions in the United States of America in 1914, and the rate of penetration amongst the total population was around 10%.

Moreover, it had more than one million telephone subscribers in the German Empire. In contrast, in terms of penetration rate, though not in terms of subscribers, Canada is 6% after the United States of America (Wallsten, 2001). Investments made by countries in the establishment of telephone infrastructure have consistently increased. The increase in assets has made this technology more attractive for users by increasing accessibility and testability, essential factors in technology adaptation. Telephone technology reached approximately 1.2 billion subscribers in the early 2000s. In other words, telephone technology locked into telecommunication technologies. Towards the 2010s, the use of telephone technology shows a decreasing trend, as seen in the chart below. In particular, the diffusion of mobile telecommunication technology is a significant factor in the decline of the trend toward telephone technology as these technologies have reduced the use of telephones while the replacement process for telephone technology has slowed. The main factor in this slowdown is internet usage (Grzybowski, 2014). Fixed broadband internet broadcasting is distributed over the telephone infrastructure as the WIFI technology used in households and workplaces is provided through this fixed telephone infrastructure. This situation has caused fixed phone habits to remain to a certain extent even though they have decreased, and there are more than 800 million telephone subscribers worldwide.

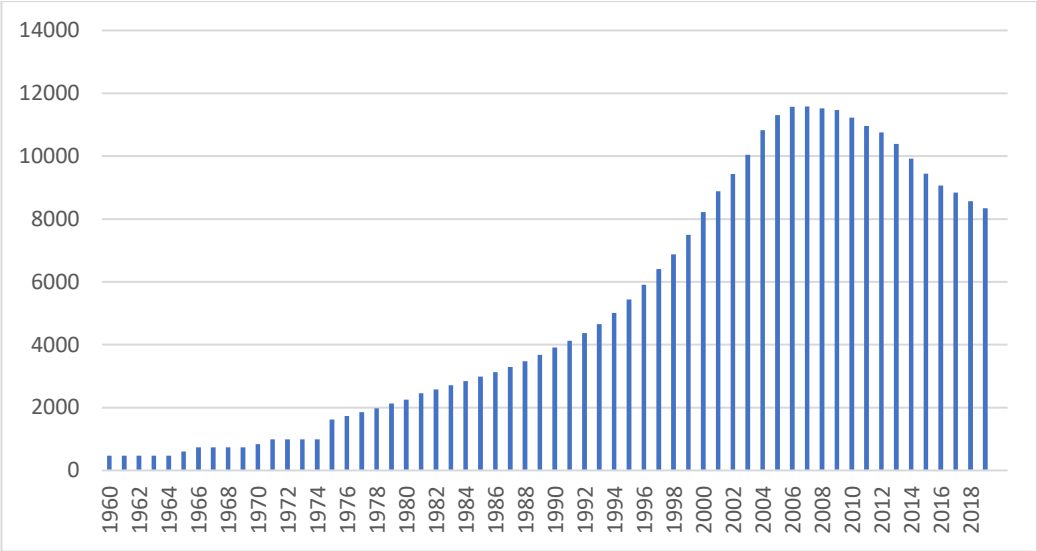


Figure-3: Total Fixed telephone Subscriptions in the World

Source: World Bank, International Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database

In summary, modern telecommunications' history begins with the invention of the telegraph. When the telegraph was invented, it was the fastest means of communication for people. The significant advantage of this technology has increased investments in this field, and both an international and transoceanic infrastructure network has been established, resulting in the further development of this technology. However, telephone technology is a more effective means of communication than the telegraph. More than one message is transmitted simultaneously with the phone, making it more effective. This advantage enabled the phone to replace the inferior telegraph technology. Since the second half of the 20th century, the spread of technology has accelerated and reached 1.2 billion unique users worldwide, locking the telephone technology into the telecommunication market. However, the advancement of mobile telecommunication technologies has reduced the trend toward the fixed telephone. Today, mobile telecommunication technologies are the most widely used telecommunication technologies.

3.2. The Evolution of Mobile Telecommunication

The telecommunications industry has also reflected the development of wireless technologies such as radio, television, and satellite. At the beginning of the 20th century, telephone technology was wired and provided only voice services between limited, physically cabled locations. The mobile telecommunication technologies emerged towards the end of the 20th century by reflecting the progress in the field of wireless technologies onto the telecommunication sector. Mobile telecommunication is the process of sending, transmitting, and receiving information remotely for communication purposes. This form of signal transmission happens with the help of some mobile devices such as a cell phone, computer, or other wired or wireless devices (Chavis, 2021). The most important feature distinguishing mobile telecommunication technology from previous technologies is that it allows communication from areas covered by the telecommunication network without being tied to a fixed location. In addition, mobile telecommunication technology has gradually developed since the 1950s, and the opportunities it offers to its users have increased and diversified. This gradual development is called a generation in technology, and mobile telecommunications technologies have evolved in successive generations.

The first generation (1G) of the technology, which emerged in the 1980s, uses analog technology. Despite its limited voice features and certain disadvantages such as being bulky and expensive, it offers a genuine mobile service (Merchant, 2020). 1G cannot provide many services that mobile telecommunications technology offers to people today. There is no data communication, only voice service, and it provides this in a low capacity, with poor connection, and through a less secure connection. 1G and mobile telecommunication technologies have started to attract attention as they offer a location-independent service compared to telephone technology, locked into the communication sector despite its limited capacity and capabilities. With this innovation brought by 1G, it meets the needs of individuals better than the previous technology. It makes the solution more compatible with the communication need. By the 1980s, it was pretty remarkable that a person could call a number from anywhere. This situation attracted the attention of potential users and enabled mobile

telecommunication technologies to be tested. By 1990, mobile telecommunication technologies had experienced tremendous growth, and the number of subscribers reached nearly 20 million (Agrawal et al., 2015). This trend continued with other generations.

On the other hand, 2G is known as Global Technologies for Mobile (GSM), a second-generation wireless mobile telecommunication technology. 2G was launched in Finland in the early 1990s, and this generation offered text and visual message services for the first time (Meraj, Kumar, 2015). Moreover, the General Packet Radio Service (GPRS) was announced as "2.5G," and it improves data capacity in GSM. In addition, with the wireless application protocol and similar technologies, web pages have been transferred to smaller screens such as mobile phones. In this context, the first versions of data services in mobile telecommunication technologies are offered as services together with GPRS technology. Although telecommunication technologies are primarily associated with data consumption, the first two generations of mobile telecommunication technologies are mostly voice-centered services. Accumulated stocks have a significant impact on the diffusion and adaptation of 2G technology. The dramatic increase in usage with 1G has introduced people to mobile phone usage, and individuals have observed the benefits of mobile telecommunications technologies. As the number of people using mobile phones increases, so will the number of people aware of the mobile phone's existence. This tendency towards technology has led to a rise in investments in this field for more advanced performance features and widespread infrastructure investments. Therefore, this indicates a positive link between mobile phone generations, as more 1G adapters mean more informed consumers and increased demand for 2G phones (Liikanen et al., 2004). Moreover, the urbanization, the increase in broadband penetration, and GDP per capita parameters have fostered the technology adaptation processes of 2G and superior technology that is the third generation (3G) (Bohlin et al., 2010).

ITU is officially named 3G, which aims to provide wireless access to the global telecommunications infrastructure through satellite and terrestrial systems, such as International Mobile Telecommunications-2000 (IMT-2000) (Pereira, Sousa, 2004). 3G services include wireless voice telephony, broadband wireless data, mobile

television, GPS (global positioning system), video calls, etc. In addition, this generation enables network operators to provide users with a broader range of more advanced services and achieve greater network capacity through improved spectral efficiency (Meraj, Kumar, 2015). In general, 3G provides a more advanced data service performance compared to the inferior generations. However, the technology adaptation and diffusion process of 3G has not been as smooth as the transition of the previous generation. Products and services for 3G technology generally started later than expected (Chatterjee et al., 2019). This lack of products and services in the supply processes has also affected the experience of 3G among users and the observation of its results. Due to low demand and insufficiently informed users, the diffusion of the 3G rate has been slower than inferior generations.

On the other hand, the data services in telecommunication technologies have been revolutionized with the fourth-generation technology (4G). Announced around the world in early 2010, 4G is theoretically the first generation to use Long-Term Evolution (LTE) technology to provide very high download speeds, better latency (less buffering) for end users, improved sound quality, instant messaging services and social media, quality streaming and faster download speeds (Keenan, 2020). The applications that people use on their mobile phones are mainly due to the data download speeds experienced in 4G and the other possibilities it offers. In this sense, data-driven technologies and services developing with 4G are expected to develop in the fifth generation (5G).

5G is a significant evolutionary development that supports data-driven technologies and complements previous mobile networks with new service capabilities (Rejeb, Keogh, 2021). 5G is still in the early adaptation process, and the first applications for the technology have recently been released. However, many key features of 5G, such as very high download speeds, high capacity, low latency, and more security than the previous generations, differentiate the use of this generation. In this context, it is expected that the users of 5G will be not only people but also objects. It will develop the concept of the Internet of Things that will enable entities to communicate with each other.

Global System for Mobile Communications (referred to as “GSMA”) has published The Mobile Economy Report 2020, which shows the current and forecast distribution of generations. The graph shows that 4G is the most widespread generation of mobile telecommunication technologies since 2017. Moreover, although 3G technology emerged in 2009, it surpassed the previous generation 2G, which appeared in the early 2000s, only in 2018. This situation is seen in the graph detailing the decrease in 2G usage rather than the increase in the spread of 3G. Moreover, it is seen that 5G is still a new technology and is in the process of early adaptation, and its space continues to increase.

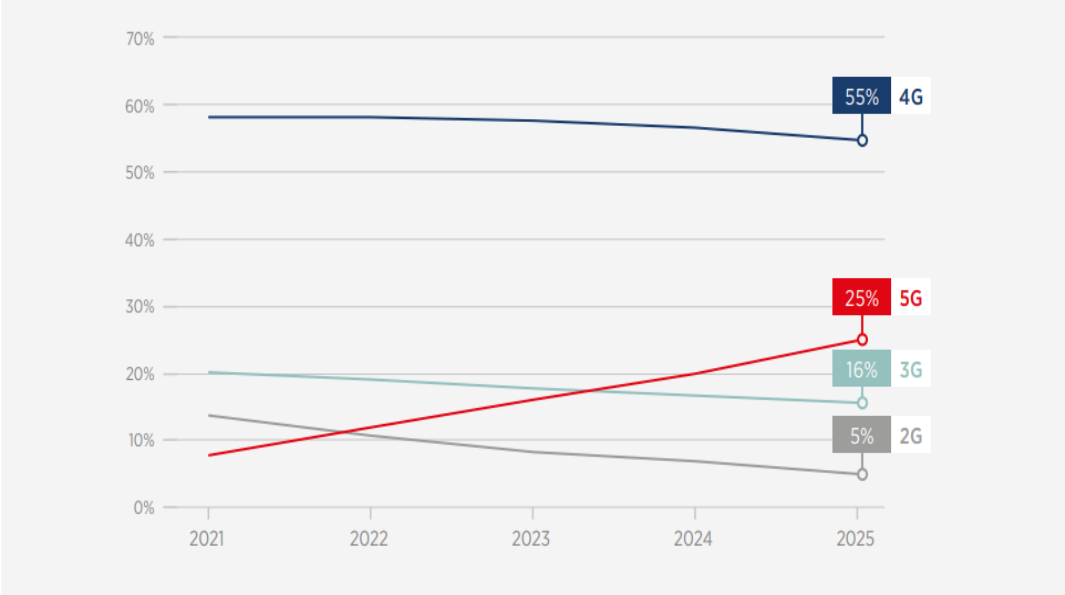


Figure-4: Generation Penetration Rate over years

Soruce: GSMA, The Mobile Economy 2022

Unlike previous communication technologies, mobile telecommunication technologies offer location-independent, faster, and more effective communication services. Moreover, they provide a different service portfolio in terms of communication with data services. The main driver of mobile telecommunications adoption is technological progress allowing continued cost reduction and equipment performance improvement (Bohlin et al., 2010). In this sense, Graph-3 showing the change in the number of mobile subscribers over the years proves that mobile telecommunications technologies have spread dramatically around the world in a few decades. Mobile telecommunications technology, which had thousands of subscribers

when it first emerged in the 1980s, reached a million subscribers worldwide within only ten years. With the spread of GPRS and 3G technology in the world in the early 2000s, mobile telecommunication subscribers have exceeded 1 billion. In the following years, mobile telecommunication technology has continued to increase exponentially. As of 2019, there are approximately 9 billion mobile subscriptions, about 6 billion of which are unique mobile subscribers[8]. Within this context, it can be seen that mobile telecommunication subscription has reached a penetration rate of approximately 110% over the world. Therefore, telecommunication sector has been locked into mobile telecommunication services by replacing its predecessor, the telephone technology.

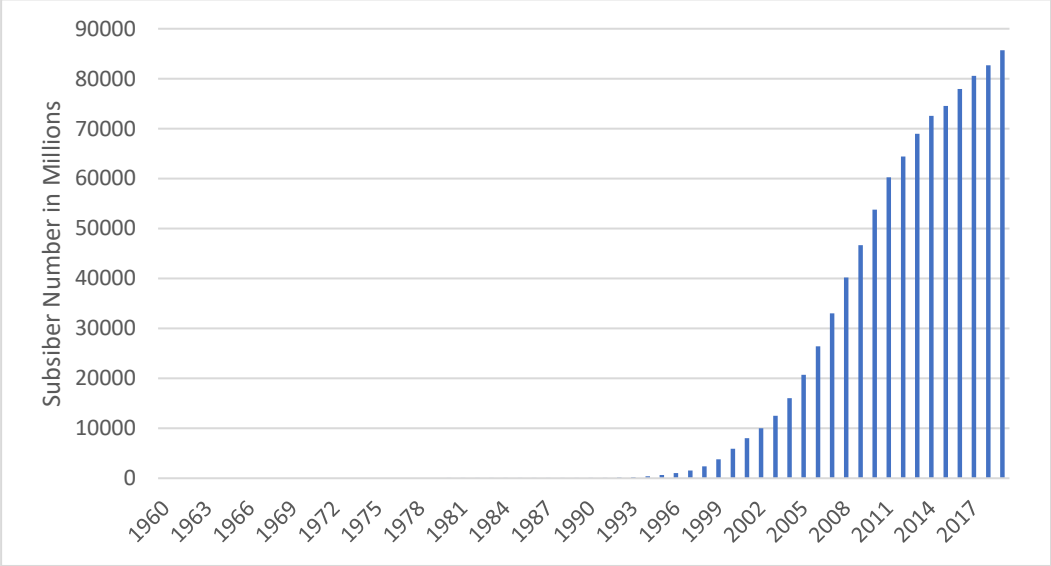


Figure-5: Mobile Cellular Subscriptions in the World

Source: World Bank, International Telecommunication Union (ITU) World Telecommunication/ICT Indicators Database

In conclusion, mobile telecommunication technologies started with 1G in the 1980s, with poor voice quality and low capacity. Despite this limited capability and capacity of 1G, the location-independent communication service has attracted users' attention and has reached 20 million users in ten years. The stock accumulation of these users and the dissemination of usage-based information were also effective in the transition to 2G, the following technology. 2G includes voice and text message service along

[8] https://www.gsmaintelligence.com/data/

with more advanced voice service. It also offers the first examples of data usage with GPRS technology. The aforementioned technological developments continued with the third generation. However, the technology adaptation process has been slow due to the late introduction of products and services for 3G. In this sense, as in the previous generation transition, the diffusion of 2G does not positively affect the transition to 3G. On the other hand, 4G is the most common technology in the mobile telecommunications market. 4G stands out as the fundamental technology that offers advanced data services that are widely used within communication technologies today. Although 5G is assumed to be a much more advanced technology in data-based communication, it is still in the early adaptation period. The development of generations in the mobile telecommunication sector is also reflected in the number of users. Currently, there are approximately 9 billion mobile telecommunication technology users in the world. With the development of mobile telecommunications technology, the number of users is expected to increase.

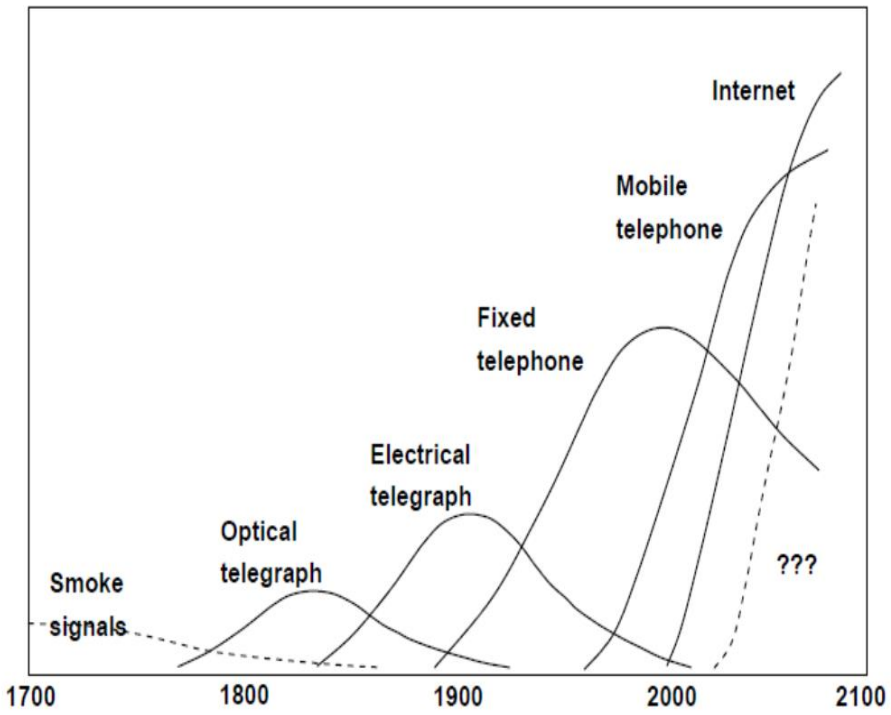


Figure-6: The Telecommunication Technology Adaptation Processes
Source: (Cordeiro, 2008)

In this context, figure above shows the telecommunication technology adaptation processes. Currently, the sector has been locked into mobile telecommunication technologies, and the diffusion process continues.

3.3. History of Telecommunication in Turkey

The modern telecommunication history in Turkey started in the Ottoman Empire period with the telegraph line installed in 1847[9] and the first telephone circuit in 1881 (itunews, n.d.). Firstly, administrative institutions and organizations were established for telegraph technology in the Ottoman period. Between 1855 and 1871, a high telegraph commission oversaw telegraph operations in the empire. In 1871, the telegraph commission united with the Ottoman postal administration and formed the Postal and Telegraph Ministry (Postal and Telegraph Nezareti), an administrative union that would continue until the end of the empire (Lewis, 2018). The Ottoman Empire was experiencing a modernization process during this period. In order to establish and maintain telegraph technology infrastructure in the Ottoman Empire, legal arrangements and well-trained bureaucrats were required. In this context, it contributed to the modernization process of institutionalization. Moreover, the Ottoman Empire had a very wide geography and was engaged in many wars during this period. Therefore, the telegraph's ability to provide communication in the field within the wartime geographical boundaries also increased its importance. Both institutionalization and communication possibilities contributed to the diffusion of the telegraph in the Ottoman Empire.

On the other hand, the American Western Electric company established the first telephone system in Istanbul in 1911. The Company granted a 39-year franchise, found "Dersaadet Telefon Anonim Şirketi" to operate the telephone, but the company was seized during the 1st World War (Kent, 2012). With the establishment of the Republic of Turkey in 1923, telephone and telegraph services were taken over from the Ottoman Empire and reorganized. In 1936, the Post and Telegraph Administration (PTT) was

[9] The first telegraph line was constructed by the British as a requirement of the Crimean War before 1847.

established by law and was charged with performing telecommunication services at the country level (Kent, 2012). However, telephone technology suffered from a lack of investment as the state had monopolized it until public policy changed in the 1980s. According to the World Bank, the telephone service exceeded the number of million subscribers at the end of the 1970s. After the 1980s, infrastructure investments in the technology started to increase, and it surpassed 10 million subscribers in the 1990s and reached a peak of approximately 20 million subscribers in the mid-2000s (Kanberoğlu, Kara, 2014). In this context, increasing infrastructure investments, changing public policy in order to ease access to technology by individuals, and an increased tendency towards the technology can be shown as the main effects in the diffusion of telephone technology in Turkey. Due to the enormous growth of the telephone market, the telephone and postal services were separated from PTT in the 1990s. In 1994, the PTT was divided into the General Directorate of Post to provide postal and telegraph services, and Türk Telekom was created as a state-owned company to provide telecommunications services (OECD, 2002). In the same year, Türk Telekom was allowed 49% privatization by enacted law. The fixed telecommunications infrastructure owned by PTT was transferred to Türk Telekom to carry out telecommunication activities. Moreover, the privatization process was carried out after Türk Telekom left PTT. This process was completed on 14 November 2005, and 55% of its shares were transferred to Ojer Telekomünikasyon A.Ş.[10] However, telephone usage has shown a downward trend due to the growth of the mobile telecommunication market. According to the market data published by ICTA, the prevalence rate in Turkey, which has 12,448,604 fixed telephone subscribers as of the fourth quarter of 2020, was approximately 14.9%.

Mobile telecommunications technologies in Turkey started in the early 1990s. Turkcell, the first mobile operator in Turkey, started to provide GSM service in February 1994. By signing a 25-year GSM license agreement with the Ministry of Transport on April 27, 1998, Turkcell has continued to provide mobile voice and data communication-based services to its customers[11]. Moreover, Telsim also started to

[10] https://www.turktelekom.com.tr/hakkimizda/sayfalar/kilometre-taslari.aspx

[11] https://www.turkcell.com.tr/tr/hakkimizda/genel-bakis

operate in the field of mobile telecommunications in Turkey at almost the same time as Turkcell. In 2005, Telsim was bought by Vodafone (Milner, 2016). The Turkish mobile market was further expanded with the launch of Aria, owned by two new GSM operators, Türkiye İş Bankası and Telecom Italia Mobile, and Aycell, owned by Türk Telekom. Aria and Aycell merged in the following years to form Avea Company in 2004 (itunews, n.d.). Türk Telekom later bought all the shares of Avea and the company was named TTMobil under the Türk Telekom Brand.

In terms of the application of mobile telecommunication technologies, Turkey has lagged behind the world within the context of historical progression. 2G, GSM technology, which emerged in the 1990s worldwide, was accompanied by two companies established in 1994. According to the data of the World Bank[12], 1 million subscribers were reached in approximately three years during which only 2G service was available in Turkey. The spread of mobile telecommunication services accelerated with the experience of early adopters of technology in Turkey and the impact of the diffusion trend in the world. As the use of mobile telecommunication technologies increased, it attracted more attention and reached 35 million subscribers in about ten years. Despite the rapid diffusion of 2G usage, the transition to the next generation in Turkey has been later than the rest of the world.

3G technology, which emerged in the world in the early 2000s, started to be applied in Turkey after the concession tender held in 2009[13]. The diffusion rate of 3G technology in the world was late compared to the previous and next generations, mainly due to the late delivery of applications and services for 3G users. By adopting this technology later than the rest of the world, Turkey actually suffered less from this handicap. However, the diffusion rate of 3G technology in Turkey was slower compared to other generations. 3G technology brought a radical change compared to 2G, especially with the data services it offers. Turkey did not have the sufficient infrastructure for this radical change and there were not enough devices to use the 3G

[12] https://data.worldbank.org/indicator/IT.CEL.SETS?end=2019&locations=TR&start=1960&view=chart

[13] https://www.cumhuriyet.com.tr/haber/3g-imtiyaz-sozlesmesi-30-nisanda-imzalanacak-58476

service (Gülhan, Mehmet, 2019). On the other hand, these effects on diffusion rate were not observed 4G in Turkey. The main factor here was that the majority of 3G compatible devices were also compatible with 4G technology (Gülhan, Mehmet, 2019). In the intergenerational transition, the cost is less likely to be a disadvantage in technology adoption. Moreover, 4G technology provides higher data download speed than previous generations. Considering the rise of social media and the concentration of user habits on data services, the rapid spread of 4G is not surprising.

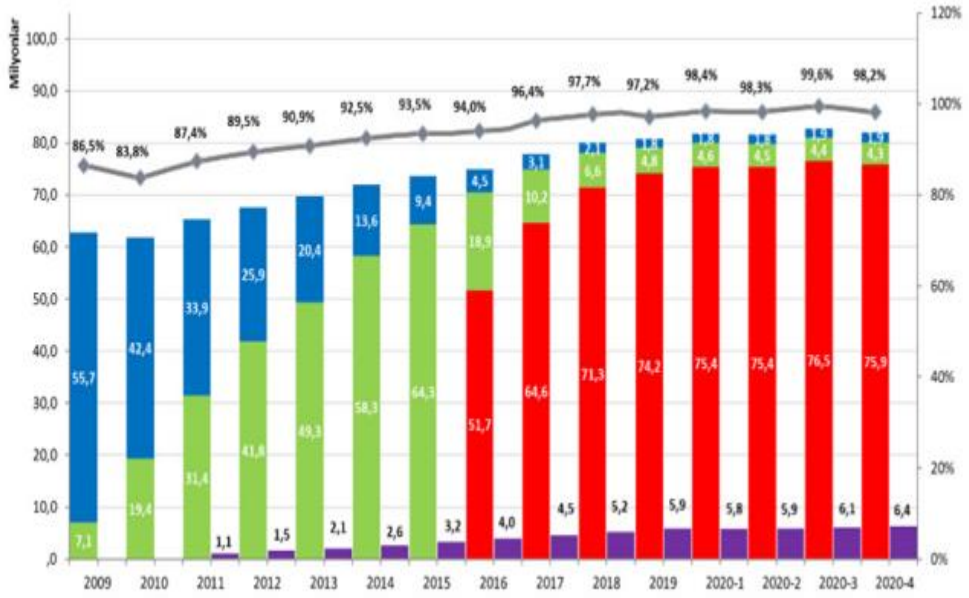


Figure-7: Generation Penetration Rate over years in Turkey[14]

Source: ICTA, Quarter Reports

In the 2020 report of market data published by ICTA, user transitions between generations in Turkey can be seen in the graphic above. Moreover, as of the end of December 2020, there are 82,128,10412 mobile subscribers in total, including machine-to-machine communication (M2M) subscribers, corresponding to a prevalence rate of approximately 98.2% in Turkey. In conclusion, the history of telecommunication in Turkey started in the 19th century with telegraph and telephone services. Institutionalization in telecommunications also started in the same period, and in the first half of the 20th century, telegraph and telephone services were

[14] Red represents the number of 4G subscribers, green represents the number of 3G subscribers, and blue represents the number of 2G subscribers.

consolidated under PTT. In the early 1990s, the widespread use of telephone services in Turkey and the world caused the separation of telephone and telegraph services institutionally, and Türk Telekom Company started to offer telephone services, and the company was privatized in 2005. In the field of mobile telecommunication technologies, services were created with two companies established in the 1990s. With the merger of the two companies based in the early 2000s, three companies have actively been serving in the mobile market. However, Turkey lagged behind many countries globally at the beginning of the implementation of 3G and 4G technologies. Nevertheless, this has not prevented the rapid diffusion of mobile telecommunications technologies. Currently, mobile telecommunications technologies serve more than 80 million subscribers and have replaced telephone technology.

