MACROECONOMIC EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN TURKEY AND OTHER OECD MEMBER COUNTRIES

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ABSTRACT

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This thesis investigates the effects of ICT on economic growth in Turkey and other OECD member countries. After discussing the theoretical relationships between ICT usage and economic growth, we test the positive impact of ICT revolution on economic growth econometrically. In the empirical part of the study, we perform panel data analyses by employing data sets that belong to 30 OECD member countries for 1999-2008 period as well as carrying out time series analyses for only Turkey by using data between 1980 and 2009. We find out that ICT usage and production have a positive significant effect on economic growth in OECD case. However, due to some methodological difficulties and insufficiency of critical mass regarding ICT area and complementary physical and social infrastructures in Turkey, we cannot find any significant relationship between ICT and economic growth for Turkish case.

Keywords: ICT, economic growth, Turkey, OECD

ÖZ

BİLGİ VE İLETİŞİM TEKNOLOJİLERİNİN TÜRKİYE VE DİĞER OECD ÜYESİ ÜLKELERDEKİ MAKROEKONOMİK ETKİLERİ

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Bu tez, Türkiye'de ve diğer OECD üyesi ülkelerde bilgi ve iletişim teknolojilerinin (BİT) ekonomik büyüme üzerindeki etkilerini incelemektedir. BİT kullanımı ve ekonomik büyüme arasındaki teorik ilişkiler incelendikten sonra, BİT devriminin ekonomik büyüme üzerindeki olumlu etkisini ekonometrik olarak test ediyoruz. Bu çalışmanın deneysel kısmında, 30 OECD üyesi ülkeye ait 1999-2008 yıllarını kapsayan veri kullanılarak panel veri analizi yapılmış, ayrıca Türkiye'ye ait 1980-2009 yılları arasındaki 30 yıla ait veri kullanılarak zaman serileri analizi gerçekleştirilmiştir. OECD ülkeleri için yapılan analizler neticesinde BİT kullanımı ve üretiminin ekonomik büyüme üzerinde önemli bir olumlu etkisi olduğu sonucuna vardık. Fakat bazı yöntemsel zorluklar ve Türkiye'de BİT alanında gerekli eşik değere ulaşılamamış olunması ile tamamlayıcı fiziksel ve sosyal altyapıların eksikliği nedeniyle, Türkiye için yapılan uygulamalı çalışmalar neticesinde BİT ile ekonomik büyüme arasında istatistiksel olarak anlamlı bir ilişki olduğu kanıtlanamamıştır.

Anahtar Kelimeler: BİT, ekonomik büyüme, Türkiye, OECD

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INTRODUCTION

Getting wealthier and increasing living standards of its citizens are undoubtedly among primary objectives of all nations in the world. Sustainable economic growth depends heavily on profitability and competitiveness of economic activities carried out within a country. Productivity and ability to producing high value-added products and services are the main determinants of these economic competences. Moreover, technological progress is highly related with both productivity and value-added of economic activities. Practically, technological improvements get involved in this causal link in two ways. First, diffusion of new technologies in other sectors leads to usage of knowledge and other physical and human capital more efficiently which consequently creates productivity gains. Second, new technological products and services are usually high value-added ones.

Britannica Online Encyclopedia briefly defines technology as “the application of scientific knowledge to the practical aims of human life”. According to Donald Schon, technology is “any tool or technique: any product or process, any physical equipment or method of doing or making by which human capability is extended”. Roger Schroeder sees technology as “that set of processes, tools, methods, procedures and equipment used to produce goods or services” (as cited in Fleck and Howells, 2011, p. 2). Therefore, technological progress can be defined as any improvement in human capability to produce goods or services by using various factors of production.

In today’s world, it is an exception to find a person that has not met with any of the information and communication technologies (ICT). However this extensity may bring together an incomplete understanding about the context of the term. Layman may think that ICT is just computers and cell phones but it is surely more than those.

Organization for Economic Cooperation and Development (OECD) defines ICT sector to include products like "office, accounting and computing machinery; insulated wire and cable; electronic valves and tubes and other electronic components; television and radio transmitters and apparatus for line telephony and line telegraphy; television and radio receivers, sound or video recording or reproducing apparatus, and associated goods; instruments and appliances for measuring, checking, testing, navigating and other purposes; industrial process equipment" as well as services like "wholesale of computers, computer peripheral equipment and software; wholesale of electronic and telecommunications parts and equipment; telecommunications; renting of office machinery and equipment (including computers); computer and related activities" (OECD, 2012d).

With the great improvements within itself during recent decades, ICT came to the fore as one of the most vigorous areas in terms of technological progress. As a result of high R&D and innovation potential of the sector and booming demand to its products, ICT sector has emerged as a major and rapidly growing one in modern economies. Over and above, ICT is accepted as a general purpose technology. General purpose technologies, like steam engine and electricity in the past, are used by most of the other sectors for different purposes and trigger technical improvements and innovational activities in economy wide level (Bresnahan and Trajtenberg, 1995). In fact, ICT diffuses to the all segments of the economy and the society and, thus, leads to usage of knowledge and other physical and human capital more efficiently which eventually creates productivity gains. As a result of ICT diffusion, new jobs, professions and fields of business activity emerge, some of the old ones disappear, structure of labor market, characteristics of jobs and organizational forms change. Furthermore, important alterations in public administration as well as social and daily lives of individuals occur.

The term ICT revolution is used to express this widespread ICT diffusion and concomitant radical and influential changes in different aspects of social and economic lives. Analyzing the repercussions of this revolution provides a suitable workspace for those who basically want to investigate the relationship between technological progress and economic growth. In this manner, the current study examines the macroeconomic impacts of ICT revolution by focusing on the simultaneous evolutions of economic growth and ICT usage and production.

1.1. Motivation and Purpose of the Thesis

Both desirable and undesirable effects of ICT revolution on different parts of the economy and the society deserve particular attention and actually have been a popular research subject. In relevant studies, different aspects of this revolution are brought forward depending on perspective and purpose. In order to test the direction and magnitude of the overall economic impacts of ICT revolution, macroeconomic analyses, which elementarily observe how the economic situation of individual countries evolves as ICT diffusion in those countries increases, are employed. Such studies naturally have to be contented with investigating a specific country or group of countries for a certain time period.

This thesis aims to analyze macroeconomic influences of ICT revolution both theoretically and econometrically. In the theoretical part, we evaluate the economics of ICT with a broad perspective by touching various segments of social and economic spheres. In order to test the findings of the theoretical analyses, in the empirical part, we are trying to find out whether ICT had a positive effect on economic growth in OECD member countries between 1999 and 2008 and in Turkey between 1980 and 2009. Thus, this thesis presents an up to date investigation of ICT-economic growth relation in terms of involved time span and sample of countries.

In OECD countries results of ICT revolution generally occur in a more advanced level compared to other parts of the globe. Because, this group commonly constitutes of developed countries which possess necessary and complementary social, technical and economic elements for ICT revolution. Moreover, post-2000 period is usually treated as the time span in which results of that revolution would be observed substantially due to generation of a critical mass in terms of ICT diffusion in that interval yet. In the light of these two facts we think that investigating OECD member countries for the post-2000 period will be very useful to see macroeconomic impacts of ICT revolution clearly. In addition, performing separate econometric analyses for only Turkey allows us to make comparisons between two cases and helps us to draw worthwhile conclusions.

Vast majority of similar studies that go after macroeconomic effects of ICT revolution are limited with only results of ICT usage. As distinct from them, we are also interested in the production side of the ICT area. Since, we believe that ICT revolution promises more than the benefits that can be reaped by just importing ICT products and services and utilizing them. According to us, ICT production volumes and capabilities of individual countries have a significant meaning in terms of economic potential of them for both present and the future. Because, first of all, ICT is accepted as a general purpose technology and gaining production competences in such an area that have potential to affect the entire economy provides important economic and strategic advantages to its owner. There exist various positive externalities and spillover effects due to ICT production like improved innovation capacity in other areas, increased quality of human capital and enhanced general knowledge base. Furthermore, as ICT products are usually high-value added ones, rise in domestic ICT production volume reverberates positively in balance of foreign trade. Besides, being able to produce strategic ICT products within the country, especially which are used for military purposes, helps the reduction of dependence on foreign countries.

Combining the theoretical and empirical results that we obtain at the end, we sketch some lessons peculiarly for Turkey. Because ultimate objective of this study is offering suggestions for policymakers in Turkey. We think that if the associated benefits can be anticipated properly, decisions regarding the total amount and distribution of ICT investments may be taken more appropriately. Besides ICT investments, if it can be proven that there exists a positive and significant relationship between ICT production competences and economic development of a country, policymakers can be further encouraged to fulfill necessary actions that will improve the ICT production capabilities and volume of the country more proactively.

1.2. Overview of the Thesis

The organization of the thesis is as follows. After this introduction in the first chapter, Chapter 2 takes a look at the theoretical background of both economic growth and ICT revolution as well as interaction between these two issues. Firstly, fundamental economic growth theories, both of those that explain the economic growth exogenously and endogenously, are looked through. Then, economics of ICT is examined comprehensively. This examination includes the dynamics of ICT sector itself as well as consequences of ICT revolution regarding knowledge creation and utilization processes, work environment, electronic services, electronic commerce, labor market, public administration and social transformation. Later in Chapter 2, we present a representative and rich sample of similar studies that are curious about the relationship between economic growth and ICT. Our literature survey reveals that most of those studies reached positive results in terms of that relationship.

Third chapter browses the ICT sector in OECD area in general and specifically in Turkey. In this regard, policy frameworks, priorities and implementations by OECD level and in Turkey during post 2000 period are investigated. It is seen that ICT policies are increasingly treated as a tool to achieve more general social and economic objectives like fostering economic growth and employment, raising productivity, improving delivery of public and private services and enhancing the welfare and living standards of the citizens. To be able to succeed these, OECD countries are taking a number of steps in technical, administrative, economic and social realms. By the same token, also Turkey is paying considerable attention to ICT area, at least by determining policies within this direction. Moreover, Chapter 3 oversees the developments in ICT area from the point of ICT diffusion, ICT production and ICT employment. This review indicates that ICT sector has made a great progress during twenty first century in OECD member countries. Turkey is not an exception; however she does not occupy a favorable position as desired compared to most of the other OECD member countries. This fact makes us think that there may some problems in ICT policy determination and implementation steps in Turkey.

Chapter 4 is where we carry out empirical analyses. In that chapter we first present relevant information about our empirical methodology. We take necessary precautions to overcome possible statistical problems like variation, unit root, reverse causality, heteroskedasticity and autocorrelation. Then we describe the model, variables, employed proxies and data sets. Our model simply relates the GDP growth with growths in capital, labor, ICT usage and ICT production. We benefit from OECD Statistics Database as the single data source. In the econometric analyses that deal with 30 OECD member countries sample, we use a balanced panel data set which consists of 30 cross sections and 10 years between 1999 and 2008 and we employ generalized least squares (GLS) and generalized method of moments (GMM) estimation methods. In the Turkey part of the empirical work, we make time series analyses with ordinary least squares (OLS) method for 30 years between 1980 and 2009. According to our results for the OECD case, all of capital, labor, ICT usage and ICT production variables have a positive effect on the economic growth in line with our expectations. These results seem reasonable when findings of similar studies are taken into consideration and provide sufficient support to argue that there exist a positive link between economic growth and both ICT usage and production. Our findings for Turkish case indicate that although capital and labor have positive impacts on the economic growth, there is not any such significant relationship between ICT usage and economic growth. We explain this fact by the insufficiency of maturity level of ICT diffusion and complementary physical and social infrastructures in Turkey.

Finally, Chapter 5 concludes by summarizing and evaluating together the results of our theoretical discussions and empirical analyses. Our optimism about positive impacts of ICT revolution on economic growth in theoretical arguments through Chapter 3 is mostly supported by the findings of econometric analyses in Chapter 4. So, we end up that Turkey should continue paying particular attention to ICT but by taking distinguishing steps and by not ignoring the production side.

CHAPTER 2

THEORETICAL BACKGROUND

The term technology has been so popular due to a general acceptance that technological progress has a positive impact on economic growth. Actually this acknowledgement is not fallacious. It is supported by findings and views of important economists and main economic theories. According to neo-classical economist Robert Solow, economic growth can be achieved in either two ways: by increasing productivity via technical change or by increasing capital intensity via saving more (Solow, 1957). Schumpeterian approach treats technological innovation as the engine of the economic growth in the long run (Taymaz, 2001). Also Karl Marx argues that technical change is the tool for capitalist economies to raise profits by increasing productivity (Foley and Marquetti, 1997). The common ground of all these views is that technology enables people to perform tasks with more quality and efficiency as well as with less effort and cost. All these advancements correspond to a number of benefits in terms of economic perspective. Furthermore, as technology improves the existing processes and products, it also helps intensively the creation of new things. All in all, it will not be an exaggeration to argue that technology has the lion share in great developments through the human history. This chapter looks how the relationship between economy and technology, namely ICT in line with the purpose of the current study, is analyzed in the relevant literature. While doing this, we pay particular attention to employed empirical methodologies, presented analytical dependences, introduced logical interrelations and attained results in those studies.

2.1. Economics of Growth

Understanding the dynamics of the economic growth has long been one of the main interest areas of the economics. There are huge differences among countries in the world in terms of living standards and other economic indicators. Reasons behind both success stories and tragedies have attracted many economists' attention and thus a number of theories in order to comprehend how and why some individual economies perform well while others go through the floor were introduced.

Economic growth in the long run can be followed by change in output per labor and some economic models link it with exogenous variables whereas some others achieve to explain it inside the model.