3.4. Localization Policies in the Mobile Telecommunications Sector Worldwide

Billions of people actively use mobile telecommunications technologies. Therefore, mobile telecommunications companies generate vast amounts of income. The total revenue of companies providing mobile telecommunications services worldwide is more than $ 1 trillion. Moreover, the payment of companies is forecasted to increase steadily in the coming years. Therefore, the sector is one of the key elements to lead to economic growth. Especially in developed countries, the revenues of the mobile telecommunication sector constitute a severe share in the GDPs of the nations (Gruber, Koutroumpis, 2011). Based on the world bank's data, the revenue in the sector alone constitutes more than 1% of the total GDP in the world.

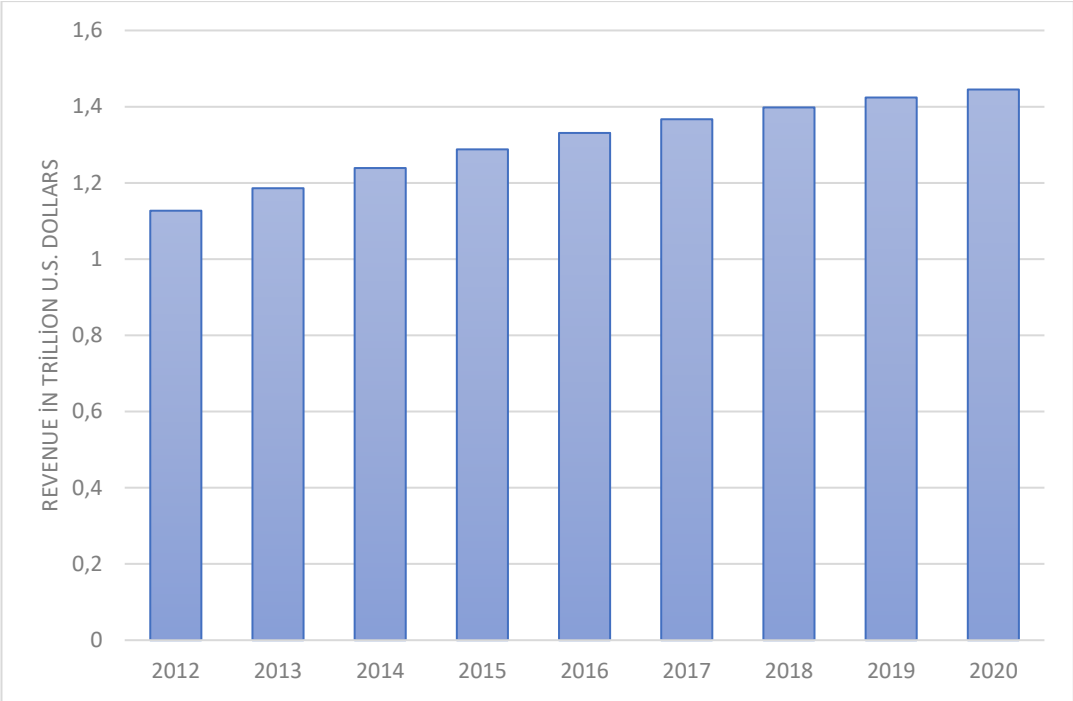


Figure-8: Mobile Operators Revenue [15]

Source: Statistica, Total Revenues of Mobile Operators Worldwide

On the other hand, the mobile telecommunication sector requires significant investments in infrastructure to maintain and upgrade the services. According to The Mobile Economy 2022 report published by GSMA, a capex of 600 billion dollars is foreseen only for infrastructure investments of mobile operators.

However, a limited number of suppliers can produce mobile telecommunication infrastructure equipment. Currently, Huawei, a China based company, is the leading infrastructure supplier in the market. Moreover, Ericsson, Nokia, and ZTE also operate in the same market and follow Huawei in terms of revenue. The mobile telecommunication infrastructure is a knowledge-intensive industry due to being classified as high-technology production[16]. Moreover, high research and development cost is an important barrier to entry into the market. Therefore, the market is identified as an oligopoly market with limited suppliers.

[15] The statistic shows the forecasted total revenues of mobil operators worlwide from 2012-2020

[16] https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an2.pdf

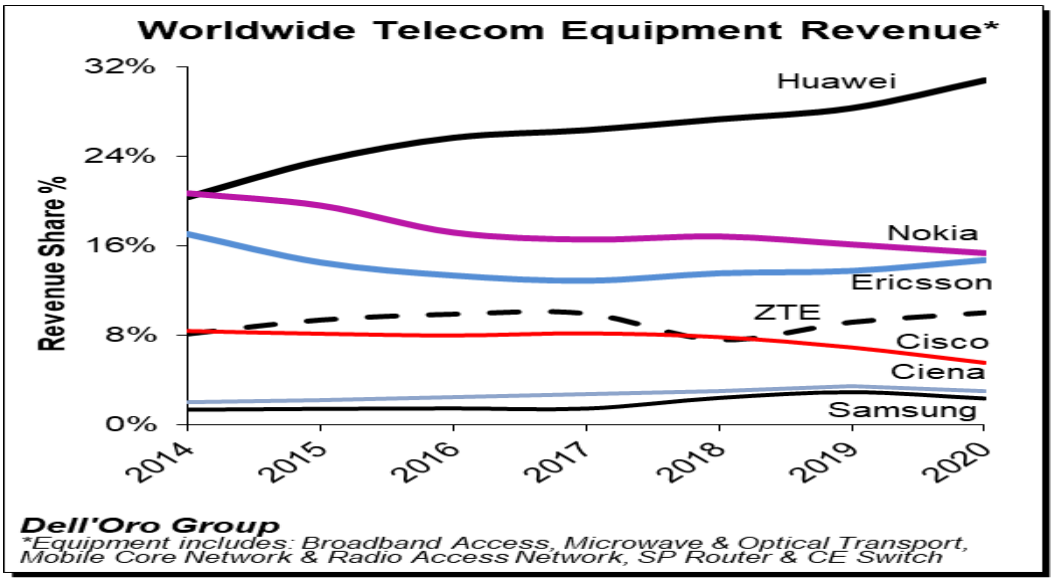


Figure-9: Total Telecom Equipment Market 2020

Source: (Pongratz, 2021)

Despite few players in the production sector, their market share has changed significantly over the past decade. The telecommunications system industry has been dominated by western companies led by the Swedish telecommunications giant Ericsson, and Siemens, Nokia, Motorola, Alcatel, Nortel, and Lucent are among the essential manufacturers (Joo etc., 2016). The mentioned dominance is clearly shown in the table below, created from different sources. Among the companies in the table, Ericsson and Nokia were established in the late 19th century and have many years of telecommunication experience. Motorola is also a company that was founded at the beginning of the 20th century and has experienced the technological evolutions of the industry. Therefore, these companies had the lion's share of the market in the 1990s. The high cost of research and development in the mobile telecommunications infrastructure market is a significant barrier to market entry. In the 1990s, there were fewer players in the market which already had a limited number of manufacturers.

Table-1 [17]Market shares for mobile telecommunication systems by manufacturer. World (W) sales for 1978, 1990; Installed line for 1996

	1987 W[a]	1990 W[b]	1996 W[c]
Ericsson	45%	40	40
Lucent (AT&T)	—*	(close to Motorola)	16
Motorola	—	30	15
NEC	—	—	12
Nokia	—	—	5
Nortel (Northern Telecom)	—	—	7
Siemens	—	—	5

Sources:[a] (*Affärsvärlden* 1987) [b] (*International Management* 1994:27; Ekwall 1991:38) [c] Calculations based on (LME 1996b). *'—' means not listed in that source.

On the other hand, Huawei, a privately-held Chinese company founded in 1987, successfully entered the global market and achieved rapid growth. Huawei aggressively increased its market share in the 2000s. As of 2012, it has become the leader in the market in terms of current revenue and surpasses well-established companies. The entry and development of a Chinese company into the telecommunications market was not an accidental event and started with a political and strategic decision made by the Chinese government. The state has a positive role in developing the telecommunications equipment industry sector. The development of telecommunications equipment began with the political and strategic decisions made by the Chinese government in 1978 (Kamasa, 2021). Policies for the strategically selected sector are planned for the long term. Emiroğlu (2015) explains the procedures that make Chinese companies the most important players in this sector in different phases:

[17] https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.202.9203&rep=rep1&type=pdf

- The first phase includes Joint Ventures for Digital Phone Switches. China's first attempt was to provide entry for various foreign companies with different types of products through the infrastructure and encourage late-arriving domestic companies to develop their products. Foreign products dominated the Chinese market due to the cooperation of foreign enterprises with local firms. This situation caused mismatches and high prices between existing products and potential market needs, especially in rural areas.

- The second phase is titled Know-How Transfer about Digital Switch Technology. The activities of foreign partnerships in China were an essential resource for diffusion through domestic companies and assimilation of necessary knowledge on critical technologies. This strategy has helped establish technology transfer channels as a government policy. Chinese industry ministries have deliberately organized engineers from other parts of the local industry to receive training or job rotation in joint-venture firms.

- The third phase is Awareness and Attempt to National Digital Switch. The primary purpose at this stage is to encourage domestic equipment suppliers through technology transfer and local R&D studies of domestic companies, and dissemination of technology. In 1991, a research consortium developed the HJD-04, a new switch type that caters to lower network levels rather than high-end urban markets such as multinationals and joint ventures products.

- The fourth phase starts focusing on Mobile Technologies. As a government-led project, the Chinese telecom industry developed a national standard for 3G, Time Division Synchronous Code Division Multiple Access (TD-SCDMA), with Ministries' encouragement. Thus, China will be able to manufacture equipment and systems using the TD-SCDMA infrastructure without signing license agreements with US and EU patent holders.

- Chinese 3G Standard; TD-SCDMA is the Fifth phase. In 2000, ITU accepted the standard created by China as a valid standard for 3G. Moreover, investments have been made in commercializing products manufactured by

Chinese companies that adhere to this standard. Cooperation has been made with companies from various different countries. Furthermore, the project includes core systems, chips, terminals, software systems, test environments, TD SCDMA mobile phones, data cards, etc., and encompasses a value chain. As such, there is a production network around TD-SCDMA, and this value chain will also bring significant value to the country's economy.

As a result of the policies mentioned above, Huawei is currently the company with the largest revenue share in the mobile telecommunications industry. Therefore, the policies implemented by China in the last few decades can be described as successful. However, different countries would also like to be manufacturers in the mobile telecommunication sector. While Turkey is one of these countries, there are a few others outside of Turkey that also carry out specific policies.

First of all, India's National Telecom Policy, published in 2012, includes innovation, R&D, and localization policies for the telecommunications sector. The objectives of these policies involve encouraging innovation, indigenous R&D, and manufacturing in order to serve the domestic and global mobile telecommunication market by increasing skills and competencies. Moreover, promoting synergies between manufacturers, R&D centers, academia, service providers and other stakeholders is another vital objective in order to ensure cooperation and reorientation in the development and deployment of new products and services[18] suitable for the Indian environment. The national plan aims to reach at least 60% (minimum value-added 45%) in 2017 and 80% (minimum value-added 65%) in 2020 by establishing a chain of domestic products in the telecommunications sector.[19]

Moreover, Indonesia continues to work on the development of the telecommunications industry by establishing innovation policies in the field of telecommunications and implementing various innovation strategies to follow the development of the recent

[18] 2G / 3G base station, SIM card, access routers, DWDM based network transmission equipment, GPON devices, microwave radio systems, network management systems, billing software for 4G broadband network and Wi-fi wireless systems

[19] https://dot.gov.in/sites/default/files/NTP-06.06.2012-final_0.pdf

technology. The innovation network was created in Indonesia to develop new products and services in the field of telecommunications, to upgrade existing 3G and 4G technologies, and to initiate 5G trials. In addition, digital services such as free quota, digital payment, big data, Smart City B2B Solution, Smart Campus, Airport Management System, e-government, and IoT Solutions are also being developed (Pramudita et al., 2019). In 2017, 4G / LTE equipment was required to contain 30-40% domestic products. Therefore, foreign companies that want to sell 4G / LTE products in Indonesia must either establish their own factories in the country or partner with local producers. This policy aims to increase the innovation capacity of the local industry (Negara, 2016). Finally, there are some policies within the scope of localization for the telecommunications sector in Brazil. The spectrum tender includes an obligation to purchase domestically produced products in networks for certain spectrum bands. This obligation starts with the conditions of 50% production in Brazil and 10% improvement in Brazil. Over time, the development rate in Brazil goes up to 20%. [20]

The limited number of examples shows that these policies include the interaction of government institutions, universities, and private companies in a system that aims to produce, spread, and use mobile telecommunications products and services within national borders. It would be correct to reconcile these policies with the national innovation system (NIS) and evaluate them in this context. It is argued that the innovation of the NIS approach exists in a system consisting of different components, and it is realized depending on the interaction of these components and the institution surrounding the whole system (Karahan, 2017). For example, India's policy document states that the academy's R&D Centers and other stakeholders cooperate for a common purpose, aiming to produce mobile telecommunications infrastructure. The case of Indonesia explains a precondition for suppliers that produce in this sector to establish factories within the country and cooperate with local companies. In this case, it can be seen that the main purpose is to ensure the dissemination of information within national borders. The experience and knowledge gained by the people working in these factories will significantly contribute to the human capital at the national level. In addition, cooperation with local companies accelerates the dissemination of

[20] https://www.anatel.gov.br/Portal/documentos/midias_teia/1101.pdf

knowledge in this sector. Within this context, it can be argued that knowledge embodied in people (as “human capital”) and technology are always at the center of economic development (OECD, 1997). These policies also indicate in which sector an innovation policy will be carried out within national borders. Policies implemented in other country examples also include targets that will shift the value-added production in the mobile telecommunications sector within national borders.

In conclusion, the annual revenue of global mobile operators is more than $1 trillion. Moreover, these companies are expected to invest around 600 billion dollars in establishing and sustaining the telecommunication network in the world. However, these products and services for mobile telecommunication infrastructure are classified as high-tech technology. A limited number of countries and companies have the capability and capacity to produce the products and services in a global scale. There are a few countries to carry out an innovation policy and the main purpose is to shift the value-added production in the sector within national borders. In this sense, different actors (academia, private and public sector, etc.) within national borders are expected to act in line with the same goal. Moreover, policies are determined in order to ensure that information in this field can flow into the country.

3.5. Localization Policies in the Mobile Telecommunications Sector in Turkey

Mobile telecommunication technologies are currently the most common communication instrument in Turkey in accordance with the global trend. The revenue of mobile operators in Turkey is approximately 50 billion TL, tripled in the last ten years, and the revenue is expected to increase in the following years.

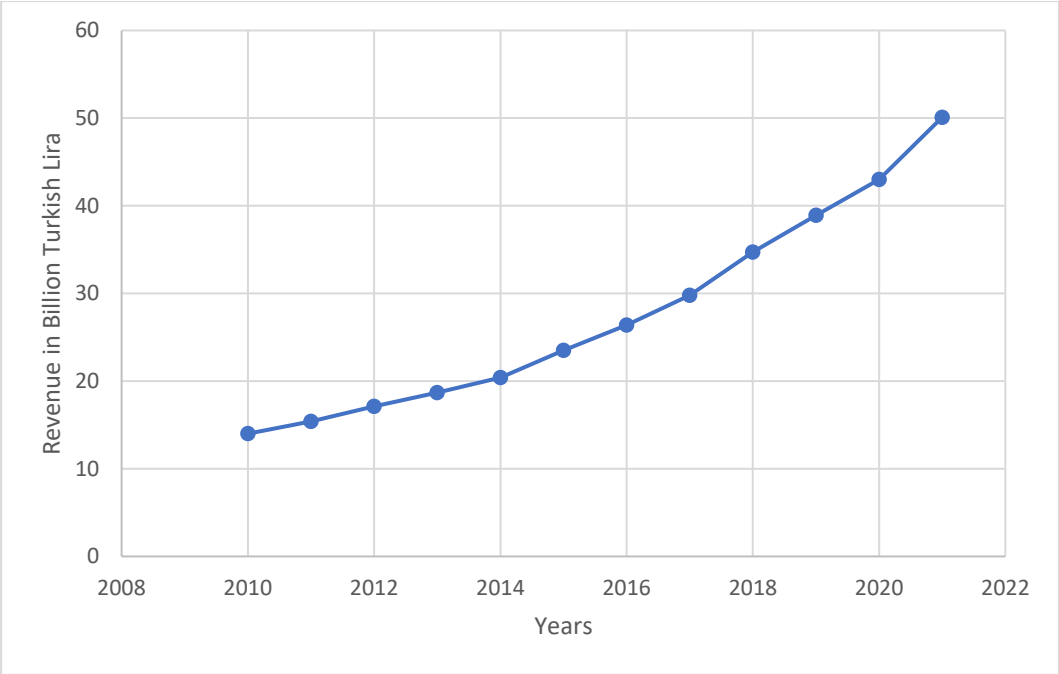


Figure-10: Mobile Operators Revenue in Turkey [21]

Source: ICTA Quarterly Market Data Report 2021-Q4

Moreover, investments in the mobile telecommunications sector, which appeals to approximately 80 million people across Turkey, continue to increase subordinately. There was a dramatic increase in investments in 2015 due to 4G auctions and related investments. Global vendors and imported items make the vast majority of these investments. Companies that have the majority of the global market, such as Huawei, Ericsson, and Nokia, have operations and R&D centers in Turkey. In this sense, Turkey has determined certain localization policies and obligations at the national level in mobile telecommunications in order to meet the needs of the sector with domestic production.

[21] The graph for the revenues of mobile operators was created with IFRS values.

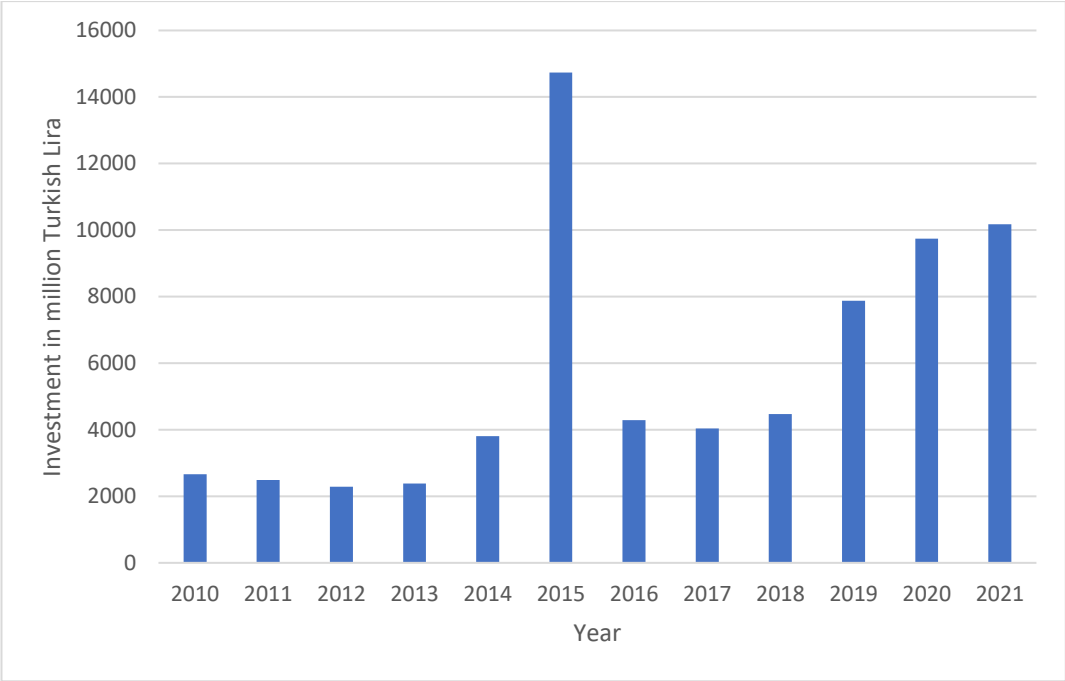


Figure-11: Mobile Investment in Turkey

Source: ICTA, Quarterly Market Data Report 2021-Q4

The localization process for the mobile telecommunications sector in Turkey started in 2009 with the 3G frequency tender. The policy for global suppliers to establish an R&D Center in Turkey is one of the unique articles in the 3G tender. Companies participating in the 3G tender are obligated to make at least 40% of their value-added purchases (ICTA determines the list of value-added acquisitions and define as in-scope list) each year from companies that have R&D Centers [22]in Turkey and employ 500 engineers. This obligation is an incentive for directing resources towards mobile telecommunications and for foreign investors to establish an R&D Center in Turkey. Moreover, the mobile telecommunication sector has determined a research direction with the policies in this sector. In addition, policymakers have established guidelines for the market structure-function by imposing minimum obligations on the market.

There is also a requirement to employ 500 engineers in the R&D centers to be established by these companies. Increasing the volume and quality of human resources

[22] In the relevant legislation, R&D Center: Is defined as a company that carries out research and development activities exclusively in the country, has sufficient R&D experience and ability, or a center organized as a separate unit within the organizational structure. No reference is made to the Law No. 5746 on Supporting Research, Development, and Design Activities.

in this field is one of the essential expectations of resource mobilization (Bergek et al, 2008). For this reason, the aim is to provide the engineers in the country with the necessary knowledge and experience in R&D activities in the mobile telecommunications sector. Among the tender conditions, there is the condition that at least 10% of the in-scope list purchases made by mobile operators every year are to be made from SMEs. This condition aims to direct the tendency of companies in Turkey towards this field in the market. This regulatory pressure on mobile operators has necessitated cooperation with SMEs. This cooperation is expected to contribute to the supervision and competence of SMEs in this sector. Moreover, it provides an opportunity for companies that want to enter the mobile telecommunication infrastructure market. In this context, we can associate this obligation with the entrepreneurial experimentation function. However, there is a legal loophole in this obligation. SMEs have the opportunity to import and sell products while cooperating with mobile operators.

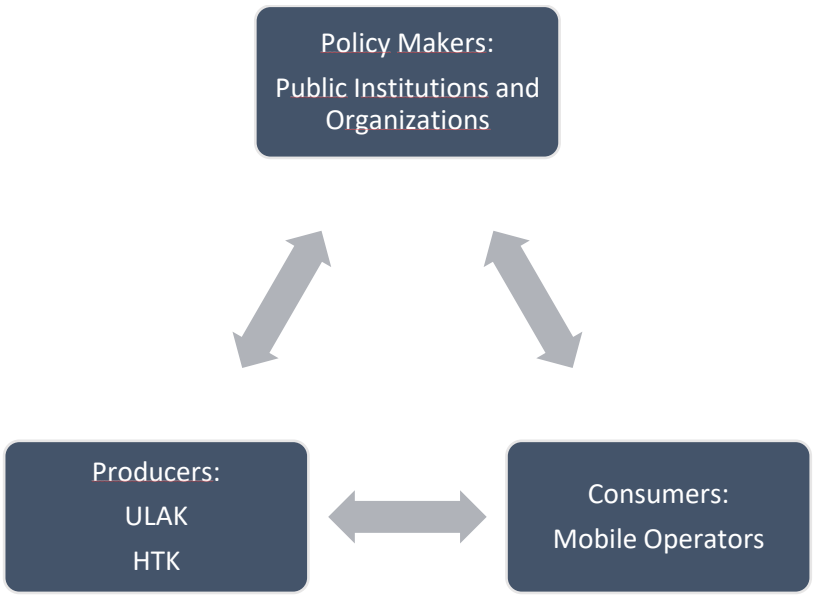
Necessary changes were made in the 4G tender to close the legal loophole which allowed SMEs to sell imported products. The 4G tender is a turning point in terms of domesticity policies in the mobile telecommunication sector in Turkey. With the 4G tender, the requirement for mobile operators to purchase 10% of value-added products from SMEs was preserved. However, purchases made from products produced by SMEs in Turkey must be included in this rate. Thus, the use of imported products in 3G has been prevented, and the domestic production requirement has been introduced. One of the tender conditions is purchasing from a supplier with an R&D Center, as in 3G. Companies that have R&D Centers in Turkey and employ 500 engineers and 250 researchers have a minimum purchase requirement of 40%.

However, the most important step towards the localization process in the 4G tender is to impose an obligation on mobile operators to purchase domestic goods. Operators authorized to participate in the 4G tender must make at least 45% of their in-scope list purchases from certified domestic products each year. A direct obligation to the market has been introduced in Turkey, and it aims to substitute high-tech products in the mobile telecommunications sector directly. Related obligation can be classified as various functions such as directing research, market formation, and entrepreneurial

experimentation. However, due to the lack of sufficient domestic supply, no operator has been able to fulfill this obligation since the 4G tender.

Starting from the 3G tender, the inability to provide sufficient supply for domestic production has revealed changes in the policies created. The innovation system has been reshaped in the form of network and actors in the new policies brought as an obligation only to mobile operators.

First, these policies include three main actors for implementing these policies in Turkey; public institutions and organizations that serve as policymakers, domestic manufacturers as producers, and mobile operators as consumers.



Under the coordination of ICTA, the Ministry of Transport and Infrastructure, the Presidency of Defense Industries, the Ministry of Transport and Infrastructure, TUBITAK, the Turkish Patent Institute, TOBB, operators, suppliers, and other relevant public institutions and organizations are positioned as the actors for the implementation of the national policies. The role of public institutions in the system, as actors, is to determine the regulations and supervise the policy studies that are carried out. For example, under the coordination of ICTA, obligations are imposed on operators within the scope of localization policies. ICTA also carries out the determination and auditing of these obligations. TUBITAK, on the other hand, gives

incentives to suppliers and R&D studies within the scope of projects. In addition, these public institutions pioneered establishing ULAK as a supplier and forming a manufacturer network of companies which cooperate within the scope of HTK. ULAK and HTK are the leading actors defined as producers within the purview of the policies determined in the country. Finally, mobile operators, which make investments in mobile telecommunication infrastructure in Turkey and play the role of consumers in this sector, are the third leading actor group for these policies.

In the National Broadband Strategy and Action Plan (2017-2020) document published by the Ministry of Transport and Infrastructure, it is stated that mobile operators are obligated to use domestic goods to provide 4G services as per the tender. The action plans in the document is compatible with knowledge development and diffusion function. In this sense, policies aim to encourage domestic production companies to develop domestic products related to the electronic communication sector and create a domestic product ecosystem. There are also action steps within this policy for facilitating domestic production and R&D activities in the electronic communication sector. In these action plans, there are issues regarding the development of incentive mechanisms for the suppliers that have the potential to produce the electronic communication networks equipment and the companies carrying out R&D activities, the development of domestic products, increasing the R&D capacity, and ultimately monitoring the development of sectoral patent rights.

Along with these action steps, those responsible for future generations have also been determined. The upcoming generation, 5G, set as a strategic target by the policy-making actors, is clearly stated in the strategy document prepared by ICTA, the institution responsible for coordination. The policies state that the mobile communication technology equipment and equipment to be used in the relevant technology must belong to a company, institution, or citizens of the Republic of Turkey established by the laws of the Republic of Turkey in the design, development, product management, and all product life cycle processes. The policies have been formed to support the R&D and production activities of the producers for the electronic communication sector within the scope of the strategic product support program with KOSGEB and TUBITAK. “End-to-End Domestic and National 5G Communication

Network Project" was created within the range of those policies. TUBITAK has supported the project with TEYTEB 101 program.

In addition, universities have also taken part in localization policies for 5G. Under the coordination of ICTA, the 5G Valley Open Test Field Project was created in the region, including the Middle East Technical University (METU), Hacettepe University, İhsan Doğramacı Bilkent University, and ICTA Headquarters in Ankara. This project aims to create an environment where universities, research centers, and entrepreneurial technology companies can test technologies related to 5G.

There is a joint 5G graduate program with METU, Hacettepe and Bilkent Universities. The program supports the stance that qualified human resources will play a critical role in developing domestic and national products and technologies with high added value. In addition, the program aims to ensure that the students will develop sustainable competency in advanced communication technologies and produce outputs in various forms such as patents, projects, and articles with their thesis studies[23].

With the policies implemented regarding 5G, it is clearly seen that both financial and human resources are directed towards this area. In addition, R&D investments and patents are supported for knowledge production and a graduate program has been established. In this context, policies for 5G can be associated with both resource mobilization and knowledge development and diffusion function.

Localization policies in the mobile telecommunications sector started with 4G. The most crucial deficiency identified in this process is insufficient domestic product supply. Therefore, actors in the role of producers are of vital importance for policies. Initially, LTE Advanced base stations, which were intended to be used for the 4G network, initiated by the Presidency of Defense Industries and developed within the scope of a national innovation project, were created to reduce dependence on imported

[23] https://www.btk.gov.tr/duyurular/5g-ve-otesi-ortak-lisansustu-destekleme-programi-2021-2022-guz-donemi-basvuru-duyurusu

products in communication technologies[24]. The project was institutionalized with the establishment of ULAK A.Ş. in 2017 In the last few years, the base stations and equipment produced by the company have been used in the networks by mobile operators who are consumers in the sector (Yıldız Ünal, 2019). However, ULAK has insufficient capacity and capability to provide the products and services used in the whole network from end to end in the mobile telecommunication sector. Therefore, HTK was established with more than 150 companies to provide products and services. Companies are classified according to their capabilities and capacities in HTK, and some are organized for specific tasks. The main goal of the manufacturers is to create an alternative for the localization of the existing infrastructure in mobile telecommunication technologies. To this end, the policy makers determined particular firms for producer roles in the system. This positions the mobile telecommunications sector as a direct area where policymakers direct research. It is also an encouring step for potential producers.

Moreover, Global Telekom ve Entegre Teknolojiler A.Ş (GTENT) [25]company was established and institutionalized in 5G technology for the End-to-End Domestic and National 5G Communication Network Project. ULAK also continues its activities within the scope of 5G and aims to finalize its process on the necessary products and services before starting the use of 5G technology in Turkey (Böcüoğlu Bodur, 2020). In this context, since there is a timing problem in regard to becoming an alternative to existing technologies, it is a more appropriate policy to work on future technologies before they are used in Turkey. Notably, goods and services are not set for future generations worldwide. Costs and risks are more reasonable for potential suppliers to enter the market for future generations. Therefore, the activities for 5G in Turkey have essential parts of the localization policies in the mobile telecommunication market.

On the other hand, the mobile telecommunication infrastructure market has an oligopoly structure, and the companies' networks are designed according to the standards determined by the limited supply. For this reason, policy studies have also

[24]http://www.sp.gov.tr/upload/xSPTemelBelge/files/lxlRY+Ulusal_Genisbant_Stratejisi_ve_Eylem_Plani_2017-2020.pdf

[25] https://gtent.com/tr/hakkimizda/gtent-nedir

been carried out to push the demand by the consumers in the sector. To provide mobile telecommunication services in Turkey, authorization or concession must be obtained through frequency auctions organized by ICTA. In each tender, important responsibilities and obligations are brought to the companies. Localization policies in the sector have been subjected to these tenders. Mobile operators in Turkey are obligated to make at least 45% of the purchases defined within the scope[26], after obtaining their 4G Authorization Certificates from domestic productions (determined by certification), at least 10% from companies manufactured by SMEs in Turkey. ICTA published the producers and principles for these obligations. The mobile operators in Turkey report the infrastructure purchases to ICTA annually.[27] According to the procedures and principles, the obligation ratios are audited by ICTA.

Moreover, the obligations are associated with certain products for the mobile telecommunications industry. The mobile operators can fulfill their obligation of domestic goods and SMEs by purchasing from certain product list groups. These product lists, determined by ICTA, also include the high added value in the mobile telecommunication sector. These product groups, which are called the in-scope lists, are listed below;

1. Base Station Security Systems,
2. Energy and Air Conditioning Systems,
3. Communication Services (Software and Hardware)
4. Network Systems,
5. Transmission Systems (software, hardware).

These titles also contain many hardware and software products and services for network and communication services, excluding investments in the nature of poles, pipes, channels, energy transmission lines, and similar facilities on the mobile telecommunication network.

[26] After the 4G tender in Turkey (2015), the domestic goods obligation is a minimum of 30% in the first year, 40% in the 2nd year, and 45% in the 3rd and subsequent years.

[27] 1-year period starting from October 2015.

Since the in-scope list is subject to the obligations of high-tech products, they are suitable for their purpose in localization policies for mobile technologies in Turkey. However, the controls regarding the obligations based on the domestic products certificate criteria are made over the invoicing. Domestic product contribution rate is calculated by subtracting the final product cost from the imported input cost and dividing this result by the final product cost. In this calculation, if the domestic contribution rate of the product is at least 51%, the relevant product can receive a domestic product certificate. However, it is not possible to accurately measure the added value in that product and the result of the innovation activities. Moreover, the obligations of mobile operators are calculated based on an invoice. It is calculated by proportioning certified domestic products and purchases made from SMEs within the total in-scope purchase. There is no control over whether investments made for liability are used in mobile operators' networks.

The aforementioned domestic goods and SME liabilities of mobile operators were recently audited by ICTA. Audit results have been published as Information Technologies and Communication Board Decision[28]. In the published Board Decisions, it can be seen that since 2016, with the beginning of the 4G Authorization, mobile operators have been fined both for not fulfilling their obligations to use domestic goods and for not meeting their SME obligations.

This thesis assumes that the most critical factor in not fulfilling the obligations is the insufficient domestic supply of the industry. In addition, it is evaluated that the products produced are not technically competent enough to be used in the operators' networks.

At the beginning of the obligation, mobile operators had to develop and plan their infrastructure for a new generation, 4G. Since the competition in the mobile operator market is relatively high, mobile operators had to establish their networks within the shortest time. Since there was no domestic alternative to global infrastructure

[28] https://www.btk.gov.tr/uploads/boarddecisions/idari-yaptirim-2016-2017-donemi-3g-4-5g-yatirim-yukumlulukleri-denetimi-ar-ge-denetimi-tt-mobil-turkcell-vodafone/248-2020-web.pdf

suppliers, mobile operators preferred the products of these suppliers. This brings out a controversial issue about the effectiveness of obligations in the innovation policies.
In fact, the aim of the obligations is compatible with the targets of the innovation policies. The infrastructure market is still an oligopoly in Turkey and is dominated by limited firms. The infrastructure of mobile operators in Turkey has been saturated by global suppliers. These suppliers' infrastructure equipment cannot be easily shifted by an alternative company's products. This technical and economic issues are also a significant barrier to entry to the infrastructure market in the mobile sector in Turkey. Without the obligations, it is unlikely that mobile operators in Turkey would prefer a domestic alternative due to severe barriers to market entry. Therefore, the obligations are assumed to be an essential part of the policy design. On the other hand, the ratio of the obligations is determined without measuring domestic supply in the sector. The most important reason for not meeting the obligations is the failure to measure the domestic supply in the country while designing the policy. Although there were significant developments in this regard, no supplier group would provide domestic supply in the sector. For this reason, compelling obligations were imposed on mobile operators while designing the policy. When creating a policy at the national level, the best options for all actors involved in an effective innovation system should be considered. Moreover, although the purchase of domestic goods has been established as an obligation, the technical competencies and performances of domestic products are also important for localization processes. Otherwise, even if mobile operators make purchases within the scope of the obligation, they may not use the product in their networks. Thus, sufficient domestic supply and required product and service quality should be provided for the products of global companies to substitute.

In addition, indirect obligations are imposed on global suppliers operating in Turkey. Mobile operators have to make at least 40% of their in-scope purchases annually from companies that have R&D centers in Turkey and employ 500 engineers and 250 researchers. Only global suppliers Huawei and Ericsson can fulfill the requirements for this obligation in Turkey. Only global suppliers Huawei and Ericsson can fulfill the requirements for this obligation in Turkey. This obligation with high purchase requirement encouraged global companies to establish R&D Centers in Turkey. It also supports the employment of engineers and researchers in the mobile

telecommunications sector. The primary purpose of this obligation is the knowledge transfer in the domestic supplier market. It will increase the innovation ability and capacity of educated and experienced human resources in the mobile telecommunications sector in Turkey. However, imposing a high annual purchase obligation of 40% on mobile operators contradicts the localization efforts. The primary purposes of this obligation are to enable trained human resources to create local alternatives or guide them towards domestic suppliers such as ULAK and HTK. In this context, even if domestic resources such as ULAK and HTK provide a particular production capability and capacity, it is an obstacle for mobile operators to shift their investments to these companies due to their purchasing obligation. This situation is a barrier for domestic companies to increase their market shares. Moreover, mobile operators have a 45% obligation to purchase domestic goods. When these two obligations are evaluated thoroughly, inconsistencies emerge in the infrastructure purchases of mobile operators.

At the beginning of 2022, ICTA published certain amendments within the legislation's scope which monitored the operators' obligations. These new regulations are based on evaluations that emerged as a result of experience with existing policies.

First, “National Communication Product” has been defined within national innovation policies and added to the legislation and literature. The new concept states that a product in the mobile communication sector should be developed with a national contribution in all processes, from design to development and product management. In addition, the intellectual, industrial, property, and usage rights of the product must belong to a company, institution, organization, or citizen of the Republic of Turkey established in Turkey. However, the concept of nationality is uncertain, and there is no straightforward, concrete content to measure it.

There are also regulations for reducing the path dependency and barriers to entry to the market in the amendments made. The total investment of an operator in a supplier’s network and communication services cannot exceed 50% of the operator's share in total assets. This article aims to prevent bulk purchases from global suppliers that dominate the market. The reason why this ratio is determined as 50% and cannot be

lowered is another obligation; the obligation to purchase from companies that have R&D centers and employ a certain number of engineers and researchers. Only global suppliers can meet the requirements for R&D obligation. According to the obligation from these suppliers, there is an obligation to purchase at least 40%. Moreover, there are additional obligations imposed on operators to enter the infrastructure supply market in the regulations. Mobile operators are obligated to provide information on procurement procedures and platforms and to announce all tender and procurement information to the bidders via an interface or internet connection in a way that trade secrets are not revealed. Since a limited number of companies dominate the infrastructure market and work directly with operators, it is very difficult for a new firm or enterprise to enter the market because most products are purchased with a direct purchase method. In this case, a supplier cannot find the opportunity to market its product. The amendments constitute a solution to market entry barriers. It is necessary to conduct a risk analysis on the issues of ensuring supply chain security and removing supplier dependency regarding the software and hardware used by the operators in their network, and submitting the evaluation report and the report containing the measures taken regarding these issues to the regulatory authority. Although the purchase limit is imposed to prevent excessive commitment to certain manufacturers in the sector, measures for market entry barriers and risk analysis are good solutions for domestic manufacturers in the country to enter the market. However, these measures have not yet been experienced and audited by an operator in a reporting period. For this reason, the results of these policies can be evaluated together with concrete examples in the following investment periods.

Finally, new regulations were made for R&D Centers and Projects. These regulations state that the purpose, scope, and outputs in R&D projects must be in line with our country's goals and strategies for developing a domestically certified and national communication product ecosystem. R&D projects carried out by mobile operators must comply with this issue. Additional criteria have been introduced for the R&D projects carried out by the operators within the scope of the operators' obligations. R&D projects must have at least one of the following items;

• R&D projects must contribute to the obligations of the Operator regarding locality.

• R&D projects should contribute to developing a domestically certified and national communication product ecosystem in our country.
• It is essential that SMEs take part in R&D projects and contribute to SMEs' competence.
• It is essential that universities participate in R&D projects and contribute to them.
• As a result of R&D projects, products and tangible benefits should be revealed, and these products and benefits should have the potential and quality to replace equivalent imported products.

In addition, 36 months have been set for the completion of R&D projects, and it has been stated that projects exceeding this period will not be considered within the scope of obligations.

The clauses added to the R&D obligations reveal the expectations from an R&D project more clearly than the previous policies. Before the changes, the details of the R&D projects in the procedures were not properly laid out and appeared vague. The explicit inclusion of the concept of national communication product here also shows how it is associated with strategic goals. In R&D projects, the expectation regarding the substitution of imported products has been reinforced.

Moreover, university collaborations in R&D projects have been one of the possible conditions for accepting a project. The role of universities in localization policies in the mobile telecommunications sector has not been clear from the beginning. Universities are arguably one of the leading actors in producing knowledge and technological innovations. While creating an innovation policy for a sector, universities are an important actor in the policies, but there is no decisive policy regarding studies in the mobile telecommunications sector. It is imperative to cooperate with universities for the acceptance of R&D projects to be carried out by the operators. Universities can understand the infrastructure market's needs and guide their R&D investments. Numerous official studies over the years also prove the positive impact of university collaboration in R&D on firm performance. The possibility of developing new products and technologies for companies that cooperate with universities in R&D is also increasing.

Similarly, cooperation in R&D projects with SMEs is an application that can increase these companies' innovation capabilities and capacities. In addition, companies can understand the sector's needs more clearly and realize their future investments by collaborating with the operators. SMEs have a solution to overcome the path dependency that prevents them from entering the market.

In conclusion, mobile telecommunication technologies have taken the lead in the communication market in Turkey. The companies in the sector earn approximately 40 billion TL annually, and they also spend 10 billion of that on investments. Therefore, specific localization policies have been established at the national level to meet the needs of the mobile telecommunications industry in the country. Under the coordination of ICTA, public agencies, mobile operators, and manufacturers are the main actors creating an innovation ecosystem in the sector. The purpose of these action policies is to enhance the use of domestic products by increasing the R&D capability and capacity in this field. In this sense, two main actors have been determined to be producers in the sector; ULAK and HTK. However, the supplier market in the industry has a path dependence on global companies. Therefore, mobile operators are obligated to use domestic products and purchase from SMEs. There is not enough supply for these two obligations, but international suppliers dominate the market, and these obligations are possible solutions to overcome market entry barriers. Moreover, an indirect duty has been imposed on global manufacturers, and they have to establish an R&D Centre in Turkey with 500 engineers and 250 researchers. The aim is to transfer knowledge and train human resources in the sector. Overall, the obligations are generally reasonable within the framework of an indigenization policy. However, obligations cannot be fulfilled due to the lack of sufficient domestic supply in the mobile telecommunication sector in the country.

3.6. Conclusion

The history of telecommunication, which started with the electric telegraph in the 19th century, continues its journey with fixed telephone and mobile telecommunication technologies today. Telecommunication technologies, which have received heavy investments globally since the 20th century due to the communication opportunities,

are constantly developing. Mobile telecommunication technologies, which started with 1G in the 1980s, are the most effective communication method. Different generations have emerged in just a few decades, and currently, the most widely used mobile telecommunications technology is 4G. In each generation, the opportunities and capabilities offered have developed. With 4G, data consumption has become an effective and widely used service type. 5G, on the other hand, is still in the early adaptation period in the world and promises to dramatically increase the speed and capacity of data service.

Mobile telecommunication technologies infrastructure equipment, which has billions of users and a very dense network structure worldwide, is produced in a limited number. A few large global firms own almost all of the market. An innovation system is required to manufacture infrastructure equipment classified as high-tech products. Many countries that want to operate in this field carry out innovation policies. Policies carried out in many countries such as India and Indonesia aim to increase the R&D capability in this field by making value-added production domestic and through human resource training. According to national innovation policies, countries have set mobile telecommunication technologies targets and directed research to this sector. Moreover, they aim to develop competence in this field by mobilizing the resources.

Turkey has set a strategic target for the mobile telecommunications sector. The policies have started as obligations with the SME purchase requirement imposed on mobile operators in 2009 and the condition of working with suppliers with R&D centers. Procedures were also reinforced with the responsibility to purchase domestic goods in the 4G tender in 2015. Despite the commitments, the methods could not achieve the desired results due to Turkey's insufficient domestic supply. Therefore, an innovation network was established, including public institutions, suppliers, and mobile operators. Public institutions have made policy revisions, and 5G, the future technology, has been determined as a new strategic target. ULAK was established, and HTK, a cluster formed by many companies producing in the sector, was defined as the supplier. GTENT company also participates as a stakeholder in policies as a manufacturer for 5G targets. Although there are domestic manufacturers in the sector, global suppliers have most of the infrastructure market. Obligations of mobile

operators have been determined as a policy tool to prevent market entry barriers. The requirement to purchase domestic goods with documents and purchases from SMEs are concrete examples.

Moreover, recent changes have imposed an upper limit on investments made by a supplier. The definition of a national product has been added to the policies, and the content for R&D projects was detailed. Several options have been identified for the acceptance of R&D projects. These options include university cooperation in projects or collaboration with SME companies. In addition, the projects' concrete contribution to the country's localization efforts needs to be proven. Finally, there are R&D centers which employ a certain number of engineers and researchers. These R&D centers belonging to global suppliers are an essential policy tool for directing the human resources in the country towards the mobile telecommunications sector. This aims to improve the volume, experience, and abilities of the human resources in this sector. Many policies implemented towards the mobile telecommunications sector in Turkey have not yet produced the desired results. The other chapters will discuss which policies can be applied for future technologies by analyzing the items that need to be developed and the working items in the policies implemented.

CHAPTER 4

METHODOLOGY

The objective of the thesis is to analyze the performance of localization policies in the mobile telecommunications sector. A qualitative research method was preferred for the data source to be used in this analysis. The qualitative approach is used to understand people's beliefs, experiences, attitudes, behaviors, and interactions and to produce non-numerical data (Pathak, et al., 2013). There are several methods for obtaining data in qualitative research: observations, interviews, surveys, focus groups, participant-observation, recordings, and document analysis.

In this thesis, the semi-structured interview is the primary resource used to obtain data. Interviews provide in-depth information on participants' experiences and perspectives on a particular topic (Turner III, 2010). Therefore, within the scope of the research, policy evaluations were made by interviewing experts from different actors. Semi-structured interviews are supported by secondary data and document analysis methods. The remainder of this part will explain how the research was conducted by giving detailed information about the interviews. Moreover, it provides information about secondary data sources and details, and the content of document analysis.

4.1. Secondary Data Analysis

Secondary data was used to analyze the effects of policies on the mobile telecommunications sector. This data was collected from reliable and international standards-based data sources such as the World Bank, ICTA Market Data, TURKSTAT, OECD. The time periods of the data collected from these sources

coincide with the implementation dates of the policies. It would be misleading to use a large time frame as the policies for the sector are not very old. In addition, mobile telecommunication is placed as a sub-category of the ICT sector in data sources. For this reason, ICT data, which is more inclusive, has been examined for data without mobile telecommunications classification. However, the content and details of the ICT data were examined. Only the information sources that are considered to provide accurate information on the mobile telecommunications sector were used. The relationship of all secondary data used with the mobile telecommunication sector, which is the subject of the thesis, has been checked.

4.2. Semi-Structured Interviews

A semi-structured interview, conducted through conversation with a participant, uses closed and open-ended questions, often accompanied by why and how questions. This method analyzes how the participants perceive the subject and understands their expectations. In this thesis, semi-structured interviews were conducted with representatives of the actors of the innovation network[29]:

1. The representatives of public institutions responsible for coordinating policy documents on mobile telecommunication technologies.
2. The representatives of mobile telecommunication companies which are consumers and mostly subject to the obligations.
3. ULAK and HTK representatives.

For the semi-structured interview, the participants were selected from the policy units of the actors. Participants manage operational processes for policies in institutions/companies. Operational processes include reporting, ensuring compliance in institutions/companies, managing official relations between actors, and exchanging views on policies. In this context, the participants both have experience with existing policies and participate in potential policy studies as stakeholders. Moreover, the

[29] The interviews were conducted with a total of 16 participants, and the actor-based distribution of the participants is not shared upon their request.

participants have at least 7 years of experience since 2015, the date of publication of their domestic goods obligations. The reason why the participants with the most industry experience are preferred is to compare the situation before the policies and the current situation and to get information about the development processes of the policies.

Moreover, the questions to be asked to each group of actors are different. The specific questions aim to learn each actor's experiences, concerns, and expectations regarding policies. In this way, policy recommendations intend concrete improvements rather than theoretical information.

The pilot interviews were conducted to get feedback on the prepared draft question sets. After the input, the question sets were finalized. Interviews were conducted in Turkish, the mother tongue of the participants. The question sets prepared for each actor group and the functions associated with these questions are given in the tables below.

First of all, the question set of semi-structured interviews with policy makers is given below. The question sets for policy makers are mainly about the fundamental motivation behind these policies and how the analyses of the policies are carried out while creating a policy. It focuses on their expectations from the policies and their experiences while implementing the policies. In addition, the questions aim to obtain information about the relations of policymakers with other actors. The evaluations of policymakers regarding their own roles in the system are also included in the question set. The questions in the table below have been prepared as general and inclusive. However, with the information received from the participants during the interview, the subject was detailed and additional questions were asked.

Table-2 Questions of Semi-Structured Interviews with Policymakers

Questions	Related Function(s)	Main Objective of Question(s)
What is the main objective of the incentives and obligations applied to the mobile telecommunication sector?	F2, F5	To understand the primary purpose of the policies.
What Is your role in production policies in the mobile telecommunication Industry as a state regulatory body?	F1, F2,F3,F5	To understand policies and expectations to establish producers as firms and networks; ULAK and HTK.
How do you evaluate the effects of policies including incentives and obligations Implemented In the sector In terms of producers and consumers In the current situation?	F1, F2, F5	To understand how policymakers value the impact of other stakeholders.
Certain international companies (Huawei, Ericsson and Nokia etc.) In terms of Infrastructure production in the sector have created a path dependency and this creates an important barrier for a new company to enter the market. How do you evaluate the policies Implemented In this sector In our country and the entry of a domestic company Into the market?	F3, F4	To understand how local producers overcome market entry barriers through policies.
Do you find current policies successful?	F1, F2,F3,F5,F6	This question includes many subtitles, but the basic expectation is learning how policies contribute to innovation capacity and ability.

Table-2 (Continued)

As a policy maker/regulatory organization, how do you perform the operations and evaluations of existing policies?	F2, F3	To understand how policy impact analysis is done.
Policy changes were made In 2022; the concept of "national communication product" has been defined, and the content and scope of R&D projects have been expanded by detailing. What are the reasons and expectations in this policy and legislative arrangement?	F1,F2,F5	Controlling the main motivation in policy arrangements.
The 5G project includes collaborations with universities, operators In the Industry and many manufacturers. What are your main expectations from this project?	F1,F2,F5,F6	To learn the timeline for 5G and to understand how this policy applies to next generation technologies.
What changes would you personally make to existing policies?		To get personal opinions.