2.1.1. Exogenous Growth

Initial attempts to understand and explain the dynamics of economic growth came from neoclassical economists. Neoclassical Growth Model describes long run economic growth by technological change but because this technological change is not determined in the model and taken as an exogenous variable, this model is also called as Exogenous Growth Model. Main contribution to this notion is by Robert Solow and the Solow Model can also be assessed as the origin of other attempts to explain economic growth.

The Solow Growth Model is constituted on four main components: output (Y), capital (K), labor (L) and technology or knowledge (A) with a production function like $Y(t)=F(K(t),A(t)L(t))$. In this production function technological progress is included in a labor augmenting way and $A(t)L(t))$ is called as effective labor. This production function is assumed to be constant returns to scale in capital and effective labor. It is further assumed that marginal product of capital and labor is positive but diminishes as they rise. In other words an increase in the stock of capital or labor will always result an increase in output but as the stock of capital or labor grows such an increase will have a relatively smaller effect on output. Other inputs than capital, labor and knowledge like land and natural resources are neglected (Barro and Martin, 2003).

The initial levels of capital, labor and knowledge are given; labor and technology are assumed to be growing at exogenous rates n and g respectively. There is also an exogenous depreciation rate ∂ which determines the lost portion of existing capital per unit time. Output is either consumed or saved and invested in order to raise capital stock. This division is realized according to another exogenous rate, saving rate s (Barro and Martin, 2003).

Equation (1) is the basic equation of the Solow Model which is called as law of motion of capital per effective labor and shows the change of the capital stock per effective labor over time. In this equation k=K/AL and f(k(t))=Y/AL represents the capital and output per effective labor respectively (Barro and Martin, 2003).

$$\dot{k}(t) = s \cdot f(k(t)) - (n + g + \partial) \cdot k(t) \tag{1}$$

s.f(k(t)) is actual investment per effective labor and (n+g+∂).k(t) is the break-even investment that is necessary to keep k(t) constant. The situation where these two values are equal (k(t) does not change) is named as the steady state. As it is derived in the equation system (2), Solow Model predicts that the economy always converge to a steady state where variables of the model either do not change or grow at constant rates (Barro and Martin, 2003).

$$Y = AL \cdot f(k) \tag{2a}$$

$$\dot{Y} = (\dot{A}L + A\dot{L}) \cdot f(k) + AL \cdot f'(k) \cdot \dot{k} \tag{2b}$$

$$\dot{k} = 0 \text{ at the steady state} \tag{2c}$$

$$\frac{\dot{Y}}{Y} = \frac{(\dot{A}L + A\dot{L}) \cdot f(k)}{AL \cdot f(k)} = \frac{\dot{A}}{A} + \frac{\dot{L}}{L} = g + n \tag{2d}$$

$$\left(\frac{\dot{Y}}{L}\right) = \frac{\dot{Y}L - Y\dot{L}}{L^2} = \frac{\dot{Y}}{L} - \frac{Y}{L} \cdot \frac{\dot{L}}{L} \tag{2e}$$

$$\frac{(\dot{Y/L})}{Y/L} = \frac{\dot{Y}}{Y} - \frac{\dot{L}}{L} = g + n - n = g \tag{2f}$$

As understood from the above equations, growth rate of output per labor is equal to rate of technological change at the steady state. Hence, Solow Model describes long-run economic growth with the technological change. But that technological change is not determined inside the model, instead it is taken as a given from outside the model. This prevents exploring the determinants of that technological change and so economic growth. One of the main sources of criticism towards the Solow Model is this achieving its aim via a parameter from outside the model. Afterwards various growth models which do not have this weakness of the Solow Model and are able to explain long-run economic growth inside the model were developed (Barro and Martin, 2003).

2.1.2. Endogenous Growth

Those subsequent economic growth models which treat the technological change endogenously are called as endogenous growth models. These models explain long run economic growth as a consequence of economic activities which create new technological knowledge and are shaped by the internal forces of the economic system. While Solow Model admits technological progress as separate from and independent of economic system, endogenous growth theory propose various economic factors that affect the rate of technological progress and, thus, the long run rate of economic growth. New technologies, products, processes, organizational forms and markets that emerge as a result of innovation and research and development efforts, improvement in human capital stock and dissemination of knowledge as well as all kinds of related opportunities, incentives and policies such as trade, competition, education, intellectual property rights, monetary and fiscal policies can be considered among those economic factors (Aghion and Howitt, 1997).

The basic, simplest and representative example of endogenous growth models is so called AK Model which takes its name from the form of the production function it uses: Y=AK. Here, A, which is assumed to be a positive constant, represents the level of technology and K represents the capital in broader sense in such a way that it includes both human and physical capitals. There is no raw labor in this model instead it is embedded in K as human capital. Marginal product of capital is equal to A and this means that there is no diminishing marginal product for capital, it is constant. This is one of the main points that separate AK Model from exogenous growth models. This constant marginal return in endogenous model is described by the existence of human capital which can be augmented by not only increase in number of workers but also improvements in quality of workers in ways such as gaining experience, learning by doing, knowledge spillovers, etc (Barro and Martin, 2003).

In AK model there exist exogenous rates for population growth (n), saving (s) and depreciation (∂) similar to the Solow Model. Output per capita (y=f(k)=Y/L) is equal to Ak where k=K/L and growth rate of income per capita is equal to growth rate of capital per capita as seen in equation (3).

$$\frac{(\dot{Y/L})}{Y/L} = \frac{\dot{y}}{y} = \frac{A\dot{k}}{Ak} = \frac{\dot{k}}{k} \tag{3}$$

If we write law of motion of capital per effective labor equation for the AK model, then plug f(k)=Ak into it and divide it with k to find growth rate of capital per capita as in equation system (4), it is shown that the economy represented by this simple AK Model can experience long-run economic growth without any exogenous technological change. Long-run per capita growth is determined by the level of technology and saving, population growth and depreciation rates. A change in these parameters leads permanent alteration in the rate of economic growth (Barro and Martin, 2003).

$$\dot{k} = s \cdot f(k) - (n + \partial) \cdot k \tag{4a}$$

$$\frac{\dot{k}}{k} = s \cdot A - (n + \partial) = \frac{\dot{y}}{y} \tag{4b}$$

In an extension of AK Model, which intends to make interpretations about human capital explicitly, physical and human capitals are dealt separately. This model uses a constant returns to scale production function like Y=F(K,H) where K represents all kinds of physical capital and H represents human capital. Similar to previous example, production function can be written in intensive form as equation (5a). Depreciation of physical and human capitals occurs at rates ∂K and ∂H respectively. Population is assumed to be constant and so growth in human capital appears only through net investment in it, education. RK and RH are the rental prices of the physical and human capitals respectively. Due to perfect competition assumption and zero-profit condition, each input is paid as much as its marginal product as seen in equations (5b) and (5c) (Barro and Martin, 2003).

$$Y = K \cdot f(H/K) \tag{5a}$$

$$\partial Y/\partial K = f(H/K) - (H/K) \cdot f'(H/K) = R_K \tag{5b}$$

$$\partial Y/\partial H = f'(H/K) = R_H \tag{5c}$$

By assumption these two types of capital are perfectly substitutable and for this reason, rates of returns for them, RK-∂K and RH-∂H, are equal in equilibrium. By using this fact and combining the equations (5b) and (5c), we can obtain equation (6) which can be solved for a unique and constant value of H/K. Thus, if we define f(H/K)=A, where A is a constant, equation (5a) can be written as Y=AK which is at the same form with above mentioned ordinary AK model. So, similar results regarding per capita economic growth applies for also this type of AK model (Barro and Martin, 2003).

$$f(H/K) - f'(H/K) \cdot (1 + H/K) = \partial_K - \partial_H \tag{6}$$

Another family of endogenous growth models makes a point of knowledge creation and dissemination process that advances parallel to firms' operations and investments on physical capital. It is thought that firms learn by doing and by investment and in this way gain experience which eventually affects productivity positively. This knowledge is further provided the use of other firms and spillover across the whole economy. On the basis of these arguments it is argued that there is no diminishing returns to capital in the economy-wide level (Barro and Martin, 2003).

$$Y_i = F(K_i, A_i L_i) \tag{7}$$

Let the production function of a firm i to be defined as in equation (7). Here, Ki, Li and Ai represent the physical capital, labor and knowledge available to the firm i respectively. Due to the learning by doing approach, when the level of physical capital (Ki) at the firm increases, there will be a raise also in knowledge level (Ai). In addition, by assumption, each firm's knowledge is a public good and available to other firms at no cost. In the long run, by perfect spillovers, the knowledge levels of all firms will be identical. So, Ai can be replaced by K, which is the aggregate capital in the economy, and individual production function can be written as in equation (8) (Barro and Martin, 2003).

$$Y_i = F(K_i, KL_i) \tag{8}$$

At the economy-wide level K=ΣKi and therefore the production function in equation (8) exhibits constant returns to capital while it exhibits diminishing marginal returns to capital at the firm level. This stableness for the social returns to capital results in endogenous economic growth (Barro and Martin, 2003).

Briefly, although both exogenous and endogenous growth models treat the technological change as the source of economic growth in the long run; exogenous growth model takes it from outside whereas endogenous growth model tries to explain it inside the model. With this aspect, endogenous growth model considers the ways through which technological progress contribute the economic growth such as knowledge spillovers, innovation, network externalities, etc. Therefore, we will adopt an endogenous growth approach in this study which actually seeks to investigate effects of technology on economic growth.

2.2. Economics of ICT

Nowadays actually for some time past, people frequently make reference to a new transformation similar to that from agricultural societies to industrial ones. It is argued that "New Economy", whose distinctive property is being knowledge based, is started to differentiate from the "Old Economy". Great improvements in technology, specifically in Information and Communication Technologies (ICT), especially in the last decades of the 20th century constitute the main supportive argument for this view. So indeed, as a result of the dominating developments in ICT during recent years, this area came to the forefront and caused radical transformations in terms of both social and economic aspects.

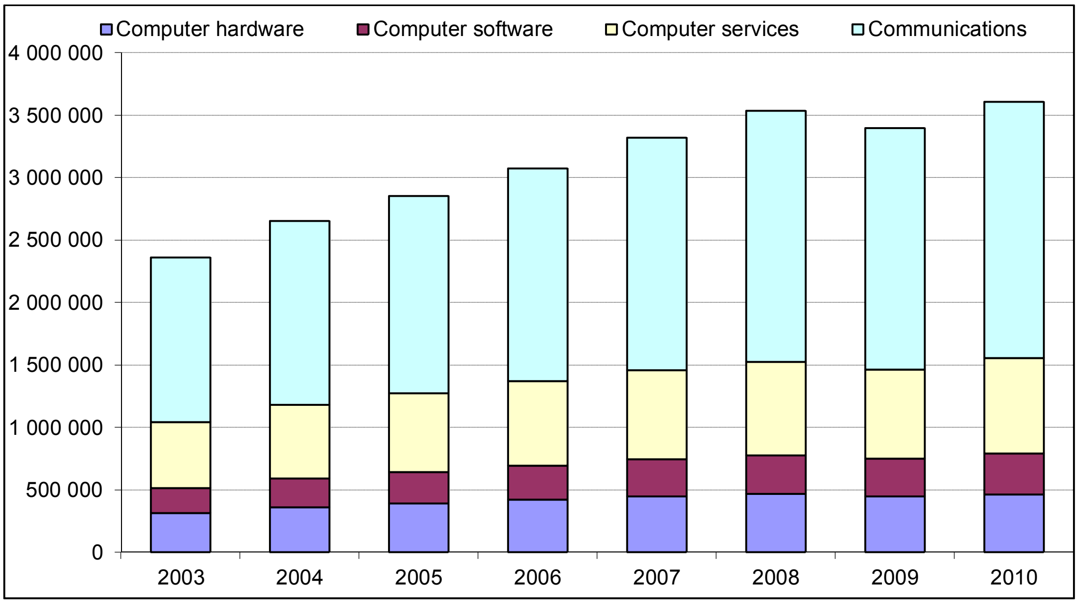
ICT sector has emerged as a major and rapidly growing one. Both economic volume and employment capacity of the sector expanded significantly. But more importantly because ICT is a general purpose technology and with the widespread usage of it in other sectors, those radical developments affected all segments of the economy and the society in general. Diffusion of ICT in other sectors leads to usage of knowledge and other physical and human capital more efficiently which consequently creates productivity gains. New jobs, professions and fields of business activity occurred, some of the old ones vanished, structure of labor market, characteristics of jobs and organizational forms changed. In addition, habits and way of entertaining and communicating of individuals as well as delivering of public services altered.

Economic effects of ICT can generally be grouped into two categories: direct and indirect effects. Size and position of the ICT sector in the economy generates the direct effects. All kinds of economic activities regarding the sector like production, marketing, trading and distribution of ICT products and services, employment within the sector, financial interactions between the ICT sector and other industries are the main channels through which ICT sector's economic effects occur.

Remaining impacts of the ICT sector on the economy can be considered as indirect effects. Change and productivity are two key words that explain those indirect economic effects of ICT. Dissemination of ICT altered the personal lives, social structure, business climate, public sector and scientific activities deeply. These alterations are generally treated as favorable ones and diffusion of ICT is strongly linked to the productivity gains in terms of both multifactor productivity and labor productivity improvements throughout the economy.

2.2.1. ICT Sector

ICT has become one of the major sectors of the modern economies. With high R&D and innovation capabilities of the sector and continuous and growing demand to its products by both individuals and other sectors of the economy, ICT sector has been expanding steadily. There is a mutual relationship among technological improvements, increasing demand and expanding size of the sector. Becoming widespread of both personal and professional usage of ICT services and products nourish the demand for the sector. This demand is not only towards existing services and products but also occasion the new ones to appear. In addition, it may require application of existing services and products in different areas with modifications. All of these constitute the driving force behind the technological improvements. As a result size of the ICT sector expands further and above mentioned mechanism is reinforced.



Source: OECD IT Outlook 2010

Figure 2.1 Worldwide ICT spending by market segment, 2003-10 (USD millions, current prices)

As seen in Figure 2.1, worldwide ICT spending has increased more than fifty per cent from 2003 to 2010 with an aberrant decrease in year 2009 due to the global financial crisis. Not only ICT spending but also value added in ICT sector is raising. When OECD area is considered, from 1995 to 2008 ICT sector value added had a compound annual growth rate of 4.7% which is higher than total business sector value added growth, 4.2%. Consequently Share of ICT value added in business sector value added has increased. In addition, ICT sector's employment growth was higher than total business employment growth for the same period. ICT sector has a high degree of globalization; global ICT trade had a 8.5% compound annual growth rate since 1996 and approached 4 trillion USD in 2008. ICT is a very convenient area for research and development activities and this sector ranks number one in R&D investment. In terms of R&D intensity, which is measured as share of R&D expenditure in total sales, ICT sector comes in second. This paid attention to R&D by the sector bears its fruit and lead the technological progress and innovation activities (OECD, 2010).

As it is revealed by the above mentioned statistics and facts, ICT sector is very dynamic. Thanks to its ability to refresh itself and introduce novel products and solutions continuously, it strengthens its position in the overall economy from day to day. Broadband internet access and fiber infrastructure, cloud computing, green ICTs and smart applications are the issues that are at the top of the agenda of the sector nowadays. Developments in these and other areas result in creation of added value and employment opportunities and by this way foster the economy.

Internet is the critical platform which plays a prominent role in the emanation of economic and social repercussions of the ICT revolution. Dissemination of broadband networks and augmentation of the capacity and speed thanks to fiber optic cabling support the Internet and make it more accessible in every respect. Cloud computing which can be defined as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" (Mell and Grance, 2011, p. 6), provides great cost advantages for organizations by enabling them to cut back the budgets allocated to hardware and software. Green ICTs and smart applications such as smart buildings, smart transportation systems and smart grids bring innovative solutions to different areas of the modern life. In addition to helping to achieve environmental targets, these technologies make it possible to use recourses more effectively, secure cost savings and productivity gains. They also induce new products and new markets thus additional economic capacity and employment opportunities.

Apart from developments within the ICT sector itself, dissemination of ICT across other fields generates important productivity raise throughout the whole economy. ICT makes both physical and human capital more productive for ICT-using industries (Erdil, 2010). There is also a wide array of means through which ICT accomplishes good jobs.

2.2.2. Knowledge

Importance and worth of knowledge in human life in terms of both social and economic aspects are admitted historically. Indeed, that is basically nothing but knowledge that enables mankind to improve its life and satisfy its needs by finding out new products and methods and thus become able to perform its activities with more quality and less effort. In addition to unprecedented human brain, major input of knowledge creation process is information. While constituting and developing the knowledge base, people need and gather information from various sources and utilize it to reach convenient outputs. Close relation between ICT and knowledge emerges from this point. By the widespread usage of ICT in all areas of economic and social life and Internet becoming a network that spreads the entire globe, dynamics of the knowledge creation process has altered substantially. ICT provided great advancements in producing, processing, storing, sharing and easy access to information (SPO, 2006a). Quality of information and communication equipments and software increased while cost of obtaining and operating them decreased steadily. Internet emerged as a ubiquitous source for all kind of information. These technologies started to be available to wide segments of people for both private and professional purposes. These developments made knowledge-creating activities more efficient. Thus, knowledge became much more accessible and abundant. Faster and easier diffusion and absorption of newly developed knowledge supported further knowledge creation. These favorable impacts of ICT grow further as more people uses ICT thanks to network effects (Bartelsman and Hinloopen, 2005).

These positive effects of ICT regarding the knowledge result in various economic improvements. First of all, mankind equipped with much more knowledge finds better ways to use on hand resources to create economic value and achieve productivity growth. In addition, innovation and R&D activities which are highly dependent on the knowledge started to be carried out more effectively and efficiently. Researchers who reach better quality and more information and who are equipped with strong computing devices and skillful software become more creative and productive. Practitioners who also take advantage of ICT in similar manners can transform new technologies to economic value more efficiently. Economic agents could be aware of successful applications, new inventions, trends, etc. in their fields and benefit from them easily and with no or very little cost. Customers can learn about different products, suppliers, prices, etc. from all around the world instead of only those that are in their narrow neighborhood. Thereby full information assumption of neoclassical theory is approached to take place. Moreover, decision makers can obtain better knowledge in terms of both quantity and quality more easily, thus can take more accurate decisions. This positively affects the general working of their organizations.

2.2.3. Work Environment

Today it is very hard to find a workplace where a computer is not present. Besides labor and physical capital productivity raises, diffusion of ICT has dramatic effects in firm and industry-wide levels. While differing according to the taken over structure and culture, ICT becomes influential on nature, variety and the way of all sorts of activities of organizations. Within the firm; organizational structures, hierarchical relationships, types, numbers and methods of tasks may alter. Outside the firm, if advantages of ICT can be captured properly new business opportunities may become available to the firm or inversely firm may lose its previous advantages against other firms that achieve to reap the benefits of ICT revolution better.

Thanks to ICT, flow of information within the firm gets easier. This brings about more informed employees, reduces necessary coordination efforts, facilitates team work, increases flexibility and leads to creation of a more open and innovative culture in the firm. As well, more effective management becomes possible by taking advantage of more influential and diversified ways of accessing information from both inside and outside of the organization (David Skyrme Associates, 2012). Various ICT applications like decision support systems also help managers by promoting decision-making processes.

ICT alters the way jobs are performed within the firm dramatically. While some tasks are modified or automated, some of them are replaced by new ones. Interrelationships with customers and suppliers are also affected by the ICT revolution. Flow of information between firms and their stakeholders increases substantially (David Skyrme Associates, 2012). Firms are now more aware of customers' needs and desires so that they can direct their customization, production and advertising activities accordingly. More effective supply chain management becomes possible. Useful software applications like enterprise resource planning systems make online tracking of the status of all tasks and resources within the firm as well as online handling of some of them. Firms can establish stronger communication channels with their suppliers and thus are able to be safer in terms of proper and timely delivery of their orders.

Physical workplace environment is another point which is subject to the effects of the ICT revolution. Thanks to ICT, settlement of employees may become independent of some of the old limitations. This provides more flexibility while organizing the workplace in both office and building wide level (David Skyrme Associates, 2012). Tele-conference systems, which enable people who are in different geographical locations to have meetings as they are in the same room, and tele-working systems which enable people to do their jobs remotely are two of the other outputs of ICT that make life easier for employees and organizations.

As seen, all above mentioned developments caused by ICT in work environment brings about various advantages for organizations. Herewith they can perform their works more efficiently, achieve considerable cost reductions and experience productivity gains. However, it is not so easy to adapt and benefit from ICT properly for all firms. Just purchasing computers and software does not solve any problems or improve anything on its own. Organizations have to have a transformation to be able to reap the benefits of ICT revolution. This transformation may be a comprehensive and complete one or may be confined with a limited scope according to the firm's necessities and characteristics. In any case, it is not free from significant costs and risks and for this reason should be managed very carefully and professionally.

Otherwise, ICT revolution may bring huge financial burdens and other kinds of costs like time wasting that go for nothing.

2.2.4. E-Services

Transfer of many daily life applications to the virtual environment and dissemination of electronic services such as e-banking, e-health, e-learning, etc. provide easiness for people by removing some of the traditional constraints, especially geographical barriers, as well as making great time and money savings possible.

In modern societies almost everyone is the object of electronic banking which started with the use of automatic teller machines (ATMs) and also contains telephone banking, electronic payment systems, electronic fund transfer, internet banking and mobile banking applications. E-banking services enable customers to carry out almost all practices that are available in branch banks. Individuals can get detailed information on their accounts, conduct fund transfers, pay bills, exchange financial instruments like stocks, bonds and shares, create new accounts and apply for credits with no need to visit a bank branch (Cristina, 2008). This rescues them from lots of physical and time limitations in addition to providing opportunity to cut back their expenses. Likewise banks make advantage of e-banking by reducing their transaction costs and expenditures for branches. They can allocate those freed resources to find more innovative ways to service customers, gain competitive advantage over their rivals and thus increase their market share.

Health is one of the main factors that determine the life quality of people and ICT brings about various improvements to the healthcare field. The term electronic health is used for all types of ICT based healthcare practices that are utilized by both patients and healthcare professionals. E-health applications involve health information systems, electronic health records, telemedicine services, health portals and a number of other ICT-enabled tools that helps in disease prevention, diagnosis, treatment, health monitoring and lifestyle management. These tools contribute to provision of healthcare services in better and more efficient ways. E-health applications enable healthcare staff to obtain, exchange and track information about patients in more advanced ways. Patients can also reach more information about their own health status. Patients' condition can be monitored remotely and some health services can be presented with no need to patients leaving their inhabitations. E-health tools are useful in relieving limits on resources in both budgetary and staffing terms and by this way affect productivity positively (European Commission, 2012). Apart from these there are various hard to quantify financial and nonfinancial benefits for both individuals and the society of preventing or treating diseases more effectively.

Electronic learning can be defined as utilization of ICT in synchronous or asynchronous and self-paced or group-based learning and teaching activities. In this context, individuals can reach both online learning resources like databases and course contents accessible via internet and offline learning packages like a hard drive or CD. Moreover, a group of learners can work together either simultaneously via technologies like videoconferencing or real time chat or with a time delay via mailing lists or text based conferencing systems. Decreasing costs together with increasing multi-media capacities of ICT promoted the electronic educational processes. Thanks to e-learning applications it becomes possible to capture, store and distribute enriched and more up-to-date information and resources in more diversified types and formats. In addition, e-learning provides great flexibility in terms of time, place and pace. Thus, people are freed from traditional constraints like attending at a classroom and using only printed resources. Educational institutions can reach markets that are beyond their periphery. People who live in disadvantageous regions both in country and international level are enabled to attain more qualified education opportunities. As well, e-learning promise important cost savings; especially corporate users show interest in it to be able train their personnel more effectively (Naidu, 2006).

2.2.5. E-Commerce

Another e-application is the electronic commerce which rose as a critical economic phenomenon and should be discussed on its own within the scope of such a study that tries to examine economic effects of ICT. Electronic commerce is the process of buying and selling or exchanging of products, services and information via computer networks. It covers any form of business or administrative transaction or information exchange that is executed using ICT (Turban et al., 2000). E-commerce involves transactions both between firms each other and firms and customers. Goods and services that are subject to e-commerce may be delivered either at real or virtual environment. For example, selling of a book via a website and delivering it to the house of the customer is in the scope of e-commerce as well as selling software and delivering it online is (Coppel, 2000).

Electronic commerce gradually takes a larger place in the economy; share of online purchasing and selling activities in total business turnover is increasing (OECD, 2010). This trend seems to continue and has various important effects on the structure and operation of the economy. E-commerce transforms the marketplace by changing the way business is conducted, paving the way for new products and markets, string up new and closer relationships between firms and customers, changing the organization in work and introducing a work environment with more knowledge diffusion, human interactivity, openness and flexibility. E-commerce has an accelerating and facilitating effect on other contemporary reforms like globalization of economic activities and increasing demand for higher skilled workers. E-commerce also brings about enhanced interaction and transparency in the economic activities while decreasing the importance of time and physical limitations (OECD, 1999). E-commerce creates a new and more efficient marketplace where search, customization, exchange, distribution and consumption processes are improved (Coppel, 2000).

Supply chain management is one of the major areas where benefits of the e-commerce are reaped intensively. One of the basic cost items that firms usually strive to minimize is inventory costs and e-commerce help them to achieve this by several ways. In electronic marketplace, firms can obtain improved demand forecasts and thus make finer adjustments in their inventories (OECD, 1999). In e-commerce context, there is higher level of information exchange between firms and their suppliers. Suppliers may be kept informed about stock levels of the firm and, thus, are able to produce and deliver necessaries of the firm just in time, sometimes even with no need to placement of an order by the firm. In addition to this, more advanced communication channels between those parties exist. Thus, transaction costs of the firms drop because of decreasing number and unit costs of transactions while speed of transactions increases. E-commerce also creates opportunity for firms to reach a greater number of suppliers directly. Because they choose out of more supplier alternatives and get rid of intermediary institutions, firms can lower their purchasing costs. Cost reductions in production and delivery of digital products rise further. Once software is created marginal cost of copying it is infinitesimal. Firms do not need to bear delivery expenses if customer can download the digital product to his computer (Coppel, 2000).

Likewise there are various advantages of e-commerce for other side of the supply chain. E-commerce significantly increases the efficiency and effectiveness of the marketing and sale processes. First of all, firms can secure radical savings in costs associated with having and operating physical stores. Establishing and running a cyber store are almost always cheaper than doing same for a real one. Those cyber stores require fewer variable costs and are 7/24 open for not only local markets but also the global one. In addition, firms can obtain more accuracy in taking orders from the customers by presenting sufficient information about their products online. Those financial and administrative procedures concerning invoices and receipts can be carried out easier, faster and more correctly in digital medium. As complexness of products rise, importance and budgets of customer support and after sale services also grow. Firms can reduce the costs significantly while usually improving the quality by moving those services to the online environment (OECD, 1999). Another advantage of e-commerce is its potential of enabling businesses to investigate customers' preferences much better. By this means firms can perform customization and marketing activities more effectively. E-commerce enables currently operating companies to reach markets that they cannot penetrate with traditional methods. It also reduces barriers to entry for especially small and medium sized enterprises (Coppel, 2000).