The questions prepared for the producers are listed below. The questions are primarily aimed at understanding the impact of innovation policies on production capabilities. In the current market, certain companies have a path dependency and an oligopoly structure. There are questions about what kind of policies have been followed to overcome market entry barriers and their consequences. Moreover, manufacturers' plans in this sector are also discussed. As in the previous table, the prepared questions are general, inclusive, and classified on the basis of function. Additional questions were asked within the scope of semi-structured interviews and the topics were detailed.

Table-3 Questions of Semi-Structured Interviews with Producers

Questions	Related Function(s)	Main Objective of Question(s)
How would you describe your role in the mobile telecommunication industry?	F1,F3,F5	To understand how producers evaluates their roles.
Could you please Inform us If there are any policies, Incentives, and obligations that directly affect you as A producer in the sector?	F1, F2, F3, F4, F5	To understand the overall evaluation of policies in terms of producers' perspective.
There are international companies that dominate the market in the mobile telecommunications sector. In this context, what is the biggest barrier you face to enter the market?	F3, F4	This question includes many sub-topics, but the main expectation is to perform the assessment of market dynamics.
International companies operating in our country are obligated to establish an R&D center and employ engineers and researchers. Does your company have personnel who have worked in these companies before?	F1, F6,	To learn the impact of policies on knowledge dissemination and human resources.
Which of the implemented policies (incentives, obligations, etc.) are the most effective for producers?	F1, F2, F3, F5	This question contains many sub-topics but the main expectation is to understand what policies are being implemented to ensure knowledge production by improving the capabilities of producers.

Table-3 (Continued)

As manufacturers, do you cooperate in projects with universities or different institutions/organizations?	F1, F6,	To learn about other stakeholders producing knowledge.
Do you have a role and expectation as a manufacturer for 5G?	F2, F5	To cross check the expectations of policy makers and producers.
As manufacturers, do you have plans for the short, medium and long term?	F5	To understand the consistency of policies.
How do you evaluate the current policies of policy makers as producers and what are your suggestions for future policies?		To get personal opinions.

Mobile operators are most affected by the policies as a obligations. Consumer inquiries are prepared as a liability assessment and include general policy considerations. In addition, it is also discussed how the domestic product supply as a consumer has changed as a result of the policies. The actor who experiences the concrete outputs of the policies is the consumers. For this reason, the evaluation of existing policies was carried out in detail. As other actors were asked, there are also questions regarding the interpretation of changes in policies. In this context, the questions created for consumers are also shown in the table below.

Table-4 Questions of Semi-Structured Interviews with Consumers

Questions	Related Function(s)	Main Objective of Question(s)
How do you see your role in the sector?	F1, F2, F3, F5,	To understand how producers evaluate their roles.

Table-4 (Continued)

Could you give information about the policies/incentives and obligations implemented in the sector, and the issues that affect you in terms of your position in the sector?	F1, F2, F3, F5	To understand the overall evaluation of policies in terms of consumers' perspective.
There are international companies that dominate the market in the mobile telecommunications sector. What are your evaluations regarding the effectiveness of the implemented policies in breaking the dominance of these companies?	F3, F4, F5	To understand market dynamics.
What is the number of companies that enter the market as a manufacturer and what are the product ranges of these companies?	F3, F4, F5	To understand market dynamics and the variety of manufacturing companies and products.
As consumers, you have an obligation to purchase CERTIFIED domestic goods and SME products. Do you find these obligations effective in creating production in the mobile telecom sector in the country?	F1, F2, F5	
What are your assessments regarding whether domestic producers have an impact on policy makers and are effective in policies and regulations on the subject?	F2, F5	To evaluate current policies.
Policy changes were made in 2022; the concept of “National Communication Product” has been defined, and the content and scope of R&D projects have been expanded in detail. What are the reasons and expectations in this policy and legislative arrangement?	F1, F2, F5	Controlling the main motivation in policy arrangements; did the inadequacy of knowledge production with domestic resources cause these regulations?

Table-4 (Continued)

What are your expectations with the 5G project in the infrastructure market?	F1, F2, F5	To cross check the expectations of policy makers and producers.
How do you evaluate the current policies of policy makers as producers and what are your suggestions for future policies?		To get personal opinions.

Interviews with representatives of different actors were carried out within the framework of the aforementioned questions. The collected information forms an important part of the research method. Another method related to the research method is explained in the next section.

4.3. Document Analysis

Document analysis, a form of qualitative research, is a systematic procedure for analyzing documentary evidence and answering specific research questions (Frey, 2018). In this thesis, a detailed analysis of the policy documents, regulations, board resolutions and reports prepared by various institutions and organizations for the mobile telecommunications sector has been carried out. Among these documents are the National Science, Technology and Innovation Strategy, the National Broadband Strategy and Action Plan, the quarterly reports published by ICTA, the procedures and principles by which the consumers control the localization policies, and the board decisions obtained as a result of the inspection of the consumers. In addition, the reports of many national organizations such as TOBB and TUSIAD were also examined. In these reports, data such as policy articles related to the mobile telecommunications sector are referenced in different parts of the thesis.

4.4. Conclusion

In summary, quantitative research methods for this thesis include a semi-structured interview, secondary data, and document analysis. Semi-structured interviews were conducted with the representatives of actors in the system defined for the mobile telecommunications sector. They are experts in the work of these representatives in policy-related units and carrying out policy processes. However, as with most studies, the current study's design is subject to limitations. As the author of this thesis, I work as an expert in one of the actors defined in the innovation network in the mobile telecommunications sector. This situation imposes certain limitations on the interview method while conducting my research. I have specific commercial and technical cooperation with the actors to be interviewed within the scope of the study. Therefore, the participants may have concerns due to commercial competition and confidentiality. In this sense, the field study was approved by the METU Human Subjects Ethics Committee. The participants were informed about the subject of the research. Maintaining the participants' confidentiality and anonymity are also crucial (Black, 1999, as cited in Rahman, 2020). The interviews do not include the financial questions that would affect commercial competition.

As a result, information was collected through semi-structured interviews, secondary data, and document analysis methods. The collected information and well-functioning policies and barriers regarding the mobile telecommunications sector are discussed in the next section of this thesis.

CHAPTER 5

FINDINGS

This chapter will discuss the results of localization policies in the mobile telecommunications sector. The discussion will include the obligations within the system, producers, audit mechanisms, and practices of public institutions, which are described in Chapter 3. As a result of these practices, drivers and barriers in the system will be identified as findings. Findings will be classified according to the functions described in Chapter 2.

5.1. Knowledge Development and Diffusion (F1)

Knowledge development is the primary function of how well a TIS works. Besides, disseminating information within the system is necessary to ensure the system's integrity. In this sense, the policy documents contain specific action steps for developing knowledge. R&D supports potential producers, promotes university-industry collaboration, and grants patents which are fundamental issues in these action steps. This section analyzes the results of these policies.

First of all, the expenditures on R&D activities in Turkey have been increasing steadily over the last decade. According to the data obtained from TURKSTAT, the ratio of R&D expenditures to GDP exceeds 1%. The chart below indicates the classification of expenses made for R&D from the central government budget according to socio-economic status. The share allocated to the telecommunication sector is shown together with the transportation and other infrastructure components. The percentage of the whole cluster from the total budget is only 6.7%. The most extensive funding is allocated to universities for general knowledge development.

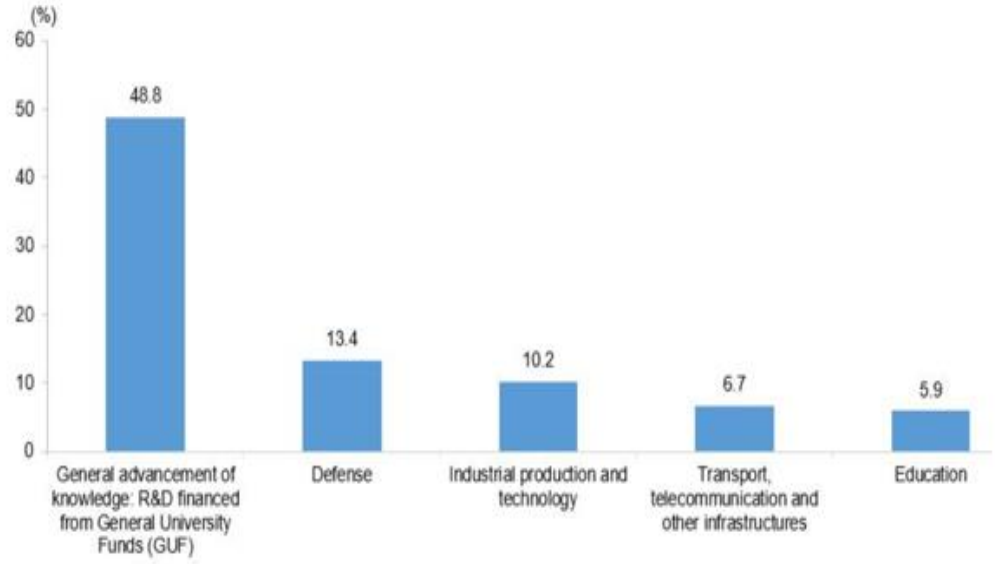


Figure-12: Top Five Socio Economic Objectives By R&D Expenditure in Turkey in 2020

Source: TURKSTAT, Appropriations and Expenditures Allocated for R&D Activities from the Central Government Budget

On the other hand, the business enterprise can also allocate resources to R&D activities. In this context, business enterprise R&D expenditures by the telecommunications sector have been analyzed with data from the OECD. As seen in the chart below, the R&D expenditures of business enterprises reached around 600 million Turkish Liras in 2015. However, the resources allocated by business enterprises decreased dramatically in the following years.

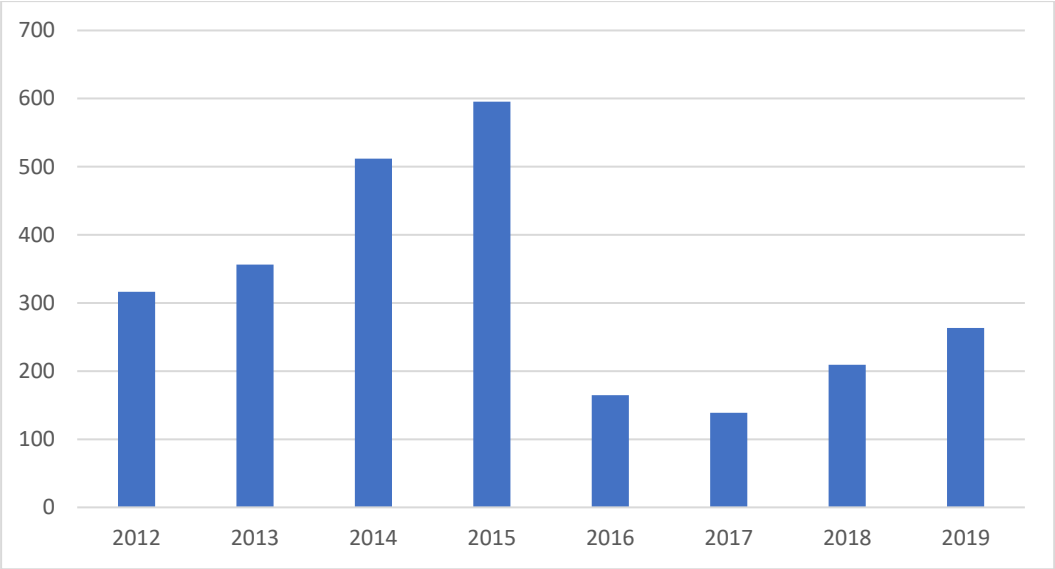


Figure-13: Business Enterprise R&D Expenditure by Telecommunication in Turkey
Source: OECD, Business enterprise R&D expenditure by Industry

As a result, R&D expenditures for the telecommunications sector are not very high both in the public budget and the budgets of business enterprises. No significant change has been observed since 2015, although the 4G tender was held in 2015, mobile operators were obliged to use domestic goods. Moreover, many policy documents were revised after this date, and policies were consolidated. While R&D expenditure statistics are expected to provide evidence of an increase in investments, the opposite trend is observed.

R&D support policies were also discussed in the interviews with the representatives of the producers. The interviewees stated that most companies benefit from R&D supports within the scope of TÜBITAK 1501 (TÜBITAK Industry R&D Projects Support Program)[30] and 1507[31] (TÜBITAK SME R&D Initial Support Program) programs and also for the End-to-End Domestic and National 5G Project (UUYM5G project). In this context, an interviewee representing a manufacturer note that:

[30] https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1501-tubitak-sanayi-ar-ge-projeleri-destekleme-programi

[31] https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1507-tubitak-kobi-ar-ge-baslangic-destek-programi

> *TUBITAK has programs for R&D support. There is also export support from the Ministry of Commerce. KOSGEB has employee support. However, it is very difficult to get these supports and the criteria for incentives are not applicable. The supports are overregulated.*

Another interviewee from different manufacturer confirms acknowledges similar R&D supports:

> *TUBITAK has support for projects, and we benefit from some of them. However, we prefer the government to buy and use our products instead of support and incentives. The supports are included in the project stages and are not sufficient for the commercialization of the product. When we applied for production-based R&D support, the product was not supported. It is necessary for the commercialization of the projects and the actual use of the products in the field.*

The data obtained from the interview brought up a different perspective on R&D support. Although the statistics do not directly show the R&D support in the sector, the interviews reveal specific R&D support programs. However, it has been emphasized that there is overregulation in the procedures for R&D support. These procedures and regulations discourage companies from applying for support programs. Moreover, R&D supports are at the project stage, and there is no support for the commercialization of the products. Among the application criteria for the TUBITAK 1501 and 1507 Support, there are articles related to the commercialization of the product. Commercialization potential has been identified as an essential indicator for project acceptance. It is aimed to develop products with strong commercialization potential. However, TUBITAK has not published up-to-date information on the commercialization rates of supported projects. In this sense, commercialization is associated with moving R&D from the laboratory to the stage where it can find application in an industrial setting (Cornford, 2002). In particular, policies in the mobile telecommunications sector aim to develop domestic products and technologies to replace the products of global manufacturers. Therefore, outputs of supported R&D should be monitored and supervised meticulously.

In addition, a collaboration between universities and industry is perceived as a way to foster innovation through knowledge exchange (Ankrah, Omar, 2015). The highest share of R&D expenditures from the central budget in Turkey is also allocated to

universities. Therefore, policymakers underline the importance of including universities as a stakeholder in projects carried out for the sector, both in the National Broadband Strategy and Action Plan and in the interviews.

However, the collaboration between universities and industry regarding R&D activities remains low compared to countries such as China and Sweden, where major producers are located. The chart below was created with data from World Bank and showed university-industry collaboration performances. Although Turkey's version is slightly above the world average, it is far below the performance of the major manufacturing countries. Because there is no data on the sub-division of the mobile telecommunications sector for university-industry collaborations, it has been discussed in the interviews.

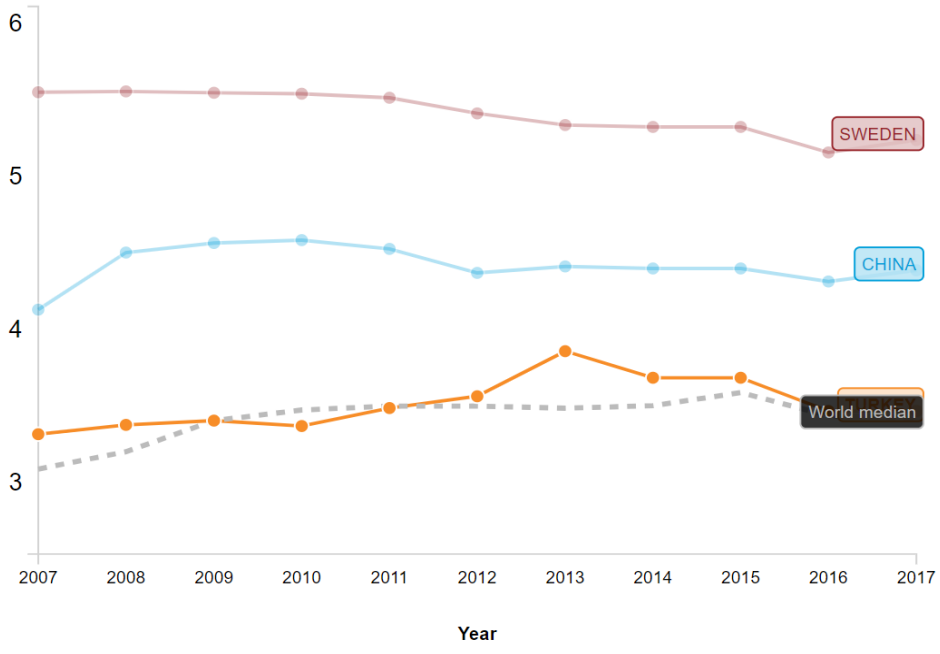


Figure-14: University-Industry Collaboration Performance in Research & Development

Source: World Bank, University-Industry Collaboration in Research & Development, Index

First, university collaborations were discussed in the interviews with the manufacturers. The representatives stated that although there are certain universities in the project within the scope of 5G, university-industry cooperation is insufficient.

Moreover, it has been noted that HTK has recently established an academic working group within itself. This working group aims to promote collaboration with universities and increase academic research in the sector.

On the other hand, the latest legislative amendments were evaluated in the interviews with the representatives of mobile operators. The university's project cooperation is an additional criterion for accepting R&D projects. One interviewee on this subject:

> *There is not much cooperation with universities in R&D projects. It is seen as a deficit by the regulatory body. This is why there has been a change in the regulations and added the criterion of cooperation with universities. However, these changes were brought as obligations. Universities are not motivated to cooperate on projects with manufacturers or operators.*

In addition, the policymakers pointed out the project with the Higher Education Institution (YÖK) to solve the lack of university-industry cooperation. In this context, there are commission decisions for the telecommunications sector in the Action Plan on Development of University-Industry Cooperation[32] published by YÖK in 2021. The focal point of their decisions is to increase university-industry cooperation in the determined areas for the future technologies. It also aims to increase the efficiency of experienced industry representatives in supervision mechanisms of R&D activities carried out within the scope of University-Industry cooperation. It also emphasized the dissemination of cyber security and information security departments in universities.
In summary, although university collaboration is not at the desired level in the sector. The additional responsibilities have been given to the system's actors for improving performance of university-industry collaboration performance. Public institutions take action steps in different policy documents to overcome this deficiency.

Finally, the patent is a critical indicator for knowledge development. Standards and patents have an essential role in the dominance of Chinese companies in the mobile infrastructure market. As explained in detail in Chapter 3, Chinese companies have changed the game when they set standards in the infrastructure market with 3G. Therefore, companies that set the standards and hold patents on this subject are at the

[32] https://www.yok.gov.tr/Documents/Yayinlar/Yayinlarimiz/2021/universite-sanayi-isbirliginin-gelistirilmesi-eylem-plani.pdf

forefront of the industry. In this context, a domestic manufacturer representative stated the following:

> *We were followers in terms of the patents. We want to be at the same level as competitors regarding standards and patents in 5G. With 6G, we want to be the market leader. A graduate program has been started with Medipol University and Istanbul Technical University for standard studies for 6G. As a result of these studies, we want to set standards by obtaining patents. In this way, we will be able to negotiate with global companies.*

Similar answers were given in interviews with representatives of other actors. The importance of obtaining a patent and set standards were emphasized. Moreover, many policy documents contain disclosures and references to patents. In this context, 6G, which does not have a global standard yet, is a realistic target. However, in the interviews, no concrete output related to patents could be shown as a result of the policies in the current situation.

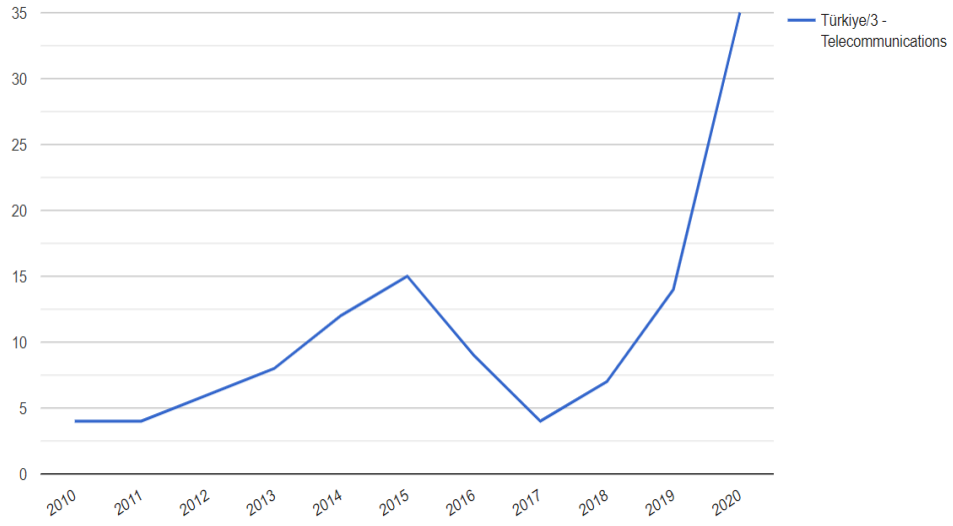


Figure-15: Patent Grants by Telecommunication, Turkey Total Count by Applicant's Origin (Equivalent Count)

Source: WIPO IP Statistics Data Center, Patent grants by technology

The table above shows the number of patents Turkey has received in the last decade in telecommunication technologies by WIPO. These statistics represent the total

number (equivalent number) by the applicant's origin. Although there has been an increase since 2017, the number of patents is still meager. The manufacturers also stated that there was neither awareness nor tendency to obtain patents. The patent acquisition is seen as an unnecessary effort for manufacturers. For this reason, it is considered that the number of applications is limited.

To sum up, knowledge development and dissemination in mobile telecommunications are significant. Policy documents contain action steps for many indicators related to this function. This section first examined R&D support as an indicator. R&D supports in the sector are not statistically remarkable. However, the data obtained in the interviews show that manufacturers benefit from particular R&D supports. In this context, the main problem is the commercialization of R&D projects. Although TUBITAK did not disclose official updated data, interviews reveal that the commercialization numbers of the projects were deficient. In this regard, manufacturers stated that their products should be used in the mobile operators' networks. In addition, World Bank data show that university-industry cooperation performance in Turkey is much lower than in countries such as China and Sweden. This situation has been confirmed in the data obtained in the interviews. Universities have been identified as stakeholders in the projects for 5G to develop cooperation. It is aimed to increase university-industry collaboration within the scope of the latest changes made in the regulations and the task carried out with YÖK. Finally, the most crucial policy regarding Patents is related to 6G. Academic studies are carried out to determine the standards of 6G and to obtain the necessary patents. In this context, targeting technology standards that have not yet been determined and cooperating with universities are valid policies for knowledge development.

5.2. Influence on the Direction of Search (F2)

Policymakers have directly addressed mobile telecommunications technologies in many strategic documents. In addition, manufacturing companies have been established or organized to replace global companies in the mobile telecommunication sector. However, the method of policymakers to persuade all system actors to these policies is not the same. Mobile operators have been obligated to use domestic goods

and purchase from SMEs with the 4G authorization certificate. The mobile operators are subjected to regulatory pressure. In case of failure, there is a possibility of administrative sanctions to be imposed on mobile operators.

In Chapter 3, the obligations of mobile operators are given in detail. These obligations are followed up with regular reports every year. The regulatory body audits compliance with the obligations on an annual basis. As a result, mobile operators were imposed administrative fines for failing to meet their obligations. Obligations have been among the most important discussion topics in interviews with mobile operator representatives. An interviewee from mobile operator representatives commented as follows:

> *The public policy towards creating demand by imposing obligations on mobile operators was insufficient to create supply. Similarly, unilateral obligations were not sufficient in the global market. As in our country, obligations have also been introduced in Brazil, and a control mechanism has been introduced before sufficient supply has been created. It has been seen that it does not contribute in terms of quality and quantity.*

Similar comments were made in the interviews with other consumer representatives. However, it is also an essential debate whether mobile operators will use domestic goods without obligation. The semi-structured interviews with consumer representatives asked about the principal motivation for using domestic products. The answers given point to the obligations. For this reason, it has been understood that the obligations are significant in directing the domestic supply. By applied policies, the demands of the consumers have been articulated. It is a justified criticism that the operators are only obliged to apply a policy and that there is no incentive mechanism. However, obligations are among the policies that work well for demanding domestic supply in the sector.

The obligations have also been evaluated as effective policies by the manufacturers. However, specific problems were encountered in its implementation. An interviewee in producers states as follows:

> *We see the obligations as a big step forward. Localization policies are leverages but unrealistic to support domestic supply. Therefore, while the obligations are being implemented, leakages occur. Likely, there were obligations in the past. The project was created without knowing how many producers there were, who was there, and what they were doing. The rollouts are completed because the producers came late. Although the state imposes fines, it cannot pressure the operators.*

Manufacturers also state that obligations should be through a different method than purchasing. The obligations regarding domestic goods and SME productions are audited by invoice control. The supervisory body controls how much of the mobile operators' total invoiced purchases are within the scope of their obligations in a reporting period. Even if mobile operators buy products within the scope of the obligation, these productions may not be used in the mobile operators' network. There is no regulation on whether mobile operators actively use domestic products. Moreover, as will be discussed in the following sections, there is not enough domestic supply in the sector, and there is a performance problem in domestic products. Mobile operators choose administrative fines over buying existing domestic products. On the other side, manufacturers demand an obligatory article to use their products directly on the mobile network.

Besides, policymakers apply policies to channel research into a particular technology within the system. 5G has been identified as a target in policy documents. The UUYM5G project and 5G Valley Open Test Field projects are meaningful proofs of the innovation policies for 5G, which are not yet used in the mobile telecommunication sector in Turkey.