E-commerce also provides a good deal of benefits from the point of customers. Disappearance of intermediaries between consumers and producers pulls down the prices significantly. Consumers can shop without traveling till stores, thus they can save time and reduce transportation costs. They can search and access more choices of products easily. This makes customers more informed and stronger and creates opportunity for them to satisfy their needs with greater convenience as well as to come up with best prices. They may also profit by increased competition among firms in e-commerce environment (Coppel, 2000). These benefits become more important for people who live in disadvantageous regions.

E-commerce has also several more general and structural impacts. Increased openness, innovation and competition augment the overall economic efficiency. E-commerce triggers introduction of new models for production, distribution, marketing and competition. It encourages firms for flatter organizational hierarchies, continuous training and collaborating with each others. The development of e-commerce has significant effects on labor market. It means new job opportunities for some whereas unemployment for some others. But it is sure that e-commerce shifts the qualification of workers towards a higher level. Effects of e-commerce are associated with some broader social changes like globalization of markets and shift towards knowledge economies (OECD, 1999).

In sum, e-commerce increase efficiency and effectiveness of economic activities and processes, decrease a number of costs and promote productivity in certain areas through several channels in different layers of the economy. These measurable and immeasurable positive impacts may also occur in economy-wide level.

2.2.6. Labor Market

Another major topic where repercussions of the developments in ICT are perceived extensively is labor market. Besides new employment opportunities created within the ICT sector, with the widespread usage of these technologies in other sectors, radical alterations take place in work patterns and occupations. Demand for ICT experts and ICT literate staff grows. As new tasks and processes appear in work environment or complexity of existing ones increases due to involvement of ICT, some new job descriptions and professions emerge. These usually require higher skills and mean employment opportunity for individuals who have suitable qualifications. Moreover, some traditional jobs are ruled out while some of them are transformed. A great number of tasks that were performed based mainly on manpower previously started to be carried out automatically or with fewer but more qualified labor force. This shift towards a higher level in terms of employee qualifications generally increases labor productivity. On the other hand, this transformation process may job descriptions more ambiguous. Thus the value of expertise may depreciate in this transformation process. At least as importantly as this, while companies capture the benefits of possible raises in labor productivity and efficiency, life becomes much more difficult for those workers who have low level of qualifications and cannot adopt ICT revolution personally. They either lose their jobs or have to accept lower wages. This makes their relative economic position in the society, which is also not so good previously, even worse. This appears as an important issue that should be handled via different ways like retraining in order to spread advantages of ICT revolution throughout the whole society.

ICT has also indirect impacts on labor market and affects the general operation principles of it deeply, alters the dynamics and structure of the employment. ICT revolution leads the separation of work from physical environments completely or partly thanks to applications like tele-working. Providing service via telephone or internet also becomes a common practice and creates new working types. These help people who normally cannot participate to labor force due to several limitations like age, gender and geographical location to find a job and contribute to the economy. Furthermore, ICT give chance for job seekers and employers to meet in online platforms. This makes it possible for individuals to get a job that is compatible with their qualifications as well as enabling employers to find personnel who is vested with job requirements in a faster and more effective way.

2.2.7. Public Sector

ICT revolution has triggered an extensive and radical transformation in public sector. E-government is one of the most popular and critical concepts that emerged as a result of developments in ICT. E-government can be defined as utilization of ICT by government to interact with and render service to citizens and businesses via different electronic channels. E-government also involves online interactions of public institutions between each other. The most common e-government implementations include a number of applications to the governmental bodies such as license, certificate and job applications, various payments such as tax, fine and bill payments, filling up forms with the aim of submitting required information or providing statistical data in electronic environments and publication of laws and regulations on the Internet (Almarabeh and AbuAli, 2010). Generally speaking, effects of ICT in public sector are similar to those observed in other areas. E-government brings about improved efficiency, diminished costs, time savings and increased productivity in public services.

Thanks to e-government applications public institutions can perform their tasks such as collecting, processing and sharing data as well as delivering government services to the citizens in an automated way with a higher speed and more accurately and reliably. This improves their performance while reducing transaction costs. As well, general service quality of public sector rises significantly. E-government enhances availability and accessibility of government services. Citizens can perform government related operations without being bound to office hours or geographical constraints and this provides great flexibility and cost-saving opportunity for them (Almarabeh and AbuAli, 2010).

E-government triggers a transformation inside the government. Government reviews and restores its own organization, administration, rules, regulations, service delivery manner and principles and processes for coordination, communication and integration within itself (Almarabeh and AbuAli, 2010). Thanks to effective information sharing infrastructures and systems as well as interoperability and compatibility at technical, logical and processes levels among different public institutions, efficiency and quality of public services increase. Moreover, with e-government, administrative burdens are relieved, bureaucratic procedures diminish, repeated information acquires by the same or different public institutions and data losses are removed. Transparency, accountability and trustability of government bodies improve, necessities of citizens can be understood better and their satisfaction increases. It is also thought that citizens may be encouraged to fulfill their obligations towards the state due to fast and clear delivery of public services. Existence of such a motivation especially in doing payments straightly and on time contributes to the growth of public revenues (Almarabeh and AbuAli, 2010).

Sharing and re-use of public sector information is another issue which relates government and economic effects of ICT revolution. Public institutions presents a wide variety of services in both online and offline environments. While doing that, they gather, produce, regenerate and spread a great amount of information in various areas such as geographical, economic, social, business, weather and educational information (European Commission, 2003). Such information is called as public sector information and it has a significant economic value thanks to ICT which makes it easier and more efficient to collect, produce, share and re-use public sector information. Information plays an increasingly significant role in modern societies which started to transform into information societies as a consequence of ICT revolution. Nowadays, there are firms whose line of business is just collecting, organizing and analyzing data. Almost all businesses, especially those in the service industry, need and make use of public sector information with different purposes. In addition to being a rich source, public sector information is sometimes the single or hardly single reference (Pollock, 2008). All in all, public sector information has a significant economic value. Government can generate an income by selling the information on its hand to the demanding parties. This would provide a surplus for the whole society by contributing to the government budget. On the other side, government may encourage and support private sector companies to use public sector information in order to produce value-added products and services or improve their existing businesses. This consequently leads the creation of additional economic worth. However, while trying to extract economic advantage from public sector information critical issues like privacy, security and intellectual property rights should be taken into consideration.

2.2.8. Social Transformation

Transforming into the information society is an integrated process and includes also social and cultural alteration in addition to change in traditional mechanisms of the economy (SPO, 2006a). Increasing usage of ICT in daily and working lives of people brings about a wide range of novelties for individuals such as those in habits, way of entertaining and networking, distribution of expenditures, education and training forms. These alterations affect a lot of complex interrelations and result in some economic consequences. Those new opportunities play an important role in achievement of easier sell-fulfillment, increased personal prosperity, advanced standards of living and grown social welfare. In addition, quality of services is improved and they are generalized throughout the country equally. Disadvantageous segments of the society, especially disabled people, who cannot or can only limitedly benefit from services become more active and integrated to the society. These contribute the advancement of social development.

As seen above, ICT has various direct and indirect effects some of which can be measured easily whereas others cannot be quantified properly. In this study, we will look at the relationship between some ICT statistics and GDP growth because all those effects that are mentioned above are more or less contained by the GDP path in the long run. Next section summarizes the previous studies that discuss this relationship.

In the light of the facts that have been discussed above, it can be concluded that ICT revolution brings about a great number of alterations to the economic, social and daily lives. While some of the effects of that transformation can be observed easily by everybody, recognizing and evaluating some of those impacts require more exertion. Furthermore, it is not so easy to quantify the exact magnitude and scope of all of the direct and indirect consequences of ICT revolution. Instead, the current study tries to measure economic impacts of ICT revolution in aggregated terms. For this purpose, GDP growth path, which seems as a somewhat acceptable gauge for the overall direction of an economy and contains the results of all those effects that are mentioned above more or less in the long run, is related with ICT statistics in order to be able to analyze the impacts of ICT revolution on the overall economy. Next section summarizes a number of previous similar studies, which discuss and investigate the macroeconomic impacts of ICT.

2.3. Summary of Previous Work

Link between ICT and economic growth has been subject to a great number of empirical studies. These studies commonly share a curiosity about exact worth of ICT and try to quantify it with different methods and different data sets belonging different countries and different periods of time. So they reach diverse results accordingly. But it should be stated beforehand that there is a general tendency in favor of ICT. A representative and rich sample of those studies is presented in this section with an ordering that generally prioritizes the studies that deal with earlier intervals. Because, we share the view which asserts that benefits of ICT can be received more as the share of these technologies in the overall economy increase and these technologies actually become widespread as time passes.

In addition to following production function framework and applying econometric analyses as the current study does, growth-accounting methodology is also widely utilized to determine the contribution of ICT to the economic growth. Growth-accounting emanates from the seminal work of Robert Solow in 1957 and explains the output growth with the growth in inputs plus growth in the efficiency. In this method, different types of capital inputs are weighted according to their income shares. Efficiency, which is defined as multifactor productivity (MFP) and actually a residual term, is used to capture the portion of output growth that cannot be related with the growth in any of the inputs. MFP growth may occur due to advancements such as introduction of new technologies, organizational improvements, resource reallocation and scale economies (Parham et al., 2001). Another critical contribution by Solow to the literature is so called "Solow Productivity Paradox" which originates from his famous 1987 quip as "you can see the computer age everywhere but in the productivity statistics" (Solow, 1987). This term refers the contradiction between intensive ICT investment after 1970s and nonappearance of expected positive effects of ICT diffusion on productivity and economic growth in the US. This situation was mainly due to lag effects; diffusion of ICT takes a longer period than expected. There are lots of studies dedicated to deal with this paradox including some of the below mentioned ones.

Norton (1992) questions the sources of differences in economic growth rates of nations and tries to investigate if telecommunications is one of those sources. He claims that there is a link between transaction costs, telecommunications, and economic growth and telecommunications foster economic growth by decreasing transaction costs in information, product and factor markets. According to Norton (1992), telecommunications makes it easier and cheaper to access relevant information and, thus, increase the efficiency of decision making processes. To test his hypothesis about positive effects of telecommunications on economic growth, Norton (1992) borrows a theoretical framework from Kormendi and Meguire (1985) who examine cross nation growth of 47 countries between years 1957 and 1977. To achieve his specific purpose, Norton (1992) adds two telecommunications variables to the original regression model. Those new variables, which are used as proxy for existence of telecommunication infrastructure, are the stock of telephones per hundred population in 1957 and the average stock of telephones between 1957 and

1977. Norton (1992) suspects that the telecommunication infrastructure can expand as a result of economic growth and so there may exist reverse causality between data for telecommunications and economic growth. To be able to clear the air, he sensibly chooses telephones stock data for the first year of the studied time interval as one of the independent variables that explains the evolution of economic growth. Dependent variable is the mean annual growth rate of domestic or national product for the sample years. As a result of regression analyses which show that telecommunications variables are positive and generally significant, Norton (1992) concludes that telecommunications support economic growth by lowering transaction costs.

Being aware of substitution of IT equipment and technical change are not the same thing, Jorgenson and Stiroh (1999) examine technical and economic effects of IT diffusion in the US during 1948-1996. They explain substitution as the introduction of computer-intensive technology that produces benefits for only those who use that technology whereas arguing that technical change occurs only if some benefits spillover to the overall economy and it becomes possible to produce more output from the same inputs. Although they accept the critical importance of communication technologies, they only focus on computer which is treated as both an investment good for firms and consumption good for individuals in their study. After revealing the continuing decline in computer prices and consequent diffusion of IT equipment, Jorgenson and Stiroh (1999) search for any significant effect of that diffusion on technical change and economic growth by employing growth-accounting methodology. They find out that aggregate total factor productivity growth per year for 1990-1996 period is lower than 1973-1990. Hence, they decide that huge investment in computer technologies that is induced by rapid price decline caused substitution of IT equipment for other inputs, not technical change. Furthermore, they present sources of output growth for U.S private domestic economy for three sub periods: 1948-1973, 1973-1990 and 1990-1996. Average output growths for these sub-periods are determined as approximately 4, 2.9 and 2.4 per cent respectively. Even though there are various factors behind this declining trend, it signals that diffusion of computers did not go hand in hand with a raise in economic growth. On the other hand, according Jorgenson and Stiroh (1999)'s findings, although computers' contribution to economic growth is negligible for the pre-1973 period, it gradually increases and reaches to the one sixth of the total economic growth between 1990 and 1996. Combining all these results, Jorgenson and Stiroh (1999) conclude that production and use of computers are changing the US economy but could not trigger a boom in output growth and total factor productivity because returns from investment to IT equipment are limited only with producers and users of it, thus, spillover of the benefits were not realized in the studied period.

Röller and Waverman (2001) investigate how telecommunication infrastructure affects the economic growth by using evidence from 21 OECD countries for 1970-1990. According to authors, increase in the production of telecommunication equipment is the first channel through which benefits of investment in telecommunication infrastructure occur. But more importantly, those benefits are reaped throughout the whole economy via decrease in transaction costs and increase in information intensity of production processes. By this way, cost of doing business falls and productive units can produce better and more. As Norton (1992), Röller and Waverman (2001) also realize that there may appear a mutual positive relationship between telecommunications and economic growth. In order to overcome reverse causality problem, besides an aggregate production function, they specify a micro model for supply and demand of telecommunication investment and establish a joint structural model. According to their claim, by this way they "endogenize" telecommunication investment and, thus, are able to control the causality effects. In addition to causality problem, they regard the existence of spurious correlation possible due to probability of correlation between country-specific telecommunication investments and other growth-promoting measures like investment in R&D and human capital. To control such correlations they include country-specific fixed effects. As a preparation to econometric analyses, they, first look at the simple correlation between GDP and telecommunications data and find a very strong association between real GDP and mainline per hundred inhabitants. For the econometric analyses, GDP is related with non-telecommunications capital stock, telecommunications capital stock, human capital stock and an exogenous time trend. Penetration rate, which is calculated as the number of mainlines per capita, is used as a proxy to measure the stock of telecommunication infrastructure. They find out that telecommunications has positive and significant effects on aggregate output growth. Moreover, Röller and Waverman (2001) rightly test if there exists any network externalities for telecommunication infrastructure differently from other types of infrastructures. They reach evidence of increasing returns to telecommunication investment and conclude that advancement of telecommunication infrastructure create higher growth effects for more developed countries which already have a higher penetration rate.

Oliner and Sichel (1994), in their comprehensive study, examine the contribution of ICT to economic growth in the US over 1970-1992 period by using growth-accounting framework and also touch on discussions regarding Solow Paradox. In their first attempt, they find that computing equipment made a small contribution to economic growth as 0.16 per cent per year on average between 1970 and 1992. When they divide this period into two as 1970-1979 and 1980-1992, they see that computers mean much more for the second sub-period. This weak influence by computers, which becomes even less important when net contribution is calculated by considering depreciations, is attributed to tiny share of computing equipment in total capital stock of the US. Apart from this base case, Oliner and Sichel (1994) think that externalities associated with computers, like building the knowledge base or learning by doing, may also be effective on economic growth. Their calculations which take externality effects into account and based on different estimates imply annually at most 0.32 percentage contribution of computers to output growth from year 1970 to 1992. Considering the fact that computers are not used in isolation, instead they are meaningful with software and computer-services labor, Oliner and Sichel (1994) extend their growth-accounting framework to include these two inputs. For this version, they can work on data for only 1987-1992 interval and find out that computing services which contain hardware, software and labor components contribute to economic growth 0.40 percentage point a year over that period. They further widen their study and examine the growth contribution of all information-processing equipment including communications. By this way, they obtain 0.31 percentage point annual contribution by information-processing equipment to output growth over the period from 1972 to 1992 which is about double that of just computers. At their most inclusive trial which involve all information-processing equipment, computer software and computer-services labor, Oliner and Sichel (1994) determine the contribution to output growth as 0.50 percentage point a year during 1987-1992. Finally, authors make forecasts for the future based on several projections and deduce that computing services will not be able to contribute to economic growth noticeably over the next ten years because share of computing services seems to remain modest. In brief, Oliner and Sichel (1994) conclude that ICT do not have a significant positive effect on economic growth of the US for 1970-1992 interval as well as it does not suggest good signs for the future. The main reason behind this is the fact that actually "computers were not everywhere".

Parham, et al. (2001) analyze the role of IT in Australia's economic growth between years 1964 and 2000 and compare it with the experience of the US. In their empirical investigation within the framework of growth-accounting, they can use data for only investment in computer hardware, which includes computing and office equipment, and computer software, which is defined as purchased or in-house developed software and large expenditures on databases, but could not involve communication equipment due to lack of available data. As we do in the next chapter, before starting the empirical part of the study, authors present relevant information about IT sector of Australia with an historical perspective. This is useful from the point of gaining a general opinion about the dynamics of IT sector in that country. With the contribution of falling prices, investment in IT became a major proportion of total investment in Australia from the mid 1980s and grew further especially in 1990s. During the period from 1964 to 2000, annual average growth in IT capital stock is calculated as more than 30 per cent. Moreover, investment in IT in 2000 is determined as approximately 18 per cent of annual market sector investment in real terms. These developments naturally increased the productive IT capital stock and the share of capital income attributable to IT in Australia. Average annual output growth in Australian market sector between 1964 and 2000 is 3.4 per cent and according to Parham, et al. (2001)'s calculations, a portion of 0.4 per cent of that growth is due to IT. But when only 1990s is considered share of IT in average annual output growth raise to 1.1 per cent. Besides, second half of the 1990s is prominently better than the first half in terms of IT contribution. When they compare their results for Australia and results of some other researchers for the US, Parham, et al. (2001) find a similar or slightly higher contribution from IT in Australia. Combining this and the fact that the US is a major IT producing country, they conclude that production of IT equipment is not necessary to benefit from ICT revolution. Current study also deals with the economic effects of ICT production capabilities of countries but hopes to reach more favorable conclusions.

In another country specific study, Ramlan, et al. (2007) seek to determine whether there is significant impact of ICT on economic growth of Malaysia. Authors state that knowledge-based economy is not confined to ICT alone but has a human capital extent beside it. Then try to determine the contribution of ICT to the human capital development in Malaysia. In their empirical work Ramlan, et al. (2007) utilize the data on imports of telecommunication equipment as a proxy for ICT and total labor employed as a proxy for human capital. They follow growth-accounting methodology and measure ICT contribution to growth in aggregate output in Malaysia between 1966 and 2005. They investigate this period by dividing it into two according to the structural transformation of Malaysian economy as 1966-1986 and 1987-2005. Contribution of ICT to Malaysian economic growth from 1966 to 2005 is calculated as the 12.6 per cent. This rate is 18.4 per cent for the second sub period and significantly better than the first one which has a value of 8 per cent. Thus, Ramlan, et al. (2007) conclude that investments in telecommunications affect the economic growth in Malaysia significantly. They also find that approximately one tenth of the growth in human capital productivity is due to ICT during the investigated years and decide that ICT played a major role in human capital development of Malaysia.

Yoo (2003) investigates the relationship between investment in information technologies and economic growth by using data from 56 developing countries for the time interval between 1970 and 1998. He uses an extended version of the augmented Solow model that is initially suggested by MRW (1992) and then modified by Nonneman and Vanhoudt (1996). Within the neoclassical framework a Cobb-Douglas type production function, which relates aggregate output with physical capital, human capital, IT capital, labor and technology, is adopted. Furthermore, countries are assumed to be at the steady state. Yoo (2003) makes his estimations based on a model which takes real GDP per person of working age in 1998 as the dependent variable and tries to explain it with average of annual ratios of real domestic investment to real GDP as a proxy for physical capital, average of percentage of the working age population that is in secondary school as a proxy for human capital, average of annual ratios of gross domestic IT investment to nominal GDP as a proxy for IT capital and, finally, compound average annual growth rate of working age population as a proxy for labor for 1970-1998 period. According to results, impact of IT investment on economic growth is found to be statistically meaningful. Therefore, Yoo (2003) argues that IT investment is beneficial for the developing countries in order to raise per capita income.

Regarding the ICT revolution as one of the leading forces behind the economic and social change throughout the world, Kim (2002) is curious about the sources of economic growth and productivity in Korea which is one of the first countries come to mind when IT is referred. It is widely known that Korea has a well-established production infrastructure in certain high technology industries such as memory chips, computing and telecommunication equipment, and other IT-related products. As Kim (2002) reports, this development is succeeded by borrowing technology from abroad and thanks to strong commitment and generous support of the government. Kim (2002) argue that IT and knowledge capital are the main sources of economic performance of Korea and tries to prove this hypothesis by using growth-accounting methodology and data for 1971-2000 interval. According to results of his empirical work, Korean economy grew annually 7.46 per cent between 1971 and 2000 on average and 1.22 per cent proportion of this is due to IT capital. This contribution corresponds to 16.3 per cent of total annual average economic growth of Korea and is treated as an important factor by the author. Similar to other studies in this field, Kim (2002) also divides the investigated period into sub periods and shows that contribution of IT to Korean economic growth has increased gradually as time passes since 1970s. Depending on both the significant contribution of IT to economic growth in the past and the upward trend in magnitude of that contribution, Kim (2002) suggests to Korea to place special emphasis on information technology area.

Apart from being the subject of many country specific studies which examine the effects of ICT, thanks to being the richest country in terms of both ICT extensity and available data in this field, the US is also used as a benchmark to understand the scale and scope of repercussions of ICT revolution in other countries. In their comparative study, Jorgenson and Motohashi (2005) analyze the sources of economic growth in Japan and the US from 1975 to 2003 with a particular interest towards the role of information technology. Their main goal is to determine whether IT investment had a major impact on economic growth in Japan, where investment in computers, telecommunication equipment and software increased dramatically after 1995, as it is the case in the Unites States in the late 1990s. For this purpose, a growth-accounting analysis, which takes IT investment consisting of computer, software and communication equipment investments of households, government and businesses, is employed. During this process, Jorgenson and Motohashi (2005) handle data for Japan rigorously to achieve compatibility with the Unites States data in order to be able to make precise comparisons. At the end, they find out that contribution of IT investment to GDP growth in Japan has been increasing since 1975 and reached to two thirds of total output growth for 1995-2003 period. This contribution is close to that in the Unites States and is actually much better in proportional terms. Therefore, this constitutes another piece of evidence that is in favor of the ICT revolution.

Whelan (2000) focuses on economic effects of computers in the US between 1974 and 1998 and states that those effects occur in mainly two ways. First, computer-producing sector is a very productive one and this also affects the aggregate productivity positively. Second, the stock of computing capital expanded significantly thanks to increased investment in computers as a result of declines in prices and this situation caused the improvement in aggregate productivity due to usage of computers. What Whelan (2000) distinctively says is that effects of computer usage throughout the economy are underestimated so far because technological obsolescence, which occurs when the capital is retired while it still has productive capacity, is not taken into account. According to Whelan (2000), normally, data for capital stocks are measures of wealth and as capital ages its value is diminished according to an economic depreciation schedule. But the productive value of the capital may be different from this and that productive value must be used in growth-accounting analyses. On the basis of these arguments Whelan (2000) calculates computer capital stock afresh and finds that it constitutes a larger fraction of total capital stock than the conventionally used measurement methods indicate. Whelan (2000) uses these estimates in his empirical implementation and calculates that computers contributed to annual economic growth of the US on average 0.50 per cent for 1974-1995 and 1.23 per cent for 1996-1998. Thus, he responds those who explain the Solow Paradox with the fact that computers were not everywhere by noting that computers might not be everywhere but they are more common than thought thus far.

Oliner and Sichel (2000) explore the main factor behind the resurgence of growth in the late 1990s in the US. Their first candidate is the ICT revolution because American firms were investing in ICT heavily with the intention of reducing costs and achieving more efficiency. Oliner and Sichel (2000) update their previous study with some modifications and more recent data that belongs to 1974-1999 period and this time they reach more favorable result regarding economic effects of ICT. They calculate the contribution to output growth from five different inputs as computer hardware, computer software, communication equipment, other capital and labor where first three components constitute the total impact of ICT on output growth. They keep Whelan (2000)'s word and following him they base their empirical work on productive capital stocks instead of wealth stocks as it is the case in their 1994 study. Contribution from the use of ICT to average annual economic growth is found to be close to previous values for 1974-1990 and 1991-1995 periods as 0.49 and

0.57 per cent respectively. However, that contribution is radically higher for the second half of the 1990s. According to results, real nonfarm business output of the US grew annually 4.82 per cent between 1996 and 1999 on average and a portion of 1.1 per cent of that growth is due to ICT. Authors also show that ICT contributed significantly to labor productivity growth in the US, especially during the second half of the 1990s. What makes their study special for us is that they are not contented with just calculating growth contribution from the use of ICT; they also search for economic effects of the computer production. We are also curious about the role of ICT-producing sector in economic growth apart from the ICT investment and usage. Oliner and Sichel (2000) state that there exist some efficiency gains associated with the production of computers and semiconductors. In order to detect those gains they decompose the contributions of computer sector, semiconductor sector and other nonfarm business sector to multifactor productivity growth. They see that approximately one half of the growth in MFP in the US over 1974 to 1999 stems from computer and computer-related semiconductor sectors. Therefore, it is concluded that importance of ICT in the economy has advanced significantly in post 1995 period and ICT contribution was substantial on the resurgence of economic growth of the US in the late 1990s.

Breitenbach, et al. (2005) complain that even though there are lots of efforts to evaluate the role of ICT in economic growth and development throughout the world there is no such a study for South Africa. As a toe-hold, they analyze the impact of ICT on South African economy. ICT sector in South Africa has followed a similar trend as in other parts of the globe and increased its share in GDP from 1.9 per cent in 1992 to 6 per cent in 2002. Strong commitment of both government and private sector played a key role in this development, but ICT sector in South Africa was still highly import dependent as of the date of the study. In order to quantify advantageous effects of the ICT revolution of South Africa, Breitenbach, et al. (2005) utilize a time series regression analysis which takes GDP as the dependent variable and try to explain it with an ICT variable. The number of the telephone mainlines per thousand people is used as a proxy for ICT and data for the period of 1975 to 2002 is exercised. Here it can be stated that an obvious weakness of their empirical implementation is working with just 22 observations. According to the results, a statistically significant relationship between ICT and GDP is proved and it is revealed that 1 per cent rise in telephone mainlines increase GDP by 4 per cent. In conclusion, authors decide that ICT is an important factor for economic growth of South Africa but they do not refrain from suggesting to test the magnitude of that relationship with a broader set of data. That unrealistic ratio between rises in telephone mainlines and GDP most probably stems from oversimplification in their regression analysis, which explains the dependent variable with just one independent variable, as well as limited number of data points.

Pohjola (2000) states that the popular view as ICT will change the world is based on an anaphora regarding significant effects of ICT on income and productivity. Although outcomes of ICT revolution are experienced in both daily and business lives, it is harder to detect those impacts on economic growth. In order to make a contribution to efforts in this area, Pohjola (2000) investigates the effects of information technology investment on economic growth in 39 developed and developing countries for the period 1980-1995 by using the augmented version of the Solow growth model as Yoo (2003). The ICT investment data is obtained from spending on computer hardware, communication equipment, computer software and computer services. Independent variable associated with ICT in the model is defined as the average of annual ratios of spending on information technology to nominal GDP. Regression results show that ICT investment has a strong impact on economic growth of the developed nations whereas when the broader sample, which involves both developed and developing countries, is taken into consideration, it is seen that ICT is not so influential on economic growth. This situation is explained by the author with the existence of a well-established physical infrastructure and a mature stock of human capital which enhance the effects of ICT revolution in developed countries. On the other side, in developing countries those complementary factors are missing or fall short. That is why they cannot benefit from ICT fully.