5G technology is still in the early adaptation process in the world, and the manufacturers have not been determined yet. For this reason, policymakers evaluate that there is a gap in the market to be a manufacturer. An interviewee in manufacturer states:

> *We support policies towards 5G. However, the projects are not viable. The UUYM5G project is aimed to produce everything related to 5G technology. You cannot do everything towards a technology that is not viable. It would be a better policy to set a clear and specific target.*

In an interview with a different manufacturer, it was stated as follows:

> *The scope of UUYM5G is vast and needs to be limited. It did not produce the desired effect. Putting everything in a sack and getting financial support causes resources to be inefficiently used. In addition, there is not much-qualified personnel to work on the project.*

In this context, the general opinion of the manufacturers is targeting 5G is acceptable, and the actors support it. However, it has been stated that the project is extensive, and it is not reasonable to produce everything with 5G. The interviews with consumers on the subject also brought a different perspective. The interviewee from the consumers stated:

> *We are in the second phase of 5G. The first phase was the project with TÜBİTAK. They continue with the incentive program initiated by the Ministry of Industry. End-to-end 5G means comprehensive coverage, and we do not think all products are accurate to domestic production. The use of domestically produced technology in 5G should be such that it does not cause performance problems in the existing 4.5G network. By analyzing the product diversity by analyzing the market more strategically rather than end-to-end.*

Consumers have similar views to manufacturers, and they consider that it is impossible to produce all pieces of equipment of 5G with domestic resources. Moreover, using a new technology brings great uncertainty and risk regarding the technology's capabilities, limitations, and development trajectory (Olechowski et al., 2015). Therefore, mobile operators have a solid concern about the products' technological maturity. Products designed for 5G are expected to perform in the operational environment adequately. In this context, the maturity level of the products can be evaluated with the Technology Readiness Level (TRL) measurement system. TRL is widely used in research and development projects to assess the maturity of technology (Bakke, 2017). For 5G, it is necessary to use products that have reached a sufficient level of maturity within the scope of TRL to eliminate the concerns of mobile operators. In addition, domestic products in mobile networks should not experience interoperability problems. Interoperability is the ability of two or more networks, systems, devices, applications, or components to communicate (Cranford, 2018). It can be expressed as the network equipment of different companies working seamlessly with each other and providing service. Currently, the networks of mobile operators in

Turkey have been established with equipment from global suppliers. For domestic equipment supplies in 5G, the necessary agreements and technical solutions should be provided so that these products do not experience interoperability problems with the products of global suppliers.

Feedback on 5G projects was also discussed with policymakers. Their justification was questioned about the extensive scope of 5G projects. Policymakers indicated that they had started projects for all equipment in the network projects related to 5G. They expect some projects to yield concrete output, even if not for all projects. In this context, it is understood that policymakers do not expect domestic production of all network equipment.

In conclusion, policymakers ensured the establishment or organization of domestic companies. It was put in the act that all consumers must acquire domestic products. Within the scope of this function, it is expected that the relations of the actors in the system will be dynamic, and the research will be guided by an interactive and united exchange of ideas (Bergek, Hekkert, Jacobsson, 2008). However, the policies determined as obligations to the operators have emerged unilaterally. Policymakers brought obligations from the top down instead of an interactive process. However, operators are not motivated to turn their attention to domestic supply without commitments. Therefore, while obligations are necessary, consumers' opinions must be considered. In addition, there is a direction by policymakers toward 5G. Although the actors found this target reasonable, the broad scope of the projects raised concerns about their applicability.

5.3. Market Formation (F3)

The market formation is often studied in terms of which user groups to target and how to improve innovation adoption, taking a diffusion perspective at its core (Boon, Edler, Robinson, 2022). Many academics have emphasized the importance of market

structure and well-articulated demand for innovation (Hekkert et al., 2007). Analyzes for this function are generally in the direction of how a new market forms. However, this thesis will consider the market formation function differently.

Details on the mobile telecommunications market in Turkey are given in Chapter 3. In summary, the mobile operators in Turkey are experienced and express their demands well. Huawei, Nokia, and Ericsson have been providing products and services to mobile operators in Turkey for many years. For this reason, the mobile network in Turkey has been established with the products of these global companies. In other words, these companies vastly dominate the mobile infrastructure market in Turkey. Therefore, within the scope of this function, policies for domestic producers to overcome barriers to entry to the market will be discussed.

First, the base station is the leading communication equipment in mobile telecommunications infrastructures. Therefore, most consumers' investments include this infrastructure equipment and components. In this context, ULAK is the manufacturer company established to produce base stations. According to the information on the official website of ULAK, the company's base stations and equipment are used in 1017 sites[33]. However, Turkey's total number of base stations is around 197 thousand[34]. Currently, ULAK has a very small market share in the mobile telecommunication infrastructure market in the country. There are two main reasons for the limited number of purchases made from ULAK. The first of these reasons is that ULAK company was established in 2017. Its global competitors have been manufacturers in the market for many years, and their competencies and capacities are much more developed than ULAK. The second reason is based on the mismatch between the establishment of ULAK and the timing of the policies. The most important policy to articulate demand within the system is the obligation of mobile operators to purchase domestic goods. However, these obligations started in 2015, and mobile operators have completed a large part of their networks by global companies'

[33] https://www.ulakhaberlesme.com.tr/index.php/tr/ulaksahalar

[34] https://www.milliyet.com.tr/gundem/turkiyede-197-bin-baz-istasyonu-var-6525677#:~:text=Bilgi%20Teknolojileri%20ve%20%C4%B0leti%C5%9Fim%20Kurumu,196%20bin%20976'a%20ula%C5%9Ft%C4%B1.

productions. For this reason, mobile operators made limited purchases from ULAK, and their products could not be used widely in the network.

The situation described above shows that there is a timing problem in obligations. An interviewee states as follow:

> *As there was no domestic supply in the sector, obligations were brought. Although we tried to buy certified domestic products, a limited number of purchases were made. We couldn't wait for a domestically certified product to come out because the sectoral competition was very high, and we have different obligations such as coverage and mobile service quality.*

It also reveals that the policies conflict with the actors' different obligations. This situation inevitably exposes the actors to administrative penalties from any obligations. Even before the establishment of ULAK, mobile operators were fined for failing to meet their domestic product obligations.

On the other hand, consumers have different concerns about using ULAK products. First of all, due to a lack of production capacity, ULAK fails to deliver the orders to the consumers on time. This situation puts global suppliers in a more favorable position. Moreover, there are specific performance problems of ULAK, such as a restarting problem in installed ULAK base stations in the network. This impairs the quality of services considerably for mobile operators. In short, ULAK does not have the necessary competence and capacity to meet the needs of mobile operators. Another complaint of consumers is the relatively high prices of ULAK products. There are two apparent reasons for high prices: one is high production cost, and the other is domestic purchasing obligations of consumers. One interviewee stated:

> *ULAK products are not technically advanced to compare with competitors. In this context, it causes quality problems in the service provided to the customer. It is much more expensive, and after-sales support is not as good as other companies. As consumers, we also pay attention to providing the necessary service in matters such as after-sales support while investing.*

Domestic purchasing obligations of mobile operators are leverage for the use of ULAK products. Because it is not capable of commercially replacing the products of global

suppliers. Therefore, ULAK needs to increase its technical competence and capacity to address consumers' concerns about the prices and performance of products. For this, ULAK needs to gain more product and service experiences. In other words, ULAK can increase its expertise in the sector through learning by doing. The fact that there is not enough room for ULAK in the market and the penetration of the market in the current generation negatively affects ULAK's experience and knowledge development with this method. In this context, the timing problem of policies indirectly affects the knowledge development and dissemination function negatively. As long as consumers do not use domestic products, there will be no increased returns for adopting domestic technology. Also, a technology exhibits increasing returns to scale if a proportional increase in all inputs allows for a proportional increase in output; this means a decreasing average cost curve (Peon, 2003). Therefore, as ULAK adoption increases, it is expected that consumers' concerns about price will be eliminated.

This situation was discussed in the interviews. Policymakers decided to use ULAK products in the Universal Service Project[35] (USP) in order to increase the prevalence of ULAK products. The government institutions launch base stations in non-commercial locations under the scope of the USP. It initiates a tender and invites all mobile operators. The winner of the tender receives the budget from the Universal Service Fund and establishes the base station sites on behalf of the government. Approximately 1.5% of the annual gross income of mobile operators is the source of the Universal Service Fund. Nearly 6 billion TL has been accumulated in approximately 15 years in that fund. In 2022, Policy makers decided to cooperate with ULAK for 4G base stations in USP and provided a purchase guarantee using the amount collected in the Universal Service Fund. Currently, ULAK products are used in 754 Universal Service sites. This way, ULAK is expected to gain experience, and if it provides sufficient service quality, the company's confidence in the market will increase.

[35] The Universal Service Project is based on the Law No. 5369 and its scope is briefly the provision of electronic communication services, including internet access, that are accessible to everyone regardless of their geographical location, at a predetermined quality and at minimum standards for a reasonable price that everyone can afford.

ULAK representative stated that the provision of 4G base stations seems a great opportunity. In addition, the increase in revenues will provide sufficient investment opportunities for capacity increase. Technically, it is seen as an opportunity to develop their competencies.

Besides, increasing the competence of the domestic manufacturer is very important in switching to 5G. In the statements made by the Ministry of Transport and Infrastructure, Turkey will not switch to 5G without installing the domestic 5G technology and that all policies and strategies are designed accordingly[36]. In case of insufficient domestic supply for 5G, the 5G network will be built with products from global suppliers. For this strategy to be put into practice, domestic producers, especially ULAK and HTK, must be able to provide sufficient supply. In this context, it is a reasonable target to hold the tender after domestic manufacturers offer sufficient supply for the transition to 5G. It will also be an alternative for mobile operators in the infrastructure market. Moreover, there should be no domestic goods obligations in the 5G tender without sufficient domestic supply. The interviewee from the consumers stated:

> *There is a statement at the presidential level that 5G will not be passed without domestic products. On the other hand, proportional-based liabilities are not very successful. We think obtaining authorization without a domestic product will create a handicap for every stakeholder.*

Representatives of other actors have similar views on domestic manufacturers' market share in 5G. However, there is an opportunity cost if domestic manufacturers are expected to be ready for the 5G transition. In many respects, 5G is associated with concepts such as corporate solutions, the internet of things, and industry 4.0 rather than individual consumers. 5G offers many solutions in the industry, from increasing productivity to autonomous vehicles. Although this technology is in the early adaptation period, many European countries, the United States of America, and China have started to use solutions. Although the solutions of 5G are far from the expectations, they are gaining experience in different fields. Turkey must analyze the

[36] https://www.aa.com.tr/tr/bilim-teknoloji/ulastirma-ve-altyapi-bakani-karaismailoglu-yerli-5g-teknolojisi-altyapisi-kurmadan-5gye-gecmeyecegiz/2078581

risk it has to bear until the domestic producer is ready. Although domestic infrastructure is a specific target in 5G in the mobile telecommunications sector, policy makers should calculate the cost and risk and develop counter-policies.

In conclusion, Turkey's mobile telecommunications infrastructure market is saturated and dominated by certain companies. The innovation policies in Turkey aim to enter this market as a player for domestic manufacturers. The critical market driver is the consumer's obligation to purchase domestic goods. However, there is a timing problem with this policy. Operators have had obligations since 2015, but ULAK was established in 2017. After the operators established their networks to a large extent, ULAK started production. Therefore, there is not enough space in the market for domestic products. This situation also prevented ULAK from developing its technical capabilities and capacity by gaining experience. In this sense, the policy makers decided to use ULAK products before the base station installations related to the project. In this way, ULAK is expected to have the chance to gain experience and confidence. For 5G, this acquired competence will be necessary because domestic infrastructure has been stated as a strategic goal by policymakers. However, many countries in the world have started to use 5G. Therefore, a risk analysis should be made for the time until the domestic infrastructure is ready.

5.4. Entrepreneurial Experimentation (F4)

This function is often referred to in the literature as investigating new technologies and applications in an entrepreneurial way (Hillman et al., 2011). It is carried out by commercial actors who also see market potential for this research. Moreover, uncertainties regarding technology can also be resolved by testing various applications and solutions. In this way, new technologies can be developed and matured because dysfunctional products and technologies are eliminated (Steen et al., 2019).

The mobile telecommunication sector has substantial potential, especially in recent years, due to the increased software needs in different fields and the digitalization of networks. Policymakers formed HTK by bringing manufacturer companies in the

sector together, especially SMEs. HTK is also an essential stakeholder in the projects carried out for 5G. Moreover, the obligation of consumers to purchase from SMEs is a factor supporting these policies. Even though the SME's obligation was in the 3G frequency tender held in 2009, there was no requirement to manufacture the products. For this reason, SMEs meet this obligation by importing products and selling them to consumers instead of producing them. However, in the 4G tender, the policy makers included the obligation of SMEs to produce in Turkey. Thus, companies are encouraged to produce equipment and components instead of importing them.

Moreover, interviews with HTK representatives confirm the policymakers' intention to support initiatives that are or have the potential to be producers. The interviewee stated the following:

> *It was difficult for small firms to communicate and cooperate with operators. HTK was established to enable these small companies to communicate with operators easily. Currently, there are around 150 companies, and they aim to sell products by contacting operators.*

In addition, a Board Decision published by ICTA brought an extra obligation to consumers. Consumers are required to submit the "Domestic Goods Certificate" given within the framework of the relevant legislation for the devices they will use in their radio link frequency allocation applications in certain frequency bands (7 GHz, 13 GHz and 80 GHz bands). [37] The determined frequencies band are critical for mobile operators for service delivery. In this particular subject, HTK was authorized to produce necessary equipment with determined frequency bands. HTK has released a prototype, and this product will receive incentives. As a result, a good opportunity has been created by policymakers for small companies and businesses to engage with consumers.

On the other hand, statistics on the number of businesses is an indicator of this function in the literature. The table below consists of the data taken from TURKSTAT, shows

[37] https://telkoder.org.tr/wp-content/uploads/2018/03/yeni_14_10_RL_Frekans_Planlamas%C4%B1_ve_Yerli_Mal%C4%B1_Belgeli_Cihaz_Kullan%C4%B1m%C4%B1_10.._.pdf

the number of enterprises by economic activity and size group. The field of economic activity has been determined as the telecommunications sector.[38]

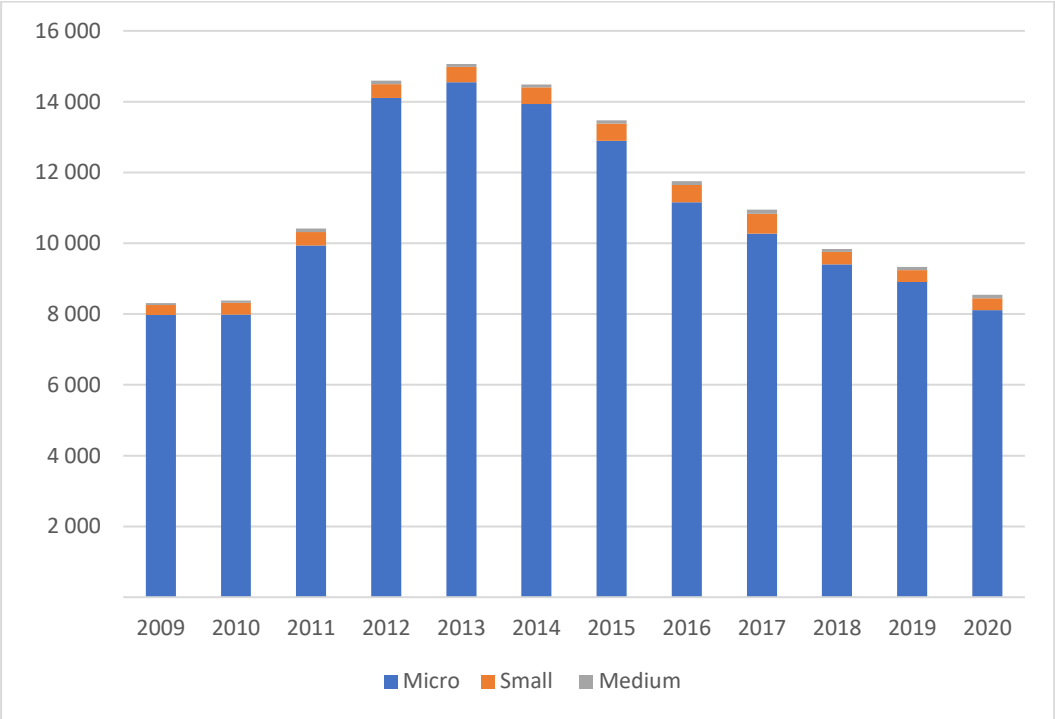


Figure-16: Number of Enterprises by Size Class and Economic Activity in Telecommunication Sector in Turkey

Source: TURKSTAT, Number of enterprises by size class and economic activity in 2009-2020

The definition of SME in Turkey includes the number of employees and financial criteria. Firms with less than ten employees and an income of less than 5 Million TL are Micro SMEs, firms with more than 50 employees and less than 50 Million TL are Small SMEs, and firms with less than 250 employees and an income of less than 250 Million TL are medium SMEs. classified as SMEs[39]. The graphic above shows that the policies implemented over the years are not quantitatively reflected in the statistics. Especially towards the years when obligations were concentrated, and HTK was formed, the number of initiatives decreased.

[38] 61 areas of economic activity (NACE Rev.2) telecommunications

[39] https://www.kosgeb.gov.tr/site/tr/genel/detay/8173/kobi-tanimi-guncellendi#:~:text=Y%C3%B6netmelik%20ile%20KOB%C4%B0%20tan%C4%B1m%C4%B1nda%20kullan%C4%B1lan%20kriterler%20g%C3%BCncellendi.&text=Buna%20g%C3%B6re%3B%20250%20ki%C5%9Fiden%20az,a%C5%9Fmayan%20i%C5%9Fletmeler%20KOB%C4%B0%20olarak%20tan%C4%B1mlanacak.

The data from TURKSTAT does not include the number of non-SME firms. A similar trend is observed in the number of these companies, which are defined as large. Therefore, there is no quantitative evidence of the number of companies that have increased their interest in this sector.

Moreover, cooperation with SMEs and enterprises was discussed during consumer meetings. The interviews evaluated the diversity in the number of companies, how the startups were supported, and the number of startups that turned into products. In this sense, the consumers did not receive any value-added contribution from SMEs and enterprises due to the policies. One interviewee stated:

> *We could not observe the SMEs much. Although domestic production requirement is well-intentioned, we could not provide a wide range of products and cooperation. Most companies do not provide an end-to-end service when creating a product. It ceases to be an SME in the form of volume. SME obligation is not sustainable.*

Consumers also emphasized the lack of after-sales support for the services and products SMEs or enterprises provide. Consumers prefer more experienced suppliers and can provide after-sales service due to service quality concerns. For this reason, investments from SMEs and startups remain limited.

In addition, mobile operators can make high-volume purchases for their infrastructure equipment. If mobile operators make a high-volume purchase from an SME, the purchase price may cause the firm to exceed the upper-income limit required to become an SME. This situation is shown as an additional problem arising in mobile operators' cooperation with SMEs. For this reason, it is considered that the condition of being an obligated SME can be revised.

To sum up, the activities of enterprises and SMEs are supported by policymakers, especially with obligations. Establishing HTK in the system as a manufacturer is crucial for SMEs. Moreover, specific policies have been published to cooperate with HTK. However, the interest of SMEs in the industry has been decreasing over the

years. There are issues that need improvement in the products produced by SMEs, such as both performance and after-sales support.

5.5. Legitimation (F5)

Many scholars interpret the legitimacy function as a prerequisite for adopting and diffusion of new technology. It corresponds to the acceptance and belief of innovation in society and policymakers. Moreover, legitimacy is formed by conscious actions by various organizations and individuals in a socio-political legitimation process that includes cognitive, normative, and regulatory aspects (Geels et al., 2008). The contents and consequences of conscious actions regarding mobile telecommunications technologies will be discussed under this function.

Turkey imports the majority of products in the mobile telecommunications infrastructure market. The economic volume of investments in the infrastructure market also prioritizes financial concerns in this area. However, in recent years, the most important political debates for localization studies in the sector are related to a different subject. Policymakers highlight the issue of cyber security in the legitimization of policies. The importance of policies with security concerns was emphasized for the acceptance of guidelines by the public.

Mobile telecommunications technologies are the most widespread communication infrastructure in the world. Despite such a widespread infrastructure, only a few companies' products and equipment are used. This situation inevitably makes countries dependent on these companies. It also raises the concern of manipulating communication infrastructures or getting information by hacking. Many countries are trying to alleviate this concern by making regulations within the scope of network information security.

Ensuring the security of mobile communication infrastructure in Turkey has been the subject of many political discussions. First of all, there is a parliamentary question in the Turkish Grand National Assembly. This question briefly includes the

determination of the security risks to be caused by the foreign origin devices of the telecom infrastructure in Turkey and the dissemination of the domestic base station of ULAK.[40] Moreover, the National Cyber Security and Strategy Action Plan (2020-2023) published by the Ministry of Transport and Infrastructure also includes the objectives of the safe adaptation and use of new generation technologies such as 5G, internet of things and cloud computing in our country. Discussions on the axis of cyber security and communication infrastructure take place not only in Turkey but also in many countries of the world. For example, Canada has banned the use of equipment from Chinese manufacturers in 5G.[41] The main concern in this ban is stated as "protect the safety and security of Canadians". Similarly, the United States has passed a law that prohibits Chinese companies in networking equipment.[42]

The debates held in the parliament and similar examples in national and international media are essential indicators for the legitimation of policies for domestic supply. Moreover, the recent regulation amendments include national security concerns for consumer investments and purchases. In this sense, other actors in the system also support the cyber security issue of policies related to the mobile telecommunications sector. Briefly, the issue of cyber security is a valid policy to ensure legitimacy within the system.

On the other hand, there are also policies within the system that will cause stakeholders to question the legitimacy of the guidelines. In this context, the interviewee from the consumers stated the following:

> *Obligations have been imposed on mobile operators to support domestic production. Obligations are also strictly followed, and penalties are given if they are not fulfilled. There is no incentive or support for mobile operators other than obligations. Policies should also support operators on issues such as tax exemptions.*

[40] https://www5.tbmm.gov.tr/develop/owa/yazili_soru_sd.onerge_bilgileri?kanunlar_sira_no=242432

[41] https://www.bbc.com/news/business-61517729

[42] https://www.reuters.com/technology/biden-signs-legislation-tighten-us-restrictions-huawei-zte-2021-11-11/

Mobile operators are only associated with obligations in the system. This affects the internal dynamics of the system. Mobile operators are under pressure to fulfill their obligations and make service commitments to millions of subscribers. Moreover, the competition in the industry is very high. While mobile operators have to use it domestically due to supply and performance problems, there is no incentive mechanism. This situation leads to the questioning of policies by mobile operators. Therefore, policies need to be revised to legitimize them within the system.

External adverse effects can be eliminated if policies are strengthened by associating them with critical concepts such as cyber security. However, policies may be adversely affected due to legitimacy debates within the system. It is discouraging for mobile operators to only participate in the system with obligations. Discussion of policies by consumers, who will use technology and are the target audience for its dissemination, harms the technology adoption process. In the interviews with consumers, incentives were highlighted. The economic benefits demanded should be discussed to solve the questions of legitimacy within the system.

Two more concerns about legitimacy were raised during the interviews. First, the public is unaware of the policies in the mobile telecommunications industry. The participants gave examples of public awareness of policies in the defense industry. It was emphasized that the policies in the mobile telecommunications sector should be similarly known. The second criticism is that the policies implemented in the sector should be considered comprehensive state policy. Certain public institutions need to be stakeholders in policies. In this criticism, representatives of multiple actors gave examples from China and its policies.

In fact, the parliamentary debates and media reports on the mobile telecommunications sector do not provide evidence of a deficiency in public awareness of the issue and the approach of public institutions. However, there are two additional issues for reinforcing the legitimization of policies. The first is the inclusion of different public institutions in the policies of the actors in the system. The other is increasing public awareness of the policies. It is necessary to evaluate how different actors in the system

can contribute to public institutions. In addition, there is a lack of performance in domestic products, as stated in other sections before. This lack of performance is reflected in the service received by the customers of mobile operators and causes complaints. Ensuring the legitimacy of the policies in terms of public awareness is necessary to increase tolerance of factors such as service quality.

In conclusion, the issue of cyber security for the mobile telecommunication sector is the most important argument for policies in the industry in Turkey and the world. Cybersecurity has come to the fore both in the parliament and in the statements made by policymakers to the media. Different system stakeholders support policies made on such a sensitive concept. However, consumers have objections to another issue. Consumers are only associated with obligations. In this case, it is discouraging that all stakeholders do not have the same interests. Therefore, reassessment of consumers' benefits in the system is essential to ensure legitimacy. In addition, the interviewees commented that there was insufficient public awareness and that all public institutions should be included in the system. Public institutions with different duties are vital to make up for the deficiencies experienced by the actors. Finally, the participants were asked not to use some information in the interviews. For this reason, additional findings cannot be shared as a result of the research in the legitimacy debate.

5.6. Resource Mobilization (F6)

This function is associated with the literature's financial capital, human resources, and complementary assets. For the success of an innovation system, it is vital to create human resources with the necessary education and experience and to mobilize the financial capital for companies/projects. Otherwise, sustainable success will not occur. Under this title, resource mobilization for mobile telecommunication technologies in Turkey will be analyzed regarding financial capital and human resources.

Financial support for scientific studies and projects is essential to knowledge production. The R&D support benefited by the manufacturers in the sector is examined in detail under the first heading of this section. However, since this sector is a new

field for domestic producers in Turkey, the availability of venture capital is also necessary for the system. In previous functions, there was no significant quantitative increase in the number of enterprises in the sector. Interviews with actors supported this fact. As an additional reason for this situation, venture capital opportunity for enterprises is an area that needs to be developed in Turkey. In this context, the table below examines how easy it is for entrepreneurs with innovative but risky projects in a country to find venture capital.

Although Turkey has shown improvement in venture capital availability in recent years, it still seems below the world average. Producers also stated that venture capital was not explicitly created for the industry. Moreover, the policymakers intended to establish an R&D fund funded by mobile operators to support manufacturers. It was stated that within the scope of the R&D fund, it could also be used as venture capital since the risk of entry in the sector is high. However, as the R&D fund will be funded only by mobile operators, it was not put into effect due to objections of mobile operators. As a result, there is no risk capital policy to support potential manufacturers.

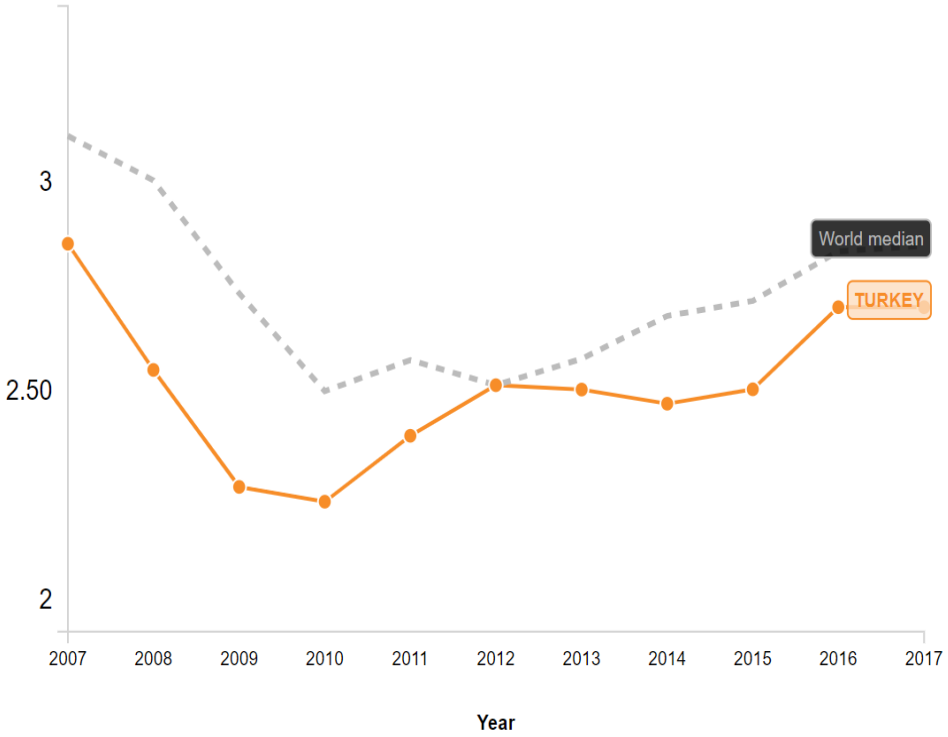


Figure-17: Venture Capital Availability

Source: World Bank, Venture Capital Availability, 1-7 (Best), Index 1-7 (Best)

Another issue related to this function is human resources that have gained competence and received the necessary training in the mobile telecommunication sector. Mobile operators must purchase at least 40% of the annual invoices from companies that employ 500 engineers and 250 researchers in their R&D centers. Policymakers state that this obligation is to provide engineers in Turkey with the necessary knowledge and experience in the sector. In this context, global suppliers can only fulfill the employment conditions based on the set guarantee purchase percentage.

The consequences of the obligation were discussed with the producers. In this context, an interviewee in the producers stated as follow:

> *We generally do not employ staff from Huawei and Ericsson. These companies hire well-trained engineers, and they pay good wages. However, they blunt these engineers by employing them on projects that are not very high quality. They do not gain much experience. Therefore, not many of the companies mentioned have joined us.*

In this case, the policies help employ engineers. Since the engineers do not work on value-added projects, they cannot acquire the desired competence and experience in the policies. In interviews with policy makers, it has been stated that engineers and researchers working in global companies are employed for a short time. As a result, it fails to provide the intended inventory of highly skilled human resources.

Moreover, postgraduate training programs create educated human resources in future technologies. As mentioned, there is a postgraduate program for 5G technologies, in which METU, Hacettepe University, and Bilkent University are stakeholders. Graduates from this program are expected to be employed by manufacturers and mobile operators. However, the interviews show that the desired result has not been obtained yet. In this context, the interviewee from the consumers noted the following:

> *5G test valley was established, master's and doctorate programs were started. However, the students working here go abroad to study or work. We, as consumers, fund this program. While we think that the students who leave here will work with us, the students go to work by finding a job abroad*

Investments in academic studies on future technologies are among the critical policies. It is a reasonable policy to create human resources for a technology that is still in the early adaptation period in the world and is not used in Turkey either. However, the results of this policy should meet the expectations. In this context, it is critical to take necessary precautions to prevent the qualified human workforce from migrating.

The final evaluation regarding human resources is based on the R&D personnel statistics obtained from TURKSTAT. The table below shows the change in the number of R&D personnel in the telecommunication sector over the years, either in finance or in non-financial institutions.

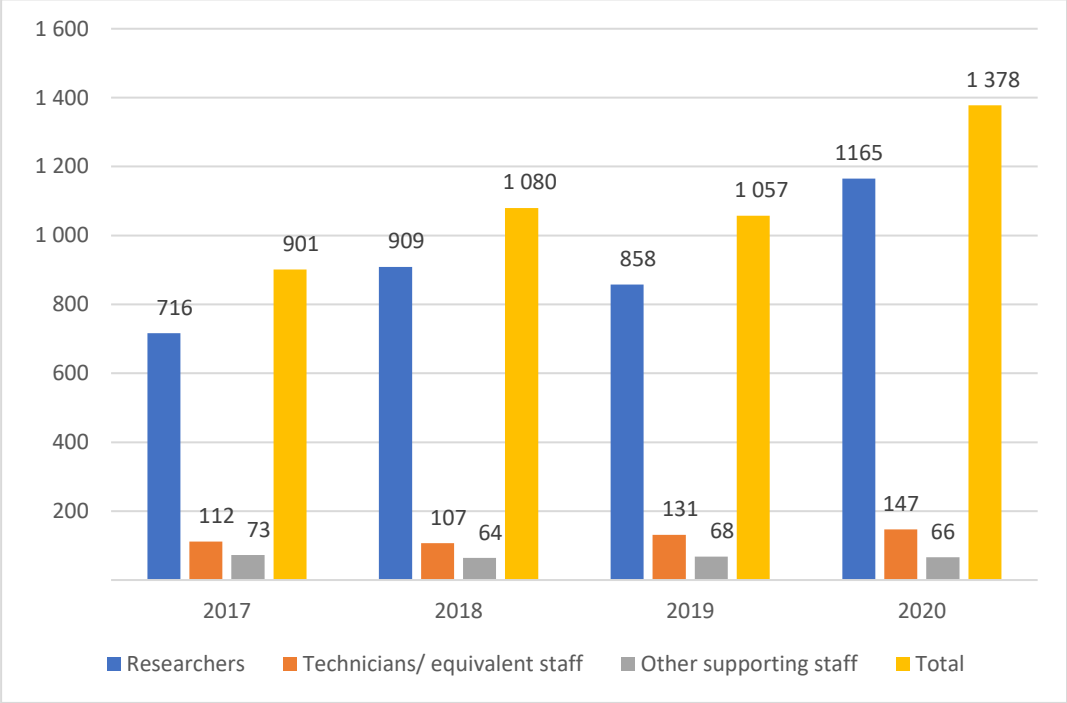


Figure-18: Financial and Non-Financial Corporations R&D Personnel by Economic Activity and Occupation in Telecommunication Sector in Turkey
Source: TURKSTAT, Research and Development Activities Research

The data show that the proportional increase is not pessimistic, especially in the number of researchers. Although the number of R&D personnel in the sector is not very high numerically, it can be assumed that there has been an increasing trend in this field over the years. In this sense, there are two critical issues for policymakers. The

first is to ensure human resources in the mobile telecommunication sector gain experience in value-added projects. The second is to create incentive mechanisms to keep and attract highly skilled engineers into the sector.

To sum up, this function evaluates financial capital and human resources policies. First, since the R&D supports in the sector were handled in the previous functions, the focus was on risk capital. According to the data, Turkey provides venture capital to startups below the world average. The interviews with the manufacturers also support this data. Although mobile telecommunication technologies are determined as a strategic target, there is no risk capital specific to this field. In addition, it aimed to establish an R&D fund financed by consumers. However, as a result of the objections of the consumers, this fund was not implemented by the policymakers.

Regarding human resources, another topic, the most important policy is the contribution of human resource work at the R&D center of global suppliers. However, manufacturers stated that although global suppliers employ well-educated engineers, they do not work on qualified projects. Moreover, there is a graduate program for future technologies in the sector. Even though the desired result from the graduate program will be obtained over the years, the people studying in this program should be kept in Turkey and the system. Finally, regarding human resources, the number of R&D personnel has increased over the years. In this context, although there is an increase in quantity, it is considered that qualified human resources are deficient.

5.7. Conclusion

This section contains a summary of the findings on mobile telecommunications technology policies. The contributions and adverse effects of policies within the defined technology innovation system will be discussed. Policies are classified based on function, and the summary will be formed this way. None of the functions are independent of each other. In addition, a policy has an impact on more than one function. Therefore, functions and policies will be addressed holistically.

Firstly, statistics show that R&D investments in Turkey are not concentrated in the sector. The share allocated to the industry from the public budget is not remarkable. Moreover, R&D investments of businesses and enterprises in the telecommunications sector remain at low levels compared to previous years.

On the other hand, semi-structured interviews indicated that R&D supports contributed to manufacturers. Contrary to statistics, attention was drawn to the problems of over-regulation of processes and project commercialization. The volume of R&D investments in Turkey should increase. The issue of commercialization of the projects was also underlined in the interviews with the consumers. Projects do not have the qualified after-sales support and performance a commercial product should have. This situation, starting from replacing the products in the market, negatively affects the indicator with many different functions. Therefore, the commercialization problem is among the barriers that policies should improve.

Other findings related to this function are university-industry cooperation and patent indicators. First, although university-industry cooperation in Turkey is close to the world average, it performs quite poorly compared to the major manufacturing countries. In this context, policymakers have considered this barrier in the recent regulation amendments. A university cooperation condition has been introduced to accept R&D projects in the sector. In the policy document prepared by YÖK, there are action steps for promoting university-industry collaboration in the sector.

Moreover, the actors in the system underperform in terms of the patent. It is essential to determine the standards set for future generations and obtain relevant patents to become a significant manufacturer in the market. By setting the standards in 3G, Huawei has gained a considerable advantage in the market. In Turkey, standard studies for 6G have been initiated with the cooperation of universities. A reasonable long-term plan has been established for patent and standard issues.

Evaluations for this function revealed an additional finding. Policymakers make revisions on the issues that need improvement in the system. Policies, especially within the scope of obligations, are followed with regular reports. Actors regularly organize

workshops and meetings. This situation, which policymakers also confirm, is used in policy evaluation and long-term planning.
The second function is to influence the direction of the search. An answer is sought as to whether the mobile telecommunication sector has been determined as a specific target. Evidence of directing research into this industry is discussed. The localization policies in this sector are found in many strategic documents. In these documents, specific duties and responsibilities are attributed to public institutions. Manufacturers have been established or organized to create the domestic supply.

In addition, mobile operators defined as consumers in the system are required to obtain a certificate of concession or authorization to continue their commercial activities. In the 4G Authorization Certificate, there is a particular condition for purchasing domestic products and products manufactured by SMEs in Turkey. While the commitments reinforce the government's strategy regarding the sector, it causes a different discussion. In interviews, mobile operators have repeatedly stated that the sector's policies are one-sided. This situation stands out both in the direction of research and in the legitimacy functions. In the system, the interests of the stakeholders are observed asymmetrically. Regulatory pressure on this issue is an obstacle for essential actors such as consumers to adopt the technology.

Policymakers have also set policies for 5G. Manufacturers have been organized in projects related to 5G. The 5G Valley Open Test Site project is aimed to create an environment where applications and technologies related to 5G can be tested with the cooperation of universities. Necessary technical and physical infrastructure has also been provided for potential producers. The criticism regarding this target is that the project's scope is unrealistic. Instead of targeting the production of all 5G networks and equipment, there should be specific targets with more added value.

As the third function, policies were discussed under market formation. These discussions were associated with the base station manufacturer ULAK. The most crucial policy instrument to be an alternative to global suppliers is the requirement for mobile operators to use domestic goods. However, there is a mismatch in the timing of the policies. By the time ULAK started production for domestic supply, mobile

operators had nearly completed their networks. Therefore, ULAK could not find enough opportunities in the infrastructure market. This situation has created deficiencies in developing their skills and capacity by gaining experience.

In the interviews with the consumers, it was stated that there are problems in the commercialization of the product, such as insufficient product quality and after-sales support, drawing attention to the lack of experience of ULAK. High prices have also been cited as an additional problem, causing it to be unable to compete with global suppliers. The public procurement guarantee for ULAK products is at least a well-designed technical competence and capacity-building policy.

In this sense, it aims to design 5G policies accordingly so as not to be a late comer in the market. Many projects are being carried out together with ULAK and HTK. It is desired to be ready in the market before switching to 5G. This will be a solution to overcome the timing problem experienced in 4G. However, there is an opportunity cost in the time until the domestic production infrastructure equipment is ready. Analysis of this cost by policymakers is essential.

Another function for creating alternatives in the market is entrepreneurial experimentation. In the interviews with HTK, it was challenging for SMEs to be involved in the purchasing processes of mobile operators. However, there has been a progress in this regard with HTK. Moreover, domestic production obligation in specific frequency bands has been introduced by policymakers. HTK is determined as a manufacturer.

The obligation to purchase products from SMEs included in the authorization documents of mobile operators is another vital tool that supports this function. The obligation to purchase SMEs was also included in the 3G Concession Agreement given in 2009. However, with the 4G authorization, domestic production requirement has been introduced. Consumers underline insufficient supply from SMEs to fulfill obligations. The data of TURKSTAT support this. It does not show an increase in the number of SMEs in the telecommunications sector.

In the legitimacy function, the discussions were carried out on the axis of cyber security. The parliament has political debates about using domestic production in mobile telecommunication infrastructure. Moreover, the announcements of the policymakers through the media were published. These explanations help the issue gain legitimacy within the system, especially at the level of policymakers.

Objections under this function come from consumers who complain about unilateral policies. Associating consumers only with obligations leads to legitimacy debate within the system. It does not persuade all stakeholders to the same level of policies.
Finally, it is about how financial capital and human resources are mobilized in the mobile telecommunications sector. Although financial resources include R&D investments, this issue has been discussed in a different function. Therefore, the focus is on the venture capital indicator. Turkey is below the world average in terms of risk capital availability. This situation also effectively keeps the number of startups limited in the sector, which has a high initial market entry cost. Although policymakers planned an R&D fund by considering this situation, it was not put into effect due to the objections of mobile operators.

Regarding human resources, the indirect employment requirement in global suppliers is an important policy instrument. However, it has been stated that engineers and researchers working with international suppliers are not employed much in domestic manufacturers. Engineers and researchers are not involved in value-added projects with global suppliers. In addition, certain universities are collaborating to carry out graduate studies within the scope of 5G. Since the students tend to work abroad, the desired result has not yet been achieved.

On the other hand, statistics from TURKSTAT regarding the number of R&D employees in the sector show a proportional increase. Although there is a trend in the industry, an increase in the quality of employees is required. It is considered that there is a need for personnel with the necessary experience in global suppliers that can take part in value-added projects in manufacturers.

The results of the research on the innovation policies implemented in the mobile telecommunications sector in Turkey are summarized above. In the next section, possible policy recommendations will be presented, taking into account the findings of the research.

CHAPTER 6

CONCLUSION AND POLICY RECOMMENDATIONS

This chapter consists of three sections. The first title refreshes the information on telecommunications history and industry analysis. The second section includes policy recommendations. Policy recommendations are classified as a function-based table. The final section briefly explains the limitations of this research and potential research topics.

6.1. Telecommunication Industry Analysis

Telecommunication technologies are indispensable for modern life. The technology, which started with the invention of the optical telegraph in the 18th century, has developed exponentially. Electric telegraph and fixed telephone services, respectively, have become the most common telecommunications technologies. In the 20th century, telecommunication infrastructure was established in large part of the world. The number of fixed telephone services subscribers has also exceeded one billion worldwide.

Towards the end of the 20th century, mobile telecommunication technologies emerged with the reflection of the developments in the field of wireless technologies. Mobile telecommunications technologies started with 1G, low voice quality, and limited capacity. However, it has attracted users' attention because it provides communication services without being tied to a specific location. The technology that improves the sound quality with 2G also offers a short message service to the users. 3G draws attention with its better data service performance than previous generations. 4G is currently the most widely used technology and shapes today's communication habits with high data download speeds. In this context, the technology that emerged only a

few decades ago has been adapted very quickly and has reached nearly 9 billion unique users.

The widespread use of mobile telecommunication technologies has also led to an enormous economic volume. Globally, mobile operators' revenues have exceeded 1 trillion dollars and are expected to increase continuously in the coming years. These operators invest approximately 1.5 trillion dollars annually to maintain the service. In Turkey, the revenues of the three mobile operators in the sector are around 50 billion Turkish Liras. These companies spend 10 billion Turkish Liras in infrastructure investments. However, there are a limited number of infrastructure suppliers in the sector despite huge volume investments. Huawei, Ericsson, and Nokia are global suppliers with the largest market share in the industry.

In this sense, many countries want to be a manufacturer in the mobile telecommunications sector due to many reasons, such as cyber security and economic concerns. However, mobile telecommunications infrastructure equipment is classified as high-tech. Specific innovation capabilities and capacity are required for the production of this technology. For this reason, many countries have technology-oriented innovation policies.

The case of China and Huawei is an excellent example of successful innovation policies in the industry. In the 1990s, the mobile infrastructure market was dominated by western companies. However, due to China's policies, Huawei started to become a manufacturer in the early 2000s, and today it dominates the infrastructure market.
In Turkey, on the other hand, policies regarding the mobile telecommunications sector have been implemented since 2015:

Many policy documents state the industry as a strategic target. Substitution of global producers is the main objective of the policies. Many public institutions and organizations, especially the ICTA, are pointed out in the policy documents as policymakers.

ULAK was established for the production of base stations. To replace global companies' infrastructure equipment, HTK has been formed with approximately 150 SMEs.

With the 4G tender, Mobile operators' annual investments must consist of minimum 45% of domestic goods.

This thesis presents a system description by consolidating the policies implemented in Turkey. The actors in the system, ICTA and other public institutions, are policymakers; ULAK and HTK are manufacturers, and mobile operators are consumers. The research determines specific drivers and barriers in the policies. The findings are shared in the 5th chapter of this thesis. Policy recommendations for the sector are also included in the next section of this chapter.

6.2. Policy Recommendations

This thesis examines the innovation policies in the mobile telecommunications sector in Turkey. The research has revealed that establishing the manufacturer of the policies, regulatory pressures on mobile operators and drivers in the policies have brought particular competence and capacity to domestic manufacturers. However, these policies are yet to provide adequate supply to the sector. The global suppliers cannot be substituted. The result of the research is consistent with the hypothesis of the thesis, which also emphasizes the uncompetitive performance of domestic manufacturers.

The research also determines specific drivers and barriers in the system. Initially, the government has implemented innovation policies in the industry for almost a decade. There are particular projects regarding future technologies. ULAK was established, and more than 150 SMEs formed HTK. These show that policymakers have identified the sector as a strategic target. The policies have been the subject of political debates and grabbed media's attention frequently. Despite many discussions, R&D support and long-term planning of the policies in the sector are some of other influential drivers. The investments of mobile operators are also articulated with obligations.

Moreover, domestic manufacturers are given a purchase guarantee with ESP. Finally, it has been observed that there is a feedback mechanism in the system, excluding obligations. It is among the critical drivers that policymakers make necessary policy revisions by considering other actors' opinions.

On the other hand, there are significant barriers to the system. There is a problem with the commercialization of R&D projects in the sector. All stakeholders in the industry have emphasized this issue. In addition, Turkey's unsatisfactory performance in university-industry cooperation is also reflected in the industry. Policymakers have recently made legislative amendments to improve performance in this regard. Mobile operators' obligations were introduced long before the existence of minimum domestic manufacturing capabilities. Policy timing prevents domestic producers from finding sufficient opportunities in the market and gaining experience. Unilateral policies in the industry also lead to legitimacy debates within the system.

In this context, the drivers and barriers in the system are briefly mentioned above. All drivers and barriers determined by the research are classified based on function in the figure below.

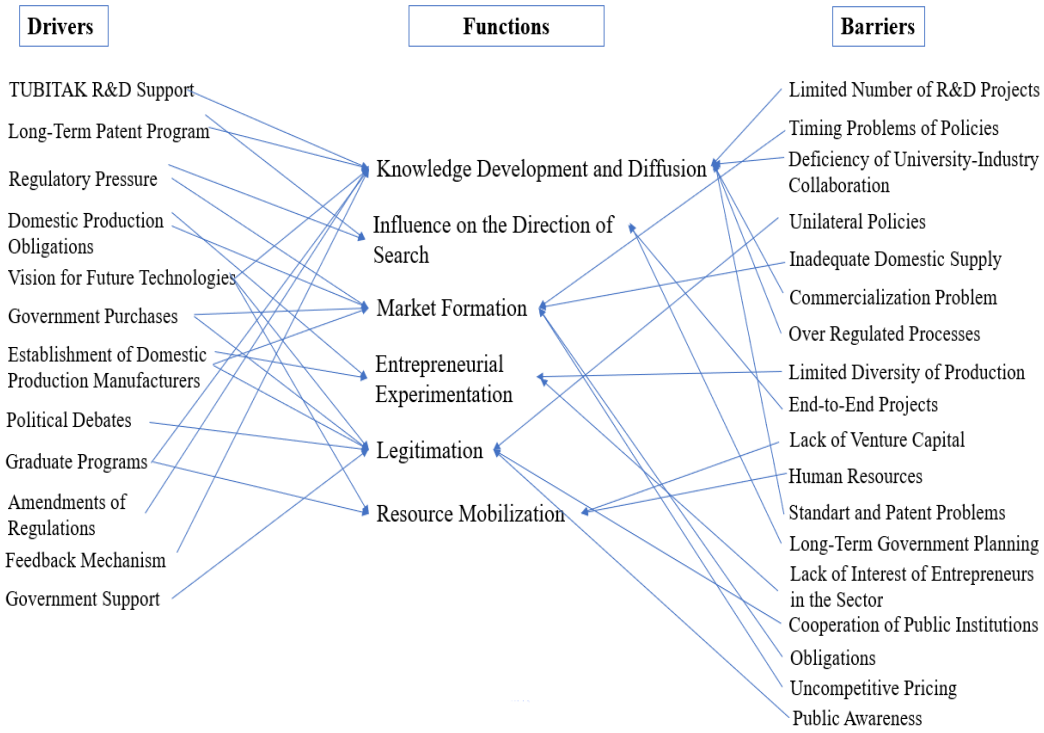


Figure-19: Drivers and Barriers in the Mobile Telecommunication Sector in Turkey

This dissertation presents relevant policy instruments for overcoming barriers related to the mobile telecommunications industry. These instruments have been formed by taking the feedback of the sector representatives in the interviews into account. Moreover, the statistics in the industry, many policy documents, and regulations are other critical data sources for policy recommendations. The table below contains primary considerations in policy recommendations, relevant policy instruments, objectives, and explanation.

Table 5: Policy recommendations

Function	**Main Issues to Consider**	**Policy Recommendations**	**Relevant Policy Instruments**	**Policy Aims and Explanation**
F1	Limited number of R&D Projects Over-regulated processes	Increasing government R&D expenditure share for mobile telecommunication sector Promoting business enterprise R&D projects Simplifying the excessive documentation process in R&D support applications	Designing an industry-based R&D support program Improving R&D allocation in the Central Government Budget Creating additional incentives for R&D projects in business enterprises, such as a tax exemption or a public procurement guarantee	This proposal aims to increase the sector's share in government R&D expenditures. Moreover, domestic manufacturers complained about the loss of workforce in the application procedures. This proposal enables manufacturers to apply for R&D project support by optimizing processes. It is also necessary to increase the interest of business enterprises in carrying out R&D activities. The policy tool

Table-5 (Continued)

				has been proposed to make investments in the sector attractive.
F1	Deficiency of University-Industry Collaboration	Promoting academic interest in the sector Dissemination of undergraduate and graduate programs Enabling academicians to cooperate with the actors in the system	Project-based employment of academics and students at universities Establishing undergraduate and graduate programs in potential areas in the sector such as cyber security, IT sector Encouraging academics in the industry to collaborate with local manufacturers rather than global suppliers	Universities are stakeholders in projects related to 5G. The data shows that the desired contribution could not be obtained. Specific project-based employment can be provided to solve this problem. In addition, essential academics in the industry are working with global suppliers to set standards on 5G. Since setting standards is

Table-5 (Continued)

				an important variable in the market, academicians should be encouraged to work with domestic producers.
F1	Commercialization Problem	Increasing the commercialization rate of R&D projects	Providing the necessary financial support to the projects during the commercialization phase	Manufacturers reported that the support provided during the project phase was not available during the commercialization process of the products. The purpose of this proposal is to ensure that the products find financial support in the commercialization processes.

Table- 5 (Continued)

F1	Standard and Patent Problems	Dissemination of standard research on future technologies and participation of other actors in the system To ensure international recognition of standards and patents. Encouraging domestic producers to obtain patents	Involvement of actors in effective organizations in setting standards in the mobile telecommunications industry such as ITU, European Telecommunications Standards Committee (ETSI), ONF (Open Network Foundation) Providing support by policymakers to ensure the international validity of the patents obtained by the manufacturers Dissemination of postgraduate programs on standards and patents Inclusion of domestic manufacturers in standard research	Setting the standards for future technologies and obtaining the necessary patents are essential to having a share in the infrastructure market. Although global suppliers set the standards for current technologies, there are opportunities for future technologies. This recommendation prevents manufacturers from experiencing standard problems in future technologies.