Oulton (2001) uses a growth-accounting approach to estimate the contribution of ICT to the growth of both aggregate output and aggregate input in England over the period of 1979-1998. In his study, ICT is taken to involve computers, software, telecommunication equipment and semiconductors (chips). According to empirical results, ICT accounted for the 13 and 21 per cents of GDP growth in 1979-1989 and 1989-1998 intervals respectively. Share of ICT in total output is also small in England but that rising trend in ICT contribution is observed for this country too. Moreover, Oulton (2001) looks at the contribution of ICT capital to the growth rate of aggregate capital stock which is calculated as the share of aggregate profits attributable to ICT capital times the growth rate of ICT capital. He finds out that approximately one half of the growth of capital services in England between 1979 and 1998 is due to the growth of ICT capital. Oulton (2001) also compares the experiences of the US and United Kingdom by borrowing findings of Oliner and Sichel (2000) for the former. Contribution from ICT capital to output growth seems to be higher in the US but those two countries share the similar increasing trend in that contribution towards more recent years.

With the motivation of learning about international experiences regarding returns to ICT investment, Dewan and Kraemer (2000) estimate an aggregate production function that relates GDP to ICT and non-ICT inputs using panel data from 36 developed and developing countries between 1985 and 1993. They aim to understand whether there exist any meaningful differences between returns from ICT investment and investment in other capital as well as comprehending differences between developed and developing countries in terms of returns from capital investments. By this way they want to question appropriateness of international lending and investment decisions. In the empirical part of the study authors employ a similar production function framework to ours and try to estimate and interpret output elasticities of ICT capital stock, which has four components as computer hardware, software, telecommunications and services, non-ICT capital stock and annual labor hours employed. Countries are distinguished into two clusters as developed and developing ones according to their GDP per capita values. Those which fall into the first group tend to have higher levels of ICT investment as a percentage of GDP. Their findings indicate that there are important differences between developed and developing countries with regards to returns from capital investments. It is estimated that ICT investment provides 53 per cent of annual GDP growth in developed countries whereas it has no statistically significant contribution in developing countries in the sample. Dewan and Kraemer (2000) explain this situation with the lack of complementary investments in infrastructure, human capital and information-oriented business processes in developing countries whereas developed countries have already built up a mature stock of ordinary capital to support economic activity. As a result they conclude that developed countries can gain substantial favors by investing in ICT while developing countries should focus on more basic investments in overall capital stock. Developing countries may also invest in ICT but this should be towards longer term ICT infrastructure projects and should be accompanied by complementary spending for infrastructure and human capital.

By putting the international perspective to the core, Schreyer (2000) looks to the contribution of ICT to economic growth in G7 countries which are namely Canada, France, Germany, Italy, Japan, England and the US between 1980 and 1996. He questions the fact that although investment in and use of ICT are not confined to the US, other developed countries could not experience growth rates as high as the US. Schreyer (2000) distinguishes three aspects through which growth effects of ICT occur. First of all, despite its relatively small share, ICT production may contribute to GDP significantly because products of ICT sector are generally high value-added ones, overall productivity of the sector is usually higher than the average of other sectors and the sector grows faster than the other parts of the economy. Secondly, ICT is a capital input; firms invest in ICT and use it while producing output as other types of capital and labor. Finally, ICT is actually a special input thanks to network externalities and spillover effects associated with it. Schreyer utilize a conceptual growth-accounting framework in order to quantify these impacts of ICT on economic growth. Due to problems with availability of relevant data, his empirical work is limited with IT hardware and telecommunications spending only and could not involve growth contribution of software and ICT-related labor. Schreyer (2000) accepts beforehand that his study may underestimate the growth contribution of ICT for this reason. In addition, he had to be very careful and precise because of making use of different data sources. According to his results also, ICT contributes to output growth significantly in the general sense. But this contribution varies across countries. While the US reaps the benefits of ICT mostly, European economies and Japan have to settle with more modest returns. Schreyer (2000) explains this situation with the relatively smaller share of service industries, which tend to invest in ICT much more, in those countries.

In a similar vein to Schreyer (2000), Colecchia and Schreyer (2001) also investigate the relationship between ICT and economic growth, especially during the 1990s. Wondering about whether the US is a unique case in benefiting from ICT, they make a comparative study but in this time Australia and Finland are included besides the countries that are surveyed in Schreyer (2000). With the same sensibility arising from working with different data sources, Colecchia and Schreyer (2001) use a growth-accounting framework in order to determine the contribution of ICT investment to the economic growth in nine different OECD countries. ICT assets consist of hardware, communication equipment and software. According to empirical results, contribution of ICT to output growth of the business sector in those nine countries over the twenty years from 1980 to 2000 is between 0.2 and 0.5 percentage points per year. Not surprisingly this contribution is higher for the more recent years. The US is the leader in reaping the benefits of ICT and followed by Australia, Finland and Canada. Over and above, Colecchia and Schreyer (2001) examine the role of ICT-producing industries in the economy and argue that existence of a strong ICT-producing industry is not a necessary condition for taking advantages of ICT as well as not being a sufficient condition for it. They prove this view with the experiences of Australia and Japan. Their empirical work indicates that growth contribution from ICT is higher in Australia, which has a very small ICT-producing sector, compared to Japan, which is one of the largest ICT producers in the world. On the other hand, authors do not abstain from mentioning the positive impacts of ICT producing industries on economy-wide MFP growth although they do not quantify those impacts. Differently, the present study tries to measure growth effects of ICT production along with ICT investment.

Armstrong, et al. (2002) examine and compare the sources of economic growth for the 1981-1995 and 1995-2000 periods in Canada where business investment in ICT grew at 16.2 per cent on average over the two decades after 1980. For this purpose, they classify total capital assets into three groups as ICT, other machinery and equipment and structures. ICT is defined to include computer hardware, computer software and telecommunication equipment. According to their estimates, ICT increased its share in total capital stock of Canadian business sector from 2.3 per cent in 1981 to 4.7 per cent in 2000 which is still a very small value despite a significant improvement. Authors analyze the growth of investment, capital stock and capital services in Canada by decomposing these into three components as arising from investments in ICT, other machinery and equipment and structures for 1981-1988, 1988-1995 and 1995-2000 sub periods. They show that ICT contributed significantly to advancements in all those three types of growths for the whole sub periods. They also implement a growth-accounting exercise in order to determine the contribution made by ICT investment to the GDP growth. According to empirical results, average annual growth of Canadian business sector between 1981 and 2000 is 3 per cent and 0.5 percentage point of this growth is due to ICT investment. Moreover, post 1995 period gives more favorable signs for the economic impacts of ICT. ICT is the only asset type which maintains and raises its contribution steadily for the entire interval. Authors also compare experiences of Canada and the US and detect that Canada could benefit from ICT at a close level to the US.

Van Ark (2001) analyzes the contribution of ICT to output growth during the 1990s for ten OECD countries which are Canada, Denmark, Finland, Germany, France, Italy, Japan, the Netherlands, England and the US. As distinct from the growth-accounting methodology that finds the ICT contribution by treating it as a separate input, Van Ark (2001) follows an alternative approach and distinguishes the total output into three sectors as ICT-producing, ICT-using and non-ICT sectors. As we do in the present study, he also bases his empirical work on OECD databases and, thus, takes advantage of working with a single data source even for multiple countries. With a similar classification to the OECD, ICT-producing sector is defined to involve IT hardware, radio, television, communication equipments, medical appliances, measurement instruments and telecommunication and computer services. Determining the ICT-using sectors is obviously more difficult because almost all industries use ICT more or less. This is achieved by making a distinction according to ICT investment and capital stock shares of the sectors. About one third of the industries with the highest ICT intensity such as publishing and printing, chemicals, electrical and electronic machinery and the financial sectors are defined as the ICT-using industries. Van Ark (2001)'s computations indicate that both ICT-producing and ICT-using sectors have a positive impact on GDP growth in all countries. As it is expected, the US is the leader in the growth contribution of the ICT-producing and ICT-using sectors combined in absolute terms. Besides the US, Finland and Japan come to the forefront in ICT-producing side whereas differences among countries are not so big for the contribution of ICT-using industries. Moreover, as most of the other studies in this field, Van Ark (2001) also detects the higher contribution of ICT in the second half of the 1990s compared to the first half. He relates this situation with the fact that characteristics of ICT as a general purpose technology are becoming stronger as these technologies become more widespread throughout the economy.

Simon and Wardrop (2002) wonder whether Australia could benefit from ICT revolution thoroughly as she does not have a strong ICT production sector but is one of the countries that invest in ICT heavily. They look at the gains from the use of IT in Australia during the 1990s by employing a growth-accounting methodology. Results of empirical work reveal that Australian economy grew 1.78 and 3.86 per cents annually on average for 1990-1995 and 1995-2000 periods respectively. IT capital, which includes both hardware and software, accounts for 0.89 and 1.26 percentage points of those growth rates respectively. While second half of the1990s seems better in terms of IT contribution in absolute terms, IT capital is responsible for one half of the output growth between 1990 and 1995 in Australia. In addition to aggregate analyses, Simon and Wardrop (2002) examine the role of IT investment for growth of individual sectors. They see that traditional industries like agriculture, mining, construction and manufacturing were not the outstanding beneficiaries of

ICT revolution. Instead, service sectors, especially communications and finance, principally took advantage of IT investment. Authors conclude that IT usage provides advantages for countries even if they cannot produce much of it as it is the case for Australia. Simon and Wardrop (2002) may be right for the 1990s while stating that traditional industries could not benefit from ICT so much. However, more recent years seem to refute that finding as those traditional sectors, especially manufacturing, also take advantage of ICT greatly.

Daveri (2002) tries to understand differences in economic growth experiences of Europe and the US during the 1990s from the perspective of ICT revolution. While about two thirds of the Unites States growth resurgence in the second half of the 1990s is related to ICT somehow, European countries' disappointing growth performances are attributed to their lagging behind in both production and adaption of ICT. To be able to evaluate this argument, Daveri (2002) first looks at the extent of ICT diffusion in Europe. He discloses that when the economic impact of ICT is the point in question, ICT diffusion should be dealt in two different respects as ICT spending and ICT investment. As he reports, in 1992 both ICT spending and ICT investment of European countries were much smaller than the US. As of 2001, while Europe as a whole caught and even passed slightly the US in terms of share of GDP allocated to ICT spending, gap in ICT investment persists despite some reduction. In addition, when ICT diffusion within Europe is taken into consideration, individual countries are found to be diversified and it is possible to group European countries into two clusters as slow and fast adopters of ICT. In order to examine the relationship between ICT diffusion and economic growth in Europe between 1992 and 2001, Daveri (2002) employs a growth-accounting methodology by using data for 14 European countries and taking ICT component as to consist of telecommunication equipment, hardware and software. His empirical analyses indicate that, along with differences from country to country, ICT did not have a significant growth effect in Europe as a whole during the 1990s despite most European countries experienced a high level of ICT diffusion. This situation is interpreted as migration of Solow Paradox from the US to Europe and is linked with several factors. First of all, notwithstanding the recent improvement in GDP portions allocated to ICT spending and investment, the value added share of ICT capital remains too small in Europe because of low levels of investment in the 1990s. This seems an important obstacle for ICT to contribute economic growth fully. Furthermore, wide-ranging organizational changes in the mode of production as well as a certain length of time to learn how to use these technologies effectively are also necessary for Europe to be able to reap the benefits of ICT revolution greatly. Daveri (2002) concludes that if Europe can handle these issues and make ICT to work properly, we can be optimistic about the ICT contribution to European economic development for the future.

A skeptical study towards the economic impacts of ICT, Gordon (2000), analyzes and compares ICT revolution with other revolutionary developments in the history. Focusing on the second half of the 1990s and bearing in mind the parallel increase in both ICT investment and productivity growth during that period, Gordon (2000) wants to show whether ICT revolution deserves to be named as the Third Industrial Revolution. He relates the First Industrial Revolution with the invention of steam engine and power loom. According to him, the Second Industrial Revolution includes establishment of running water, indoor plumping and urban sanitation infrastructures, revolution of the electricity and internal combustion engine, great inventions about petroleum, natural gas and chemicals and entertainment, communication and information innovations like telegraph, telephone, radio and television. In the empirical part of the study, Gordon (2000) finds out that 1995-1999 period, which is characterized by the rapid diffusion of ICT, is better than previous periods that coincide with the great inventions of the past in terms of macroeconomic indicators of the US. Despite the statistics are outstanding in the economy wide level, when a closer look is taken it is seen that favorable economic impacts of the ICT is limited with the production of computer hardware, peripherals and telecommunication equipments. If spillover effects are also taken into account, a 12 per cent of the economy including durable goods manufacturing seems to benefit from ICT whereas ICT revolution does not mean so much for the remaining 88 per cent although they also use ICT heavily. Gordon (2000) argues that ICT does not affect the economy and daily lives as deeply as the great inventions of the late nineteenth and early twentieth century. He explains this situation with several facts. First of all, fixed endowment of human time limits the effects of ICT revolution despite big advancements in computer technologies occur. In addition, there are some restrictions in real life regarding the replacement of individuals by computers; many jobs need to be done by human beings no matter what is the level of available technology and computers are not actually as widespread as generally thought in the economy. Furthermore, it is frustrating to look for huge gains from ICT with a time delay as it was the case for electric light and electric motors in the past. Because, while those electrical inventions were very expensive initially but became cheaper and available to a vast majority of people in the course of time, sharp declines in computer prices have already occurred and ICT has diffused across the whole economy well in advance. Being far away from Gordon's fuzzy empirical analyses as well as his pessimistic explanations that are affected by the negative prejudices towards ICT revolution, the current study is obviously more optimistic and tries to search out real impacts of ICT use and production on economic growth.

Complaining about the lack of studies that try to estimate the economic impacts of ICT revolution in post-communist economies, which are transforming from a command economy to a market economy, Piatkowski (2003) delineates the contribution of ICT to economic growth in Poland which is the largest post-communist economy in Central and Eastern Europe. Piatkowski (2003) distinguishes four channels through which ICT can influence the economic growth. Those are; increase in aggregate output due to production of ICT goods and services; contribution of productivity improvements in ICT sector to overall productivity in the economy; use of ICT capital as an input to production processes of other goods and services and spillover effects associated with ICT use and production. In order to quantify results of these influences, he employs an extended growth-accounting methodology by using data covering the period of 1995-2000. He also makes a survey about the evolution of ICT sector in Poland, as we do a similar one for Turkey, and reaches the conclusion that Poland has come a long way from 1993 to 2001 in terms of ICT diffusion. While the percentage share of ICT spending in GDP were about 2 per cent in 1993, it rose to approximately 6 per cent in 2001. In nominal terms, annual ICT spending increased six fold and Poland became the leading country among transition economies including Russia. Furthermore, real investment in ICT in Poland grew at an average annual rate of 50.9 per cent which was much bigger than the rates in the EU and the US. On the other hand, despite these improvements, average share of ICT capital in total capital stock of Poland during 1995-2000 remained at a low level as 1.5 per cent and this rate is much lower than those of the EU and the US. Piatkowski (2003)'s empirical analyses reveal the outcomes of these developments. It is found that the average contribution of ICT capital to Polish economic growth in the period of 1995-2000 was 0.47 percentage points which correspond to 8.9 percentage of average output growth which was 5.31 per cent in that period. Piatkowski (2003) shows that this ICT contribution to economic growth in Poland is much smaller compared to experiences of the EU and the US. But he relates this situation mostly with high GDP growth of Poland in that period, a bit optimistically. However, it seems that he had better to take into consideration the modest level of ICT capital accumulation in Poland for explaining that result.

Jalava and Pohjola (2005) investigate the influences of ICT on economic growth of Finland which is a special country in this regard. Finland succeeded in transforming itself a modern industrial society in the twentieth century with the significant contribution of its cutting edge telecommunications manufacturing sector. In order to determine the exact impact of ICT on Finnish development between 1995 and 2002, Jalava and Pohjola (2005) utilize the growth-accounting framework within which ICT is defined to involve computers, insulated wire and cable, electronic components, radio transmitters, TV and radio receivers and software. They argue that ICT affects the economic growth in the form of both ICT production and ICT capital services and, hence, present the results of their empirical work accordingly. In the production side, it is found that approximately one third of the output growth in Finland over 1995-2002 stemmed from ICT production. When this figure is combined with the 6 percentage share of ICT production in GDP of Finland, which is certainly at a modest level despite being the largest share among OECD countries, it becomes more obvious how significant is the contribution of ICT on economic growth in this country. Besides this, according to results of growth-accounting on the input side, ICT capital contributed 0.66 percentage points to GDP growth on average which implies that 16 per cent of output growth was due to ICT investments. Therefore, it can be concluded that ICT was helpful for the economic growth of Finland at least between 1995 and 2002.

Nasab and Aghaei (2009) test the prediction of economic growth theories that ICT investment is one of the driving forces behind the economic development for a sample of oil-reach countries. Their study includes 7 of 11 OPEC member countries as Iran, Saudi Arabia, United Arab Emirates, Kuwait, Indonesia, Nigeria and Algeria due to data availability problems regarding other four and covers the time span of 1990-2007. Their empirical methodology is similar to that is used in the present study in terms of following the production function approach and working with panel data. Nasab and Aghaei (2009) relate gross domestic product with five explanatory variables as investment in ICT, gross domestic investment, human capital, oil income and foreign direct investment. Secondary and tertiary school enrollment is used as a measure of investment in human capital. Incisively, oil income is taken into account separately on the ground of special conditions of the investigated countries. In addition, foreign direct investment variable is also included as an indicator of technical improvement. This also seems as a right decision because those countries mostly adopt new technologies thanks to foreign investments instead of producing domestically. Finally, the data on ICT involves computer hardware, software, computer services and communication equipments. According to their estimations, ICT investment induces the economic growth significantly in the OPEC member countries. Accordingly, Nasab and Aghaei (2009) advice those countries to allocate more resources to ICT investment as well as reminding them the importance of the social and cultural infrastructures and skills, that are necessary to benefit from ICT revolution fully.

A very recent study, Erdil, et al. (2010) question whether ICT revolution has a significant meaning in terms of strengthening the economic growth in the underdeveloped and developing countries. They broadly distinguish two different manners, as ICT production and ICT usage, by which ICT can influence the real economy. It is widely known that ICT production sector, which has been expanding continuously throughout the world, contributes the real economy by enlarging aggregate output as well as diffusion of ICT to other industries makes both physical and labor capitals more productive. However to be able to determine these effects for individual countries quantitatively, Erdil, et al. (2010) apply an empirical analysis by using a panel dataset for 131 underdeveloped and developing countries belonging the period of 1995-2006. They especially deal with that country sample because there are some doubts about if underdeveloped and developing countries, which generally have weak ICT producing capacities and mostly do not have sufficient human and physical capital stocks, can benefit from ICT revolution completely. In order to investigate whether ICT stock has a positive effect on the long run economic growth of those countries, they define ICT capital as a factor of production similar to physical and human capital in the production function as Yoo (2003). In their model, where annual growth rate of one year lagged GDP is the dependent variable, two separate explanatory variables are used to capture the impact of ICT on economic growth. The principal variable for this purpose is ICT stock and approximated by number of fixed line and mobile phone number subscribers per 100 people plus Internet users per 100 people. As an alternative, they also include a variable for high technology exports which are calculated as the percentage share of the value of high technology exports in manufactured exports. Besides, primary school completion rate is used as a proxy for human capital variable. At the end, Erdil, et al. (2010) find out that 1 per cent increase in ICT stock bring about approximately 0.1 percentage increase in GDP growth. On the other hand, high technology exports variable has not any significant impact on economic growth. Authors consequently conclude that ICT usage has a significant positive effect on economic growth for underdeveloped and developing countries and, therefore, they should keep investing in ICT.

2.3.1. Stylized Facts

Table 2.1 summarizes the scopes and main findings of above mentioned studies that are dedicated to ascertain the impacts of ICT revolution on economic growth experiences of various countries during different time intervals. As a result of this literature survey some common facts come into prominence and these can be stated as follows:

* ICT is a general purpose technology.

* ICT influences the economy through two main channels as ICT production and ICT usage.

* There are some different views and findings about whether ICT production capacity is a necessity for ICT revolution to show its economic impact properly.

* ICT revolution has significant effects on economic growth of developed countries.

* There are some doubts about whether underdeveloped and developing countries can benefit from ICT investments greatly.

* Extent and scope of the growth effects of ICT revolution are highly dependent on the share of ICT in total economy.

* Other elements such as complementary physical infrastructure and human capital as well as social and cultural factors have also critical importance for reaping the benefits of ICT revolution fully.

* There are strong signals about existence of externalities and spillover effects associated with ICT investment.

* The impacts of ICT investments on economic growth take time.

Table 2.1 Summary of Literature Survey

Study	Method	Period	Country(s)	Result
Norton (1992)	P.F	1957-1977	47 Countries	Positive
Jorgenson and Stiroh (1999)	G.A	1948-1996	US	Nonsignificant
Röller and Waverman (2001)	P.F	1970-1990	21 OECD Countries	Positive
Oliner and Sichel (1994)	G.A	1970-1992	US	Nonsignificant
Parham,et al. (2001)	G.A	1964-2000	Australia	Positive
Ramlan,et al. (2007)	G.A	1966-2005	Malaysia	Positive
Yoo (2003)	P.F	1970-1998	56 D/g Countries	Positive
Kim (2002)	G.A	1971-2000	Korea	Positive
Jorgenson and Motohashi (2005)	G.A	1975-2003	Japan and US	Positive
Whelan (2000)	G.A	1974-1998	US	Positive
Oliner and Sichel (2000)	G.A	1974-1999	US	Positive
Breitenbach,et al. (2005)	P.F	1975-2002	South Africa	Positive
Pohjola (2000)	P.F	1980-1995	39 Countries	Positive for D/d, Nonsignificant for D/g
Oulton (2001)	G.A	1979-1998	England	Positive
Dewan and Kraemer (2000)	P.F	1985-1993	36 Countries	Positive for D/d, Nonsignificant for D/g
Schreyer (2000)	G.A	1980-1996	G7 countries	Positive
Colecchia and Schreyer (2001)	G.A	1980-2000	9 OECD Countries	Positive
Armstrong,et al. (2002)	G.A	1981-2000	Canada	Positive
Van Ark (2001)	G.A	1990-1999	10 OECD Countries	Positive
Simon and Wardrop (2002)	G.A	1990-2000	Australia	Positive
Daveri (2002)	G.A	1992-2001	EU and US	Positive for the US, Nonsignificant for EU
Gordon (2000)	G.A	1995-1999	US	Nonsignificant
Piatkowski (2003)	G.A	1995-2000	Poland	Positive

Study	Method	Period	Country(s)	Result
Jalava and Pohjola (2005)	G.A	1995-2002	Finland	Positive
Nasab and Aghaei (2009)	P.F	1990-2007	7 OPEC Countries	Positive
Erdil,et al. (2010)	P.F	1995-2006	131 Undev and D/g Countries	Positive

Note: P.F means production function, G.A means growth-accounting

CHAPTER 3

INFORMATION and COMMUNICATION TECHNOLOGIES in OECD

As the previous chapter reveals, there seems to be a positive relationship between ICT and economic growth, especially for developed countries. Among OECD countries, which are overwhelmingly developed ones, ICT has been treated as an important issue and paid special attention in order to foster economic growth. This chapter analyzes adopted ICT policies, their implementation and outcomes in OECD countries during post 2000 period. In addition, Turkey is dealt with separately in this context in line with the main aim of the current study. Our ultimate goal is reaching ICT policy suggestions for Turkey by showing regard to experience of OECD member countries as well as developments in Turkey in ICT field from past to present.

3.1. ICT in OECD Member Countries

3.1.1. ICT Policies in OECD Area

Being aware of the economic and social importance and impacts of ICT, most OECD member countries have been designing and implementing ICT strategy and policies as well as embedding those to the broader policy visions. It is generally seen that ICT policies have become gradually more integrated to the general economic and other policies. OECD IT Outlook publications overview the ICT policy priorities in the member countries and may be a helpful reference guide in order to analyze the evolution of ICT policies in OECD area during the post 2000 period.

Before the ICT revolution becomes so widespread around the world in twenty first century, during the 1990s, governments newly faced with a transformation similar to that from agricultural societies to industrial ones. This was the transformation to information societies and started to affect all elements of the economy and society deeply in many aspects. In this early stage, governments tend to approach to the issue in a broader sense. OECD's prioritized main policy areas regarding this subject were competition, private investment, regulatory framework and infrastructures. Besides, electronic commerce, digital content, licensing, numbering and addressing, interconnection, interoperability and standards, illegal and harmful content and intellectual property rights were the first sub-questions that policy makers mull over. As time progresses and top level policy frameworks settle, different topics started to become prominent depending on the developments in technology, economy and social structure (OECD, 1997).

In the beginning of the twenty first century, OECD IT Outlook 2000 mainly focuses on electronic commerce and related issues. Readiness for e-commerce, which has technical, social and economic aspects, was a prominent issue. In this context, development of network infrastructure, diversification of access channels including mobile technologies and improvement of service quality and user friendliness were seen as the top technical priorities for e-commerce readiness. Existence of IT workers with sufficient skills and taking effective precautions for closing the digital divide within and between countries were the important issues in the social side. Ensuring security, trust, liability, privacy and consumer protection in electronic financial transactions was the main subject regarding economic aspect of e-commerce readiness. In addition to e-commerce, intelligent agent technologies, global navigation satellite systems and flat panel displays were other topics addressed by OECD (OECD, 2000).

OECD IT Outlook 2002 states that the effect of ICT on competitiveness of businesses; the possible improvements thanks to ICT regarding output, employment and productivity; the digital divide and utilizing ICT in delivery of government services as well as improving government efficiency were the policy areas that gain particular attention from the OECD member countries generally. In addition, technology development, R&D, government procurement, ICT for government use and venture finance came to the forefront as the major policy areas. Diffusion of ICT to the both households and businesses; reliability and trustworthy of electronic transactions and exchange mechanisms; security, privacy and consumer protection in the digital environment were also among top ICT policy priorities. Moreover, ICT skills which were started to be perceived as a general skill throughout the all industries as well as being an essential requirement for the ICT sector gained remarkable attention from OECD countries (OECD, 2002).

In 2004, OECD IT Outlook indicates that ICT R&D and innovation, technology diffusion, ICT skills, broadband and digital content and delivery are at the focal point of ICT policies of OECD member countries. It became more important to coordinate and evaluate economic impacts of ICT policies for countries in OECD area. E-government activities and projects were seen as a tool to improve public administration and digital networking of various parts of that. Building and extending high-speed networks like broadband infrastructure were a priority for almost all OECD member countries. Furthermore, policy makers continue to pay great attention to security, privacy and data and consumer protection (OECD, 2004).

ICT policy priorities in OECD IT Outlook 2006 were somewhat similar to the previously mentioned ones. ICT policies in OECD member countries mostly focus on fostering innovation in ICT area, especially thanks to R&D activities and innovation networks and clusters; increasing ICT usage; extending e-government services; promoting ICT skills and employment, especially via ICT education; fostering digital content; improving ICT business environment; guaranteeing intellectual property rights and advancing infrastructure, especially broadband infrastructure. In addition to these, coordination and prioritization of ICT policies remained among most important concerns of policy makers (OECD, 2006).