Table- 5 (Continued)

F2	End-to-end Projects	Targeting a strategic and specific product group in future technology projects	Determination of a specific product group instead of all infrastructure elements in the UUYM5G project by policymakers.	It is impossible and unreasonable to realize the domestic production of the entire infrastructure of the sector. For this reason, projects launched for 5G should also be limited to a particular product range. Resources need to be transferred with high-value-added technologies.
F2	Long-Term Government Planning	Determination of future targets for 5G and 6G by policymakers in consultation with actors	To publish an agenda on future technologies in the Mobile Telecommunications industry. This agenda expresses the government's vision for 5G and 6G. It should identify priority areas for public investment and commercial	Policies regarding domestic production have been gradually imposed by policymakers starting from 3G. However, other actors have concerns regarding the applicability of

Table-5 (Continued)

			innovation in the sector.	the policies. For this reason, targets for future technologies should be determined together with other actors.
F3	Timing Problem for Policies	Planning future technologies by evaluating risks and opportunities	Conducting the 5G Frequency Allocation tender after sufficient supply is provided.	Global suppliers dominate the mobile infrastructure market. Moreover, mobile operators made the majority of their network investments. The domestic manufacturer cannot find enough opportunity in the market. This is because the timing of the 4G tender and domestic production did not match. For the domestic manufacturer to find sufficient opportunity in

Table-5 (Continued)

				5G, domestic supply must be provided at a certain level. However, some countries have launched 5G with certain benefits. Policymakers should analyze the risk of late transition to 5G.
F3	Insufficient Domestic Supply	Increasing the competencies and capacities of domestic producers Improving the services provided by domestic manufacturers on issues such as after-sales support and technical support Ensuring the improvement of domestic product quality	Establish monitoring and evaluation mechanisms for domestic supply Collaborating with mobile operators and providing technical requirements together to improve the performance of domestic products Providing financial and human resources	Mobile operators reported insufficient domestic supply with performance problems. In addition, after-sales technical support provided by global suppliers cannot be provided for domestic products. Domestic manufacturers must overcome these barriers to find opportunities in

Table-5 (Continued)

			support to domestic manufacturers for after-sales support, transferring human resources from global suppliers to domestic	infrastructure market.
F3	Uncompetitive Pricing	Ensuring the elimination of price disadvantages of domestic producers Preventing elements that aim to directly or indirectly prevent, distort or restrict competition in the infrastructure market	Providing tax incentives so that domestic products can compete in price with the products of global suppliers Regular inspection of the infrastructure market by the competition authority	The high prices of domestic products encourage mobile operators to purchase products from global suppliers, even if they are under obligation. Therefore, competitive pricing of domestic producers is essential. In addition, public institutions such as the Competition Authority must ensure the necessary supervision in order to prevent

Table-5 (Continued)

F3	Obligations	Bringing obligations for domestic manufacturers Re-arrangement of domestic goods obligations of mobile operators	Establishment of production commitments of domestic manufacturers Re-arrangement of obligations for mobile operators to use domestic goods; Obligation to use domestic products in the network	Mobile operators must use domestic goods. Even though the domestic supply is insufficient in the market, these obligations are audited and mobile operators penalized. On the other hand, domestic producers do not have any obligations. The domestic producers should also fulfill specific commitments regarding the support they receive. Currently, mobile operators are obliged to purchase domestic goods and SMEs, and invoice control is carried out. There is no

Table-5 (Continued)

				obligation regarding the use of purchased domestic products. The obligations need to be revised using domestically produced products directly in mobile operators' infrastructures.
F4	Limited Diversity of Production	Increasing the number of collaborations and product diversity with SMEs	Establishment of a domestic producer database according to the competencies of SMEs. Imposing specific obligations for certain product groups for mobile operators to cooperate with SMEs	The capabilities and competencies of companies within HTK should be classified. Policies and obligations should be introduced for domestic manufacturers to produce strategic product groups. This way, the product variety provided by the entrepreneurs in

Table-5 (Continued)

				the sector can increase.
F4	Lack of interest of entrepreneurs in the sector	To increase the interest of entrepreneurs in the sector To provide the necessary facilities for entrepreneurs To provide financial support for entrepreneurs to overcome market entry barriers	Launch of programs by actors to make the sector more attractive to entrepreneurs Creation of a test environment to provide technical requirements for entrepreneurs Providing financial support for entrepreneurs	TURKSTAT data show that the interest of enterprises in the sector has shown a decreasing trend over the years. Interviews with actors confirm this data. This proposal aims to eliminate the lack of incentive programs, which is the biggest problem for companies to enter the sector.
F5	Cooperation of Public Institutions	Developing policy intelligences	Consultation with actors to improve the design and implementation of policies. Ensuring that necessary public institutions and organizations are	Public institutions and organizations with different duties are required to contribute to policy. For example, the Competition

Table-5 (Continued)

			included in the system	Authority has been stated in more than one interview to overcome the pricing barriers. In the policy evaluations made with the actors in the system, the public institution needed should also be determined.
F5	Unilateral Policies	Renunciation of unilateral obligations	Establishment of incentive programs such as tax reductions for mobile operators in case of using domestic goods Exemption from coverage obligation and service quality obligations in case of domestic product use Bringing obligations such as service quality	While mobile operators have obligations in the system, manufacturers benefit from incentives. Unilateral policies cause legitimacy debate within the system. This proposal primarily aims to encourage mobile operators with incentive programs.

Table-5 (Continued)

			standards to manufacturers within the system	
F5	Public Awareness	Conducting public awareness campaigns and other outreach activities	Increasing public information about domestic production activities in the mobile telecommunication sector (conventional media tools, social media, declarations of public institutions, etc.)	Domestic production in the sector is not known enough by the public. Actors expressed the lack of support for domestic production. Mobile operators, in particular, advocate public awareness and support as an essential tool to prevent the consumer satisfaction problem related to the performance problem in domestically products.
F6	Lack of Venture Capital	Creation of venture capital for enterprises	Establishing public support programs for companies on venture capital	The infrastructure market is saturated, and the initial cost is

Table-5 (Continued)

			Creating a fund program for mobile operators to provide support to manufacturers	very high. Lack of capital support is one of the significant market entry barriers in the industry. In this context, it is necessary to ensure that this risk is eliminated for manufacturers by policymakers or mobile operators.

Table-5 (Continued)

F6	Human Resources Experiences	Directing human resources to value-added projects	To Establish monitoring and evaluation mechanisms to projects in global manufacturers Creating incentive programs should be established to ensure the employment of human resources by domestic producers	The human resources in global manufacturers work on unqualified projects. Moreover, the domestic manufacturers do not employ engineers or researchers from the R&D centers of global suppliers. This proposal aims to enable engineers and researchers to work on value-added projects and to transfer human resources to domestic producers.

For the policies to achieve their purpose, R&D support should be increased first. Among the government expenditures, the R&D budget allocated to the telecommunications sector is inadequate. Many manufacturers mentioned the excessive loss of workforce in applications to R&D projects. Besides, the university-industry collaboration performance is not at the desired level. The research showed that academics do not have a significant motivation to cooperate with domestic manufacturers. The dissemination of postgraduate programs related to the sector can

also increase academic interest. As in 5G projects, universities can be stakeholders in various projects. Moreover, it has been observed that academics collaborate with global suppliers on essential tasks. Incentives and programs should be created for universities, scholars, and students to cooperate with local producers.

Patents and standards are also among the most critical issues in policy recommendations. The vital infrastructure manufacturers have increased their market shares by setting standards. Moreover, setting the standards are also fundamental in solving the interoperability problem of the products of different manufacturers. For this reason, it is necessary to have an essential role in determining the standards in the sector. Policy recommendations emphasized the importance of participating in international institutions and organizations regarding standards. In addition, policymakers should support the patents for international validity. These studies on standards should not remain only as a graduate program and should be expanded. Many actors in different countries participate in the standards research because it emerges as a result of long-term research.

The commercialization problem in R&D projects is another barrier that must be overcome in the sector. Manufacturers reported that the projects could not be completed because there was no financial support during the commercialization phase. There is no up-to-date data on how many of the projects supported by TUBITAK have been commercialized. This proposal considered the manufacturers' opinion. In addition, regular disclosure of up-to-date data by TUBITAK will be helpful for the follow-up of policies.

Policy recommendations in the second function are related to extensive projects and long-term planning for 5G. In 5G projects, a product group should be strategically determined, as many actor representatives stated in the interviews. Projects should be created for this product group. In addition, long-term planning in the sector should become more evident. It is impossible and unreasonable to build all the equipment of the 5G infrastructure with domestic resources. Although there is research for 6G standards, there is no mention of any different policies. Policymakers should determine long-term plans by discussing them with other actors in the system.

Within the scope of the market formation function, there are proposals for domestic manufacturers to substitute global companies. First, domestic goods obligations imposed on mobile operators create regulatory pressure on demand. However, there is an insufficient domestic supply problem in the sector. All policy proposals aim to create adequate supply in the industry. This function includes many additional issues such as cooperation with mobile operators, transferring the necessary financial capital and human resources to domestic manufacturers.

Unilateral policies are an essential debate for this function. Policies support domestic producers without any commitments. Their products are not qualified to compete with the products of global companies. An incentive should be provided to mobile operators with regards to using domestic goods. Moreover, regulatory pressure should be provided on domestic producers with specific commitments. Regarding high price, it is among the additional suggestions that authorized public institutions should inspect the necessary competition conditions.

Moreover, 5G projects are one of the most critical issues for this function. Policymakers clearly state targets for domestic equipment for 5G. Therefore, 5G tender should be made after sufficient domestic supply is provided to avoid timing problems like 4G. However, as indicated in the table, policymakers should analyze the risk of a late transition to 5G. As an additional suggestion, policies may differ for the infrastructure to be created for corporate solutions. The 5G tender will take place in the form of the allocation of specific frequency bands. Mobile operators will establish infrastructure for corporate solutions with these frequency bands. In this context, 5G is associated with corporate solutions rather than individual users. Policies may differ for 5G so that Turkey does not lag behind the world in corporate solutions. Domestic infrastructure may not be required for infrastructure serving corporate solutions. This way, Turkey's late adaptation problem for 5G can be prevented.

In another function, there are suggestions for increasing the number and variety of enterprises in the sector. The regulatory agency cooperates with HTK for the domestic production requirement at specific frequencies. An increase in such obligations may

enhance cooperation with SMEs and enterprises. Moreover, the technical infrastructure and capital problem will be solved by creating unique programs for entrepreneurs by policymakers and mobile operators.

In the legitimacy function, the actors' representatives' feedback is critical. First, a proposal for eliminating the lack of public awareness is given in the table. Public awareness is also associated with customer complaints. Performance problems in domestic products cause customer complaints to mobile operators. Informing customers where domestic products are used will enable customers to show tolerance for the operators' performance.

Besides, mobile operators have obligations on many issues such as service quality and coverage. Mobile operators which use domestic products should be exempted from certain responsibilities. Having incentives rather than obligations for mobile operators helps resolve the legitimacy debate within the system.

The actor representatives also demand that different public institutions should also support the policies. In this regard, the Competition Authority has been pointed out to ensure healthy competition in the sector. It should be provided that different public institutions support policies within the scope of their duties and authorities.

Finally, policy recommendations have been made regarding venture capital and human resources. The initial cost of the mobile telecommunications industry is very high. Financial aid is required to minimize the risks for manufacturing companies. This financial resource can be created by a public support program or a fund provided by manufacturers and mobile operators in the sector.

As for human resources, the most striking finding is that engineers and researchers working in R&D centers of global suppliers are not employed by domestic manufacturers. The reason is that engineers and researchers are not employed in value-added and strategic projects. The policy recommendation in this regard is to audit the projects in which the human resources work.

To sum up, policymakers hold regular meetings with other actors. The effects of the policies are also monitored through regular reports from mobile operators. The effectiveness of the feedback mechanism in the system has been observed as an essential driver. This study has taken this situation into account. The findings and policy recommendations will be discussed with the actors in the system. It aims to contribute to achieving desired results for future technologies.

6.3. Limitations of the Study

The data collection method for this thesis was determined as semi-structured interviews, secondary data analysis, and document review. There are certain limitations arising from this methodology.

First and foremost, the author of the thesis works at one of the actors in the system. Therefore, in the semi-structured interviews with the sector representatives, the actors' commercial aspects could not be discussed in detail. The interview question sets do not include any pricing, purchasing process, or commercial collaboration issues. Moreover, the participants requested that some of the discussions in the interviews should not be included in the content of the thesis. These issues have created specific gaps in the evaluation of the collected data. For example, in the findings, the complaints of mobile operators about the high prices of domestic manufacturers could not be detailed. Any commercial information shared in the interviews is also not published in this article. In the legitimacy function, certain feedback of the interviewees could not be shared as additional findings.

Being an employee in the industry provides an advantage in accessing and obtaining information on policy documents related to the sector. However, some of these documents are strictly confidential. It shows that mobile telecommunication technologies are a strategic target for the country. On the other hand, it blocks referring to these documents in the thesis. It is not allowed to share technical and commercial information.

On the subject of secondary data, there is no sub-section of the mobile telecommunications sector in many data sources. In certain parts of the research, the telecommunications sector data were used. Some data sources were not used because the content was too broad, and the information about the content was not clear. Mobile telecommunication technologies are a strategic sector in Turkey. Therefore, it is necessary to generate and publish data on the mobile telecommunications sector for potential research.

Additionally, this research was conducted during the Covid-19 Pandemic period. Conditions such as curfews and remote education imposed due to the pandemic have caused certain limitations in the study. Some of the interviews were conducted via video conference or telephone due to the participants' health concerns. This makes it challenging to conduct an interactive discussion with the participants.

Finally, this thesis is the first academic study to consolidate and discuss innovation policies in the mobile telecommunications industry. The research shows that policymakers also have targets for future technologies. In this context, two crucial potential research topics stand out. The first one is related to the targets of 5G projects. In Turkey, 5G is not deployed yet. Policymakers frequently highlighted domestic production for the transaction to 5G. Therefore, the policies about 5G will be a potential research topic. The other one is policies about standards and patents. Setting standards and obtaining the necessary patents in the mobile telecommunication sector is essential for having a noticeable share in the infrastructure market. This thesis also indicates that Turkey has plans for 6G standards. The results of these plans will be a decicive indicator of Turkey's ambition of becoming an infrastructure producer. Therefore, the subject of standards and patents in the mobile telecommunications industry can be a unique and outstanding research topic.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

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Sayı: 28620816 /

14 OCAK 2022

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Erkan ERDİL

Danışmanlığını yürüttüğünüz Musa ACAR'ın "Mobil Telekomünikasyon sektöründe yerlileştirme çalışmaları" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **0059-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
İAEK Başkan

B. TURKISH SUMMARY / TÜRKÇE ÖZET

Dünya çapında 9 milyar mobil telekomünikasyon servislerini kullanan abone bulunmaktadır ve bu abonelerin yaklaşık 6 milyarı tekil kullanıcılarıdır. Üstelik gelişen teknoloji ile birlikte mobil telekomünikasyon teknolojileri sadece bireysel abonelere değil makinelere de (M2M vb.) hizmet vermektedir. Türkiye'de ise Bilgi Teknolojileri ve İletişim Kurumu'nun (BTK) yayımladığı pazar verilerine göre 2022 yılı birinci çeyrek dönemi itibariyle yaklaşık 87 milyon mobil abone bulunmaktadır (M2M abonelikleri dahil) ve %103,2 yaygınlık oranı bulunmaktadır.

Mobil telekomünikasyon sektörünün hem dünyada hem de Türkiye'deki yaygınlığının ekonomik olarak da önemli etkileri bulunmaktadır. Öncelikle dünyada çapında telekomünikasyon faaliyeti gösteren firmaların gelirleri yıllık yaklaşık 1.5 Trilyon Dolar sevilerindedir. Türkiye'de ise mobil telekomünikasyon hizmetini Turkcell İletişim Hizmetleri A.Ş. (Turkcell), Vodafone Telekomünikasyon A.Ş. (Vodafone) ve TT Mobil İletişim Hizmetleri A.Ş. (TT Mobil) firmaları sunmaktadır. BTK pazar verilerine istinaden bu firmaların 2021 yılı itibariyle gelirleri yaklaşık 50 Milyar TL'dir. Dünya'daki ve Türkiye'deki sektör verileri incelendiği zaman ise firmaların gelirlerinin artan bir trende sahip olduğu görülmektedir.

Dünya çapında milyarlarca kullanıcı gelir açısından çok büyük önemi bulunsa da bu kullanıcılara hizmet vermeyi sürdürebilmek ve gelişen teknolojiyle altyapıyı optimize edebilmek için çok önemli yatırımlar gerektirmektedir. GSMA'nın verilerine göre önümüzdeki birkaç yıl içinde 5G'ye geçişle birlikte yaklaşık dünya çapında mobil telekomünikasyon altyapısına yaklaşık 600 Milyar Dolar yatırım (CAPEX) yapılması beklenmektedir. Türkiye'de ise 3 mobil operatör 2021 yılı itibariyle 10 Milyar TL'den fazla yatırım gerçekleştirmiştir. Bu yatırımların hizmet ve servislerin gelişmesiyle birlikte artarak devam etmesi beklenmektedir.

Mobil Telekomünikasyon teknolojilerinde, milyarca kullanıcı, dünya çapında altyapı yaygınlığı ve önemli ekonomik hacmine rağmen altyapı ekipmanları küresel belirli sayıda firma tarafından üretilmektedir. Mobil altyapı ekipmanları (baz istasyonları, network yazılım ve donanımları vb.) Eurostat ve birçok kurum ve kuruluş tarafından bilgi yoğun bir endüstri ve yüksek teknoloji olarak sınıflandırılmaktadır. Bu nedenle de bu ekipmanların üretimi belirli inovasyon kabiliyeti ve kapasitesi gerektirmektedir. Dünya çapında Huawei, Ericsson ve Nokia başta olmak üzere sınırlı sayıda firma mobil telekomünikasyon ekipman pazarını domine etmektedir ve oligopol bir pazar yapısı bulunmaktadır.

Bu kapsamda birçok ülke hem ithalat başta olmak üzere iktisadi kaygılardan dolayı hem de son zamanlarda önemli bir kavram olarak karşımıza çıkan siber güvenlik nedeniyle bu pazarda bir altyapı üreticisi olmak için inovasyon politikaları yürütmektedir. Türkiye bu ülkelerden bir tanesidir.

Bu tez, Türkiye'nin mobil telekomünikasyon sektöründe uyguladığı inovasyon politikalarını incelemektedir. Araştırma sorusu ise; Türkiye'de mobil telekomünikasyon sektöründe uygulanan politikaların iyi işleyen ve gelişmesi gereken hususları neler olduğudur. Araştırma ülkedeki yerli üreticilerin inovasyon politikaları sonucunda belirli üretim yeteneği ve kapasitesi kazansa da bunların küresel üreticiler ile rekabet etme konusunda yetersiz olduğu hipotezini test etmektedir.

Araştırma kapsamında yapılan çalışma inovasyon sistemleri yaklaşımı benimsenerek gerçekleştirilmiştir. Literatürde birçok farklı tanımı olsa da inovasyon sistemleri kısaca, belirli bir amaç için çeşitli aktörlerin faaliyetlerini ve etkileşimlerini içeren bir ağ olarak tanımlanabilir. İnovasyon kapsamında bilgi üretmek için bireysel bir aktör, görevleri tek başına yerine getiremez. Ağlarda ekonomik kaynak sağlayan üreticiler, tüketiciler, üniversiteler, kurum ve kuruluşlar, politika yapıcı olarak hareket eden kamu kurumları gibi birçok aktör bulunmaktadır. Yenilik arayışlarında, çeşitli bilgi, bilgi ve diğer kaynakları kazanmak, geliştirmek ve değiş tokuş etmek için diğer kuruluşlarla etkileşime girerler. İnovasyon sistemi yaklaşımı da bu etkileşimleri konu alır.

Literatür incelendiğinde birçok farklı inovasyon sistemi yaklaşımın olduğu görülmektedir. Bunlardan ilki, bir ulus devlette kurulmuş veya kök salmış kurum ve kuruluşları içeren Ulusal İnovasyon Sistemidir (NIS). İkinci olarak, bölgesel yenilik sistemi (RIS), NIS'ın bir alt kategorisi olarak tanımlanabilir. Önceki iki yaklaşımın aksine, sektörel inovasyon sistemi, sınırlamasını belirli bir coğrafi alan yerine bir sektör veya endüstriye dayandırır. Literatürde de mevcut olan bir diğer yaklaşım ise teknolojik yenilik sistemleridir (TIS). Kısaca bu yaklaşım, sistem bileşenlerinin etrafında şekillendiği belirli bir teknolojiye odaklanır. Türkiye'de mobil telekomünikasyon teknolojilerine yönelik uygulanan politikalar incelendiğinde, bu politikaların inovasyon sistemi yaklaşımına uygun olarak dizayn edildiği tespit edilmiştir. Politikalar kapsamında bir sistem içerisinde belirli aktörler bulunmaktadır ve bu aktörler arasında etkileşim ve politikaların sebep olduğu sonuçlar ortaya çıkmaktadır. Bu nedenle inovasyon sistemi yaklaşımı bu araştırma için uygun görülmüştür. Ek olarak bu politikalar mobil telekomünikasyon teknolojileri gibi belirli bir teknoloji odağında yoğunlaştığı için de TIS yaklaşımı benimsenmiştir.

TIS içerisindeki aktörlerin etkileşimleri, normlar, regülasyonlar bir sistem içerisinde planlanmış veya planlanmamış işlevlere tekabül etmektedir ve bize sistemde neler olduğunu göstermektedir. Bu kapsamda literatürde "Teknolojik yenilik sistemindeki işlevler" kavramı, belirli bir teknolojik alanda yenilikleri geliştirme, yayma ve kullanmanın genel "amacına" bir veya daha fazla sistem bileşeninin (bileşeninin) katkılarını (olumlu veya olumsuz) ifade etmektedir. Bu tez kapsamında da Türkiye'de mobil telekomünikasyon teknolojilerine yönelik inovasyon politikaları literatürde tanımlanmış 6 farklı fonskiyon kapsamında ele alınmaktadır. Bu fonksiyonlardan ilki, bilgi geliştirme ve yayılımı fonksiyonudur. Modern ekonomide vurgulanan bilgi geliştirme, inovasyon sistemlerinin temel amacıdır. Belirli bir teknolojideki yenilik faaliyetlerinin temelini oluşturur. Sistemde üretilen bilgilerin farklı aktörler tarafından işlenmesinin, sistemin işlevselliği için hayati önem taşıdığı varsayılmaktadır. Bilimsel, teknolojik (örn. sistem entegrasyonu), üretim, lojistik, uygulamaya özel ve tasarım gibi çeşitli türleri olan bilgi geliştirme için farklı kaynaklar vardır. İkinci fonksiyon, araştırmaların yönüne etkisidir ve belirli aktörlerin sisteme girmeleri ve görevlerini yerine getirmeleri için yeterli teşvik veya baskıyı konu almaktadır. Pazar oluşumu üçüncü fonksiyon olarak yer almaktadır ve bir teknolojik çıktı için pazar oluşumunu

incelemektedir. Girişimcilik deneyi dördüncü fonksiyon olarak yer alır girişimleri belirsizliği azaltmanın birincil kaynağı, yeni teknolojiler ve uygulamalar için bir arayış anlamına gelir. Beşinci fonksiyon politikaların meşruiyetini incelerken son fonksiyon ise politikalara gerekli kaynak aktarımının sağlanıp sağlanamadığını sorgulamaktadır. Bu tez Türkiye'de uygulanan politikaları bahse konu fonksiyonlar kapsamında değerlendirerek bulgularına ulaşmıştır.

Tezin bir diğer bölümü telekomünikasyon sektörüne yönelik tarihsel bilgi ve gelişim sürecini aktarmaktadır. Ancak bu bölümde asıl olarak hem dünyadaki mobil telekomünikasyon sektörüne yönelik uygulanan politikalar değerlendirilmektedir hem de Türkiye'de uygulanan inovasyon politikaları detaylandırılmaktadır.

Öncelikle dünyada uygulanan politikalar incelendiğinde en dikkat çeken örnek Çin ve Huawei firmasının mobil altyapı ekipman pazarında hangi politikalar ile pazar lideri olduğudur. Mobil altyapı pazarı tarihte de sınırlı sayıda üreticiye sahip oligopol bir pazar yapısına sahip olmuştur. 1990'lı yılların ortasında henüz 3G dünya üzerinde kullanıma başlamadan Ericsson firmasının başını çektiği Nokia, Motorola, Alcatel, Nortel, and Lucent gibi batılı firmalar tarafından mobil altyapı pazarı domine edilmektedir. Ancak Çin'in uyguladığı inovasyon politikaları kapsamında Huawei birkaç on yıldır sektörde üretici olmasına rağmen mevcut durumda pazar lideri konumundadır. Politikaları literatürde incelendiğinde özetle; Çin üretim yeteneği geliştirmek ve bilgi aktarımını sağlayabilmek için küresel firmaları yerel firmalarla ortak girişim şirketleri şeklinde iş birliği yapmalarını sağlamaktadır. Bu iş birliği kapsamında gerekli insan kaynağına bilgi aktarımı ve deneyimi kazandırılması amaçlanmaktadır ve politikalar bu çerçevede devam etmektedir. Ancak en dikkat çeken noktalardan bir tanesi Huawei firmasının 3G ile birlikte teknolojide standart belirlemesi (TD-SCDMA) ve bu standardın uluslararası organizasyon tarafından (ITU vb.) geçerli olarak kabul edilmesinin sağlamasıdır. Bu sayede teknolojide önemli bir atalım gerçekleştirmiştir ve pazarda etkin bir oyuncu olabilmiştir. Huawei firmasının bu kapsamdaki faaliyetleri 4G'de de devam etmiştir ve standart (LTE) belirleyerek pazar lideri konumuna erişmiştir. Sektöre yönelik diğer ülke örnekleri incelendiğinde, Brezilya'nın Endonezya'nın ve Hindistan'ın altyapı pazarında üretici olabilmek için politikalar yürüttüğü görülmektedir. Bahse konu ülke örneklerinde de politikalardaki

genel çerçevenin katma değerli üretimin ülke içinde gerçekleştirilmesi ve yerli üreticilerin teşvik edilmesini içerdiği anlaşılmaktadır.

Türkiye'de ise politikaların son 10 yıldır yoğunlaştığı ve 4G ihalesinin gerçekleştiği 2015 yılından itibaren de daha önemli hale geldiği görülmektedir. Öncelikle Türkiye'de politika yapıcı kurum ve kuruluş tarafından yayımlanan birçok politika dokümanında mobil telekomünikasyon sektörü stratejik bir hedef olarak belirlenmiştir ve başta BTK olmak üzere TUBITAK, TOBB gibi birçok kamu kurum ve kuruluşu da bu hedeflerde politika yapıcı ve düzenleyici kuruluş olarak adreslemiştir. ULAK HABERLEŞME A.Ş. (ULAK), ticari operatörler tarafından kullanılan mobil ve geniş bant iletişim sistemlerine yönelik Ar-Ge ve mühendislik faaliyetlerini yürütmek üzere 2017 yılında kurulmuştur. Ayrıca OSTİM tarafından desteklenen ve BTK'nın da teşvikiyle haberleşme teknolojileri sektöründeki paydaşların iş birliğini için 2017 yılında Haberleşme Teknolojileri Kümesi (HTK) kurulmuştur. HTK, ekonomi ve sanayide kurmak, iş birliği yapmak, güçlendirmek, yerli ve milli kalkınmaya katkıda bulunmak amacındadır. Sektörün ihtiyaçlarını karşılamak, uluslararası pazarlarda rekabet etmek, üniversitelerin bu konuda geliştirdikleri bilgiyi ticarileştirmek, donanım, yazılım ve malzeme üreticileri ile sektörde hizmet veren işletmecilerin ihtiyaçlarını karşılamak, iletişim teknolojileri sektöründeki paydaşları bir araya getirmek ana görevlerindedir. ULAK ve HTK, Türkiye'de yenilikçi faaliyetlerin artırılması ve bu faaliyetlerin ticarileştirilmesi için ulusal yenilik politikalarının temel unsurlarıdır. ULAK ve HTK ayrı tüzel kişilikler olmalarına rağmen mobil telekomünikasyon sektörüne yönelik altyapı çalışmalarında kamu destekli projelerde yer almaktadırlar.

Türkiye'deki politikaların en önemli hususlarından bir tanesi de mobil operatörlere getirilen yükümlülüklerdir. Türkiye'de mobil telekomünikasyon sektöründe hizmet verebilmek için frekans ihalesi ile yetkilendirme alınması gerekmektedir. Turkcell, Vodafone ve TT Mobil bu kapsamda 2015 yılında gerçekleşen 4G ihalesine girmiştir. İlgili ihalede yetkilendirme şartları arasında yerli malı yükümlülükleri bulunmaktadır. Bu yükümlülüklerden ilk öncelikle mobil operatörler mevcut durumda her yıl kapsam içi yatırımlarının (BTK tarafından belirlenen ve özetle sektördeki katma değerli ürünleri içeren ürün listesi) en az %45'ini yerli malı belgeli ürünlerde temin etmekle

yükümlüdür. Bununla birlikte her yıl kapsam içi alımlarının en az %10'unu KOBİ'lerin Türkiye'de ürettiği ürünlerden almak zorundadırlar. Son olarak ise her yıl kapsam içi alımların en az %40'ının ise Türkiye'de Ar-Ge Merkezi bulunan ve bu Ar-Ge merkezinde 500 mühendis ve 250 araştırmacı çalışan firmalardan almakla yükümlüdür. Bu yükümlülük küresel üreticiler olan Huawei ve Ericsson tarafından yerine getirilebilmektedir ve bu yükümlülükteki temel amaç Türk mühendis ve araştırmacıların sektöre yönelik yetenek ve deneyim kazanmasıdır. Bu yükümlülükler mobil operatörlerin yıllık olarak yaptığı raporlamalar ile takip edilmektedir ve BTK tarafından denetlenmektedir. Yakın zamanda bu yükümlülüklerde belirli revizeler gerçekleştirilmiştir. Öncelikle "Milli Haberleşme Ürünü" tanımı mevzuata eklenmiştir. Henüz net bir ölçüm yöntemi bulunmasa da yükümlülüklerde bu kavrama katkı da önemli bir husus olarak belirtilmiştir. Ayrıca Ar-Ge projelerin kabulü için üniversite iş birlikleri, KOBİ iş birlikleri gibi önemli şartlar getirilmiştir. Son olarak ise bir operatörün bir firmadan yıllık olarak yapabileceği maksimum oran toplam kapsam içi alımlarının %50'si olarak belirtilmiştir.

Ayrıca 5G için yerelleştirme politikaları da başlatılmıştır. Horizon 2020 projelerine katılımı güçlendirmek için ulusal konsorsiyumlar oluşturmak için ulusal teknoloji girişimleri ve teknoloji platformlarının oluşturulması teşvik edilmektedir. 5G TR Forum, bu ulusal girişimlerin örneklerinden biridir. 5G ve ötesi yeni nesil iletişim sistemlerinde altyapı pazarlarında yer alacak özgün hizmet ve teknolojilerin geliştirilmesini sağlamayı hedeflemektedir. Ayrıca HTK tarafından BTK, OSTİM ve TÜBİTAK desteğiyle "Uçtan Uca Yerli ve Milli 5G Şebeke Projesi" (UUYM5G) başlatılmıştır. 5G ağları, 5G yeni telsiz, çekirdek ağ, ağ yönetim sistemi, telsiz link vb. ekipmanların temel altyapı parçalarının Ar-Ge süreci yerel firmalar tarafından başlatılmıştır. Hedef, 5G teknolojisinin küresel tedarikçilere olan bağımlılığını azaltmak ve 5G ile birlikte mobil telekomünikasyon altyapılarında yerli kaynakları kullanmaktır. Bu nedenle, sektördeki ileri telekomünikasyon teknolojilerinde politika ve yükümlülükler uygulanacağı görülmektedir.

Türkiye'de uygulanan politikaların hedeflenen amaca yönelik etkileri ve politikalardaki bariyerleri tespit ederek politika önerileri oluşturmak için yarı yapılandırılmış mülakatlar, ikincil veri kaynakları ve kapsamlı doküman analizi ile

araştırma gerçekleştirilmiştir. Gerçekleştirilen araştırmada Türkiye'deki politikalar kapsamında bir sistem tanımlanmıştır. Sistem içerisinde; Kamu Kurum ve Kuruluşlarının yer aldığı grubu politika yapıcı aktörler, ULAK ve HTK'yı üreticiler olarak ve Mobil Operatörleri ise sistemde tüketici rolündeki aktörler olarak sınıflandırmıştır. Bu kapsamda yarı yapılandırılmış mülakatlarda sistemde bulunan aktörlerin temsilcileriyle mülakatlar gerçekleştirilmiştir. Mülakat sorularının içeriği her bir aktör grubuna göre değişmektedir ve sistem içerisindeki rollerine göre sorular şekillendirilmiştir. İkincil veri kaynakları ise OECD, TÜİK ve Dünya Bankası gibi güvenilir veri kaynakları kullanılmıştır. Bu kaynaklarda telekomünikasyon sektöründe ya da mobil telekomünikasyon sektörüyle direkt ilişkilendirilemeyecek veriler kullanılmamıştır. Son olarak ise farklı kamu kurum ve kuruluşu tarafından yayımlanan politika dokümanları, kurul kararları, mevzuatlar, kanunlar detaylı bir şekilde incelenerek araştırmadaki bulguları saptamada yöntem olarak kullanılmıştır.

Ancak araştırmada belirli sınırlamalar bulunmaktadır. Tezin yazarı, tanımlanan sistemdeki aktörlerin birinde profesyonel olarak çalıştığından ötürü, yarı yapılandırılmış mülakatlarda ticari veri olabilecek, satın alma, fiyatlandırma gibi sorulara yer verilmemiştir. Aktör temsilcileriyle yapılan mülakatlar bu tür kaygılar göz önünde bulundurularak gerçekleştirilmiştir. Ayrıca sektörde çalışan bir profesyonel olarak birçok politika dokümanına erişim imkânı bulunsa da bu dokümanların paylaşılmasına izin verilmemiştir ve bu nedenle çalışmada bu tür bilgiler yer almamıştır.

Belirtilen çerçevede gerçekleştirilen araştırma sonucunda politikalardaki iyi işleyen ve bariyerler tespit edilmiştir. Bu bulgular fonksiyonel şekilde sınıflandırılmıştır. Bu kapsamda öncelikle birinci fonksiyon olan bilgi üretimi ve dağılımı başlığı altında tespitlere yer verilmiştir. Öncelikle, Türkiye'nin telekomünikasyon sektörü için Ar-Ge harcamalarına merkezi bütçeden ayırdığı toplam payın çok dikkat çekici olmadığı görülmüştür. Telekomünikasyon sektörü diğer alt yapı elementleriyle birlikte %6,7 seviyelerinde Ar-Ge harcamalarından pay almaktadır. Bununla birlikte, Türkiye'de Telekomünikasyona göre ticari işletme Ar-Ge harcamaları 2015 yılından itibaren düşüş göstermektedir. Bu durum sektör temsilcileriyle yapılan mülakatlarda değerlendirilmiştir. Üreticiler, TÜBİTAK 1501 (TÜBİTAK Sanayi Ar-Ge Projeleri

Destekleme Programı) ve 1507 (TÜBİTAK KOBİ Ar-Ge Başlangıç Destek Programı) programları ve ayrıca Uçtan Uca Yerli ve Milli 5G Projesi (UUYM5G projesi) için belirli desteklerin olduğunu belirtmiştir. Bu kapsamda sınırlı da olsa Ar-Ge destekleri olduğu tespiti ortaya çıkmıştır. Farklı bir indikatör olan üniversite sanayi iş birliği performansı incelendiğinde Türkiye'nin genel performansının dünya ortalaması civarında olduğunu ve diğer üreticileri ülkeler olan Çin ve İsveç'in çok altında olduğu görülmüştür. Üniversite sanayi iş birliğini geliştirmek adına yakın zamanda gerçekleştirilen mevzuat değişikliklerinde belirli ek şartların getirildiği ve HTK da yakın zamanda bir akademi çalışma grubu kurmuştur. Ayrıca YÖK tarafından da üniversite-sanayi iş birliğini arttırmak için yapılan çalışmalarda telekomünikasyon sektörünün de yer aldığı görülmektedir. Bu fonksiyon altında sektör için en önemli indikatörlerden biri de patent ve standart çalışmalarıdır. Türkiye'de patent sayıları artsa da küresel tedarikçilerle rekabet edecek boyutta değildir. Ancak Türkiye'nin 6G için İstanbul Teknik Üniversitesi ve Medipol Üniversitesi iş birliği ile standart belirleme çalışmaları devam etmektedir. Üreticiler mülakatlarda standart çalışmalarının önemini de ayrıca vurgulamıştır.

İkinci fonksiyon altında, politika yapıcılar birçok stratejik dokümanda bu sektöre yer vermiştir ve sektördeki yükümlülükler ile regülatif bir baskı oluşturarak mobil telekomünikasyon sektörüne araştırmaların yönlendirilmesi için bir hedef olarak göstermiştir. Üstelik UUYM5G projesi ile de gelecek teknolojilere yönelik de projeler oluşturulmuştur. Ancak bu başlık altındaki en önemli tartışma UUYM5G projesinin kapsamının çok geniş olduğu ve uygulanabilirliğine yönelik soru işaretleridir. Mobil operatörler 5G için de sektörde yerli malı yükümlülükleri olacaksa yeterli arzın belirli performans kriterleriyle birlikte olması gerektiğini savunmaktadır. Bu nedenle de 5G'ye ilişkin projelerin çıktıları yerli arz için oldukça önemlidir.

Pazar oluşumu fonksiyonunda ise en dikkat çeken husus, sektördeki yerli malı yükümlülükleri ile yerli üreticilerin üretime başlama zamanlamasının farklı olmasıdır. Şöyle ki; yükümlülükler 2015 yılında başlamıştır ancak yerli üreticiler ilk prototipleri 2017 yılından sonra üretebilmiştir. Bu nedenle mobil operatörler 4G şebekelerini küresel tedarikçilerin ürünleriyle kurmuştur. Yerli üreticiler üretime başladığında ise Türkiye'deki mobil altyapı pazarında yeterli fırsat bulunmuyordu. Üstelik mobil

operatörler yerli ürünlerde performans problemi olduğu, talebi karşılamakta yeterli kapasitenin sağlanmadığı ve satış sonrası işlemlerde sorunlar olduğu bilgisini paylaşmıştır. Sektörde de yeterli yerli arz bulunmamaktadır. Bu kapsamda mobil operatörler yerlilik yükümlülüklerini yerine getiremediği için idari yaptırımla da karşılaşmıştır. Politika yapıcılar tarafından özellikle ULAK tarafından yetkinliğin de arttırılması için Evrensel Hizmet Projesi kapsamında kamu alımı gerçekleştirilmiştir. 2022 yılı itibariyle Evrensel Hizmet Projesinin yeni fazında kurulacak baz istasyonlarının 4G baz istasyonunu ULAK karşılayacaktır. Bu şekilde ULAK'ın deneyim kazanarak kapasitesini arttırması amaçlanmaktadır. Ancak benzer durumun 5G'de yaşanmaması için yeterli yerli arz oluştuktan sonra Türkiye'de 5G ihalesinin yapılması önemlidir. Bu noktada da dünyada belirli ülkeler 5G kullanımına geçmiştir. 5G teknolojisinin geç adaptasyonunun maliyeti hesaplanarak yerli arz beklenmesi kararının verilmesi gerekmektedir.

Dördüncü fonksiyon ile ilgili olarak öncelikle mobil operatörlere getirilen KOBİ'lerden alım yükümlülüğü ve 150 civarında firmanın HTK altında kümelenmesi ve faaliyet göstermesi oldukça önemli politikalar arasında yer almaktadır. Üstelik politika yapıcılar tarafından belirli frekanslarda ekipman kullanımı için yerli ürün şartı getirilmiş olup bu şartın sağlanması için de HTK bünyesindeki firmalarla iş birliği yapılmaktadır. Ancak istatistikler sektördeki KOBİ sayılarının azalış gözlemlenmektedir. Pazarda yeterli fırsat olmaması ve pazara giriş maliyetlerinin yüksek olması, KOBİ'lerle yapılan iş birliklerinde performans ve satış sonrası destek problemleri bunda etken olarak görülmektedir.

Politikalardaki meşruiyet tartışmaları beşinci fonksiyon altında işlenmiştir. Mobil telekomünikasyon sektöründeki yerli üretim çalışmaları Türkiye Büyük Millet Meclisi'nde politik tartışmalara konu olduğu görülmektedir. Bu tartışmalardaki en önemli husus siber güvenlik kaygılarıdır. Özellikle dünya çapında da birçok ülkede kritik öneme sahip mobil telekomünikasyon altyapısının siber güvenlik kaygılarından dolayı birçok tartışmaya konu olduğu görülmektedir. Üstelik sektördeki yerlileştirme çalışmalarına Cumhurbaşkanı ve Bakan seviyesinde de birçok defa dile getirildiği ve yerliliğin öneminin vurgulandığı medya haberlerinde görülmüştür. Sistemdeki aktörlerin de sektördeki yerlileştirme çalışmalarını hem iktisadi hem de siber güvenlik

gibi önemli hususlardan dolayı desteklediği görülmektedir. Ancak sistem içerisinde mobil operatörler açısından bir kaygı söz konusudur. Mobil operatörler sistem içerisinde yükümlülükler ile ilişkilendirilmiştir. Üreticilere destek ve teşvikler söz konusuyken mobil operatörler yükümlülükler kapsamında denetlenmektedir. Bu durum da sistem içerisinde meşruiyet tartışmalarını politikalardaki önemli bir bariyer olarak ortaya çıkarmaktadır. Ayrıca mobil operatörler tarafından ve üreticiler tarafından sektörde yapılan çalışmaların kamu tarafından daha fazla bilinmesi gerektiği vurgulanmıştır.

Son olarak ise kaynak aktarımı konusundaki hususlar incelenmiştir. Kaynak aktarımı konusunda finansal destek ve insan kaynağı hususları incelenmiştir. Öncelikle, risk sermayesi bulunabilirliği açısından Türkiye dünya ortalamasının altındadır. Mobil altyapı pazarına giriş bariyerleri sert olmasına rağmen girişimlerin risklerini karşılayabilecek sermaye desteği bulunması çok kolay değildir. İnsan kaynağı açısından ise Huawei ve Ericsson gibi firmaların belirli sayıda mühendis ve araştırmacı çalıştırması oldukça önemli bir politikadır. Ancak yerli üreticiler bu firmalardan çok fazla istihdam sağlamadıklarını bunun nedenin de küresel firmaların katma değerli projelerde yerli mühendis ve araştırmacıları çalıştırmadığı olduğunu belirtmektedir. Politika yapıcılar da küresel firmaların Ar-Ge Merkezlerinde çalışan mühendis ve araştırmacıların kısa dönemli istihdam edildiklerini gördüklerini belirtmişlerdir. İnsan kaynağı konusunda istatistikler ise sektöre yönelik Ar-Ge çalışanlarının sayısının arttığını ortaya koymaktadır. Üstelik 5G projeleri kapsamında Orta Doğu Teknik Üniversitesi, Hacettepe Üniversitesi ve Bilkent Üniversitesi'nin ortaklaşa düzenlediği bir yüksek lisans programı da bulunmaktadır.

Araştırma kapsamında tespit edilen bulgular neticesinde politikalardaki bariyerlere çözüm olarak politika önerileri oluşturulmuştur. Politika önerileri yine fonksiyonel bazda sınıflandırılmıştır ve tez içeriğinde tespit edilen her bir bariyer özelinde ayrıştırılmıştır.

İlk fonksiyon kapsamında Ar-Ge Projeleri, Standart çalışmaları, üniversite sanayi iş birliği gibi konularda gelişim gösterilmesini içeren hususları içermektedir. Özet olarak

aşağıdaki tabloda yer alan öneriler sektördeki bilgi üretimini ve dağılımını geliştirmeyi hedeflemektedir.

Bariyerler	Politika Önerileri
• Sınırlı sayıda Ar-Ge Projesi • Aşırı düzenlenmiş süreçler • Üniversite-Sanayi İşbirliğinin Eksikliği • Ar-Ge Projelerinin Ticarileşme Sorunu • Standart ve Patent Sorunları	• Merkezi Yönetim Bütçesinde Ar-Ge tahsisinin iyileştirilmesi, • Endüstriye dayalı bir Ar-Ge destek programı tasarlamak, • Kamu alım garantisi gibi ticari işletmelerde Ar-Ge projeleri için ek teşvikler yaratmak, • Siber güvenlik, bilişim sektörü gibi sektördeki potansiyel alanlarda lisans ve yüksek lisans programları oluşturmak • Sektördeki akademisyenleri küresel tedarikçiler yerine yerel üreticilerle iş birliği yapmaya teşvik etmek • Ticarileştirme aşamasında projelere gerekli finansal desteğin sağlanması • ITU, Avrupa Telekomünikasyon Standartları Komitesi (ETSI), ONF (Açık Ağ Vakfı) gibi mobil telekomünikasyon endüstrisinde standartların belirlenmesinde etkin

	kuruluşlarda aktörlerin katılımı • Üreticiler tarafından alınan patentlerin uluslararası geçerliliğinin sağlanması için politika yapıcılar tarafından destek verilmesi

İkinci fonksiyonda ise politika yapıcılar tarafından araştırmaların ve çalışmaların yönlendirilmesi konusundaki hususları içermektedir. Gelecek teknolojilere yönelik projelerin kapsamı çok geniştir ve politika yapıcıların 5G ve 6G için daha net hedefleri sistemdeki diğer aktörlerle paylaşması gerekmektedir. Bu kapsamda ikinci fonksiyona ilişkin özet tablo aşağıda yer almaktadır.

Bariyerler	Politika Önerileri
• Uçtan Uca Projeler • Uzun Vadeli Devlet Planlaması	• UUYM5G projesinde tüm altyapı unsurları yerine belirli bir ürün grubunun politika yapıcılar tarafından belirlenmesi, • Mobil Telekomünikasyon sektöründe geleceğin teknolojileri hakkında bir gündem yayınlamak. Bu gündem, politika yapıcıların 5G ve 6G vizyonunu ifade etmektedir. Sektörde kamu yatırımı ve ticari yenilik için öncelikli alanları belirlemelidir.

Üçüncü fonksiyon kapsamında ise temel bariyer yerli üreticilerin oligopol bir pazarda yer almasını sağlamakla ilişkilendirilmiştir. Gelecek teknolojilerde de küresel

tedarikçilerin pazarı istediği gibi domine etmemesi için politika önerileri oluşturulmuştur. Bu kapsamda öneriler aşağıdaki tabloda özet olarak yer almaktadır.

Bariyerler	Politika Önerileri
• Politikalar için Zamanlama Problemi • Yetersiz Yurtiçi Arz • Rekabetçi Olmayan Fiyatlandırma • Yükümlülükler	• Yeterli arz sağlandıktan sonra 5G Frekans Tahsisi ihalesinin yapılması • Yurt içi tedarik için izleme ve değerlendirme mekanizmaları oluşturmak • Yerli ürünlerin küresel tedarikçilerin ürünleri ile fiyat rekabetine girebilmesi için vergi teşviklerinin (yeterli yurtiçi arza kadar) oluşturulması • Rekabet kurumu tarafından altyapı piyasasının düzenli olarak denetlenmesi • Yerli üreticilerin üretim taahhütleri • Mobil operatörlerin yerli malı kullanma yükümlülüklerinin yeniden düzenlenmesi; altyapılarında yerli ürün kullanma zorunluluğu

Dördüncü fonksiyon ile de sektöre girişimcilerin ilgisini arttırması amaçlanmaktadır. Bu sayede hem sektördeki yerli üretici ve yerli ürün portföyü artacaktır hem de sektördeki belirsizlikler azalacaktır. Bu kapsamda oluşturulan özet politika önerileri aşağıda yer almaktadır.

Bariyerler	Politika Önerileri
• Sınırlı Yerli Ürün Çeşitliliği • Girişimcilerin sektöre ilgi göstermemesi	• KOBİ'lerin yetkinliklerine göre yerli üretici veri tabanının oluşturulması. • Mobil operatörlerin KOBİ'lerle iş birliği yapmaları için belirli ürün gruplarına özel yükümlülükler getirilmesi • Sektörü girişimciler için daha çekici hale getirmek için aktörler tarafından programların başlatılması • Girişimciler için teknik gereksinimleri sağlamak için bir test ortamının oluşturulması • Girişimcilere finansal destek sağlanması

Meşruiyet tartışmaları farklı bir fonksiyon olarak ele alınmıştır. Bu fonksiyon kapsamında sistem içerisindeki meşruiyet tartışmalarının sonlandırılması için öneriler oluşturulmuştur. Özet tablo aşağıda yer almaktadır.

Bariyerler	Politika Önerileri
• Kamu Kurumları İş birliği • Tek Taraflı Politikalar • Kamu tarafından politikaların bilinirliği	• Gerekli kamu kurum ve kuruluşlarının sisteme dahil edilmesini sağlamak • Yerli malı kullanılması durumunda mobil operatörler için

	vergi indirimi gibi teşvik programlarının oluşturulması • Sistem içerisinde üreticilere hizmet kalitesi standartları gibi zorunluluklar getirmek • Mobil telekomünikasyon sektöründe yerli üretim faaliyetleri hakkında kamuoyunun bilgilendirilmesi (geleneksel medya araçları, sosyal medya, kamu kurumlarının açıklamaları vb.)

Son olarak ise üretim ekosistemine gerekli kaynak aktarımının sağlanması ve insan kaynağının istenilen tecrübe ve bilgi birikimini sağlaması amaçlanmaktadır. Bu kapsamdaki öneriler aşağıdaki tabloda oluşturulmuştur.

Bariyerler	Politika Önerileri
• Girişim Sermayesi Eksikliği • İnsan Kaynakları Deneyimleri	• Girişim sermayesi konusunda şirketler için kamu destek programları oluşturmak

	• Üreticilere destek sağlamak için mobil operatörler için bir fon programı oluşturma • Küresel üreticilerde projelere izleme ve değerlendirme mekanizmaları kurmak • İnsan kaynağının yerli üreticilerin istihdamını sağlamak için teşvik programları oluşturulmalıdır.

Sonuç olarak ise bu tez, mobil telekomünikasyon sektöründe uygulanan yerlileştirme çalışmalarını incelemiştir. Tez kapsamında yapılan araştırmada sektördeki yerlileştirme politikalarının gelecek nesil teknolojilerde de devam edeceğini anlaşılmıştır. Bu kapsamda tezin amacı bu politikalara katkı sağlamaktır. Üstelik yapılan görüşmelerde sistem içerisindeki aktörlerin ve politika yapıcıların sıklıkla geri bildirimde bulunulduğu ve politika yapıcıların geri bildirimler neticesinde belirli revizeleri de yaptığı görülmüştür. Son olarak ise 5G kapsamında yürütülen projeler ve 6G için belirtilen standart çalışmaları konuyla ilgili potansiyel araştırma konuları olarak öne çıkmaktadır.

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