Towards 2008, ICT was seen as a driving force behind innovation, economic growth and job creation increasingly. According to OECD IT Outlook 2008, ICT policy areas with top priority in OECD member countries were promoting innovation and R&D in ICT as well as utilizing ICT as an effective tool for those activities in other areas; fostering e-government application and services; extending the coverage of broadband networks; advancing ICT diffusion to all segments of the society and economy; promoting ICT skills and education; increasing ICT employment and encouraging digital content creation. Besides these, public sector information and content was also mentioned among highly prioritized policy areas (OECD, 2008a).

When it comes to 2010, ICT policies in OECD member countries have become mainstream policies and intended to serve for the general social and economic objectives. ICT policies are now designed to foster economic growth and employment, raise productivity, improve delivery of public and private services and enhance the welfare and living standards of the citizens. In this respect, ICT policies are more integrated into other policy areas like health, education, environment, transportation, etc. According to the results of a questionnaire conducted by OECD on member countries, top ten policy priorities in 2010 for governments were as such: security of information systems and networks; broadband; R&D programmes; government on line, government as model user; innovation networks and clusters; ICT skills and employment; digital content; consumer protection; technology diffusion to business and technology diffusion to individuals and households. This prioritized policy areas are very similar to those of the last ten years. But, importance attributed to the certain policy areas like broadband development, technology diffusion to individuals and households and e-government activities has increased considerably in recent years (OECD, 2010).

Another very useful tool to investigate main trends and priorities in OECD area may be looking at the agenda and activities of Committee for Information, Computer and Communications Policy (ICCP) of OECD. ICCP Committee analyzes the technical, economic and social developments in ICT field with the contribution and collaboration of member governments, private sector and civil society. ICCP Committee, which also prepares and publishes IT Outlooks, supports the member governments' ICT policy making and implementation processes by ensuring the exchange of best practices, preparing policy recommendations, providing guidance and generating comparable statics in this area. This Committee has four different working parties each of which is specialized and carries out works in one course regarding the Internet economy (OECD, 2012c).

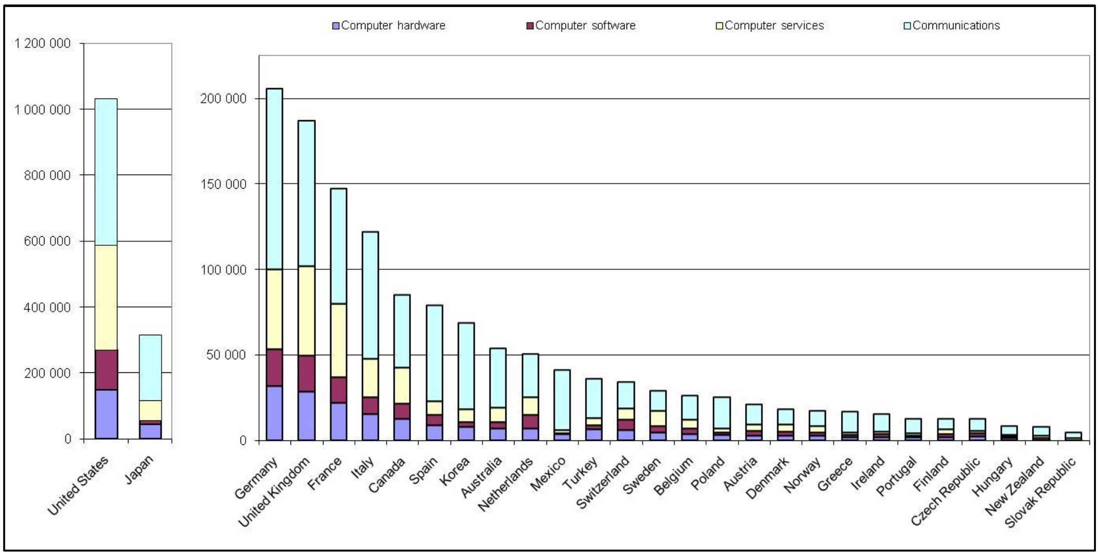
Working Party on Communications Infrastructure and Services Policy recently deals with telecommunication regulations aimed at the liberalization of the telecommunication market, constitution of the fair competition in the market, development of broadband infrastructure and convergence of different communication technologies such as telecommunication, Internet, broadcasting, etc. through fixed and wireless networks. Working Party on the Information Economy is interested in economic and social consequences of ICT revolution, developments in ICT sector, evolution of demand for the products of the sector, promotion of e-commerce, fostering digital content, re-use of public sector information, enhancing green and smart ICTs, utilization of ICT in economic recovery and availing the benefits of virtual worlds and assurance of a more transparent and open Internet. Working Party on Information Security and Privacy's hot topics include sustaining trust in the Internet economy, protection of critical information infrastructures, management of digital identity in the Internet economy, electronic authentication, fighting against spam, computer viruses and other malicious software, information security and privacy in radio frequency identification technology (RFID) applications, cyber-security strategies, domestic and cross border enforcement about privacy and protecting children on line. Working Party on Indicators on the Information Society deals with appropriate measurement of effects of ICT revolution on innovation and growth and determination of international statistical standards in ICT area (OECD, 2012c).

Apart from these studies, ICCP Committee carries out some meetings, workshops and conferences in order to discuss and improve positive effects of ICT revolution. In 2008, OECD Ministerial Meeting on the Future of the Internet Economy is organized in Korea by the ICCP Committee with the participation of ministers and other executives from member governments and high level representatives from international institutions, private sector and non-governmental organizations. After this meeting a high level policy recommendation document, “The Seoul Declaration for the Future of the Internet Economy”, is adopted. By this document, top level representatives of OECD member countries agreed on promotion of the Internet economy by supporting innovation, investment and competition in the ICT sector, increasing accessibility of ICT networks and services, benefiting from ICT in dealing with economic, social, democratic, cultural, environmental and scientific challenges, ensuring the convergence among different ICT applications, supporting creativity in the digital environment, reinforcing trust and security in the Internet and protecting and advancing the global nature of the Internet economy (OECD, 2008b).

In June 2011, ICCP Committee organized the High Level Meeting on the Internet Economy: Generating Innovation and Growth also which brought together top level decision makers and other relevant persons from all stakeholder communities. As its name implies, this meeting was mainly about positive impacts of ICT revolution on innovation and economic growth. At the end of the meeting some basic principles for internet policy making were adopted: promoting and protecting the global free flow of information; promoting the open, distributed and interconnected nature of the Internet; promoting investment and competition in high speed networks and services; promoting and enabling the cross-border delivery of services; encouraging multi-stakeholder co-operation in policy development processes; fostering voluntarily developed codes of conduct; developing capacities to bring publicly available, reliable data into the policy-making process; ensuring transparency, fair process, and accountability; strengthening consistency and effectiveness in privacy protection at a global level; maximizing individual empowerment; promoting creativity and innovation; limiting internet intermediary liability; encouraging co-operation to promote internet security and giving appropriate priority to enforcement efforts (OECD, 2011a, p. 3-6).

3.1.2. ICT Usage in OECD Area

As ICT diffuse all areas of economic and social life, usage of and demand for ICT products and services increase significantly. OECD countries are among those which spend on ICT heavily. Despite a declining trend, OECD area is the largest ICT market in the world. Total worldwide ICT spending in 1992 was estimated to be USD 1.28 trillion and 92 per cent of this, which is USD 1.18 trillion, belongs to OECD member countries (OECD, 2000). When it comes to year 2009, total worldwide ICT spending increased to USD 3.4 trillion but OECD countries' share decreased to 76 per cent, which corresponds to USD 2.57 trillion. This fact is mostly due to the rapid increases in ICT expenditures of emerging non-OECD economies (OECD, 2010). The US is the largest national ICT market by far and followed by the Japan. Figure 3.1 shows the breakdown of ICT spending in OECD countries with respect to market segment by 2007. As seen, communications is the market segment that receives the largest share from ICT expenditures of all OECD countries.

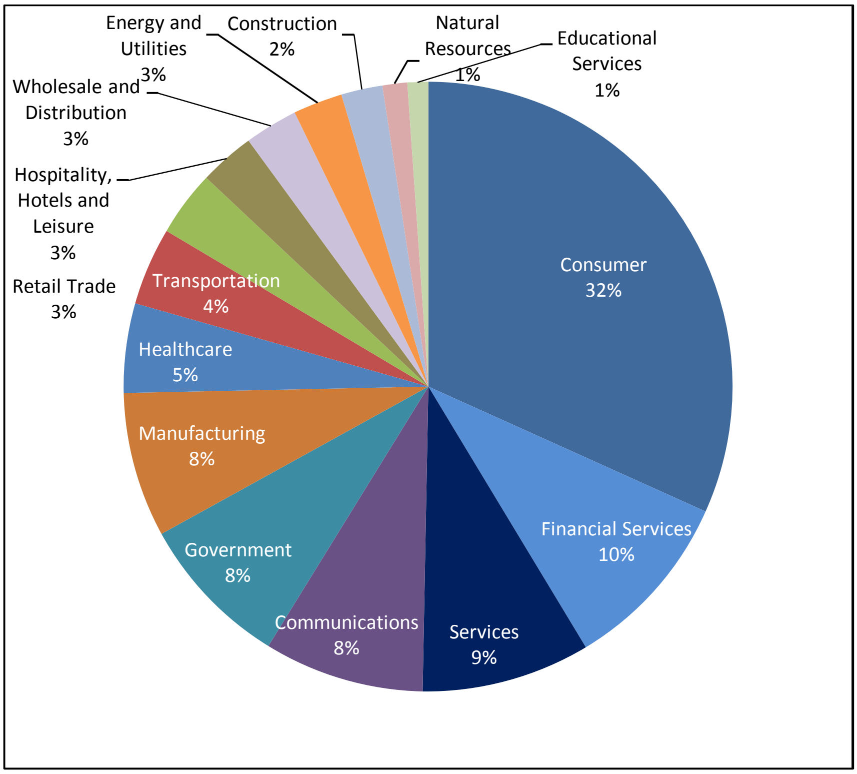


Source: OECD IT Outlook, 2008

Figure 3.1 OECD ICT spending by market segment, 2007

(USD millions, current prices)

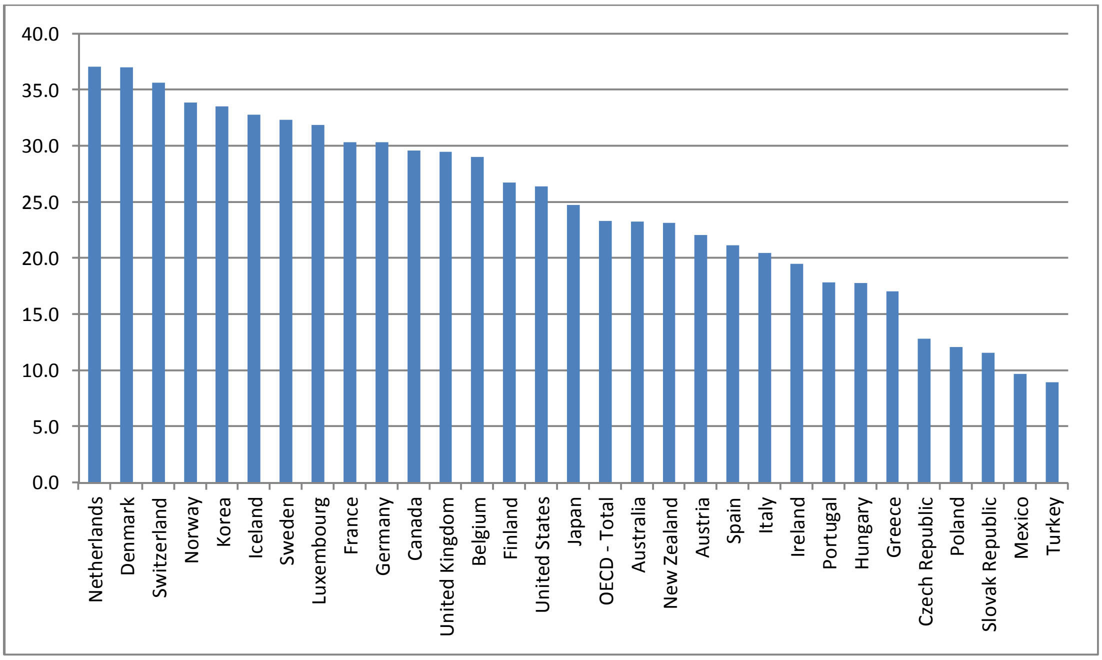
As it is the case in 2007, also by 2010 the consumer market remains to be the largest industry segment in the worldwide ICT spending. But, share of consumer spending is increasing slightly. Financial services, services, communications, government and manufacturing are the other major industry segments in terms of ICT spending (OECD, 2010). Figure 3.2 represents the breakdown of ICT spending by industry segments.



Source: OECD IT Outlook 2010

Figure 3.2 ICT spending by industry segment, 2010

Above mentioned huge ICT budgets brought about important improvements in ICT diffusion throughout the OECD member countries. From 2001 to 2007, total mobile subscribers in 30 OECD countries increased to 1.14 billion people from 604 million people and internet subscribers increased to 382 million people from 189 million people. Total communication access channels (analogue lines, ISDN lines, DSL, cable modem and mobile subscribers) per 100 inhabitants across the OECD area rose to 157 in 2007 from a value of 104 in 2001. When individual countries are investigated in terms of this statistics, it is seen that backmost countries (Mexico, Turkey and Poland) and the headmost one (Luxembourg), due to its low population, remain same. Sweden is another leading country in total communication access channels together with Italy and Greece which achieved great improvements in recent years (OECD, 2011b).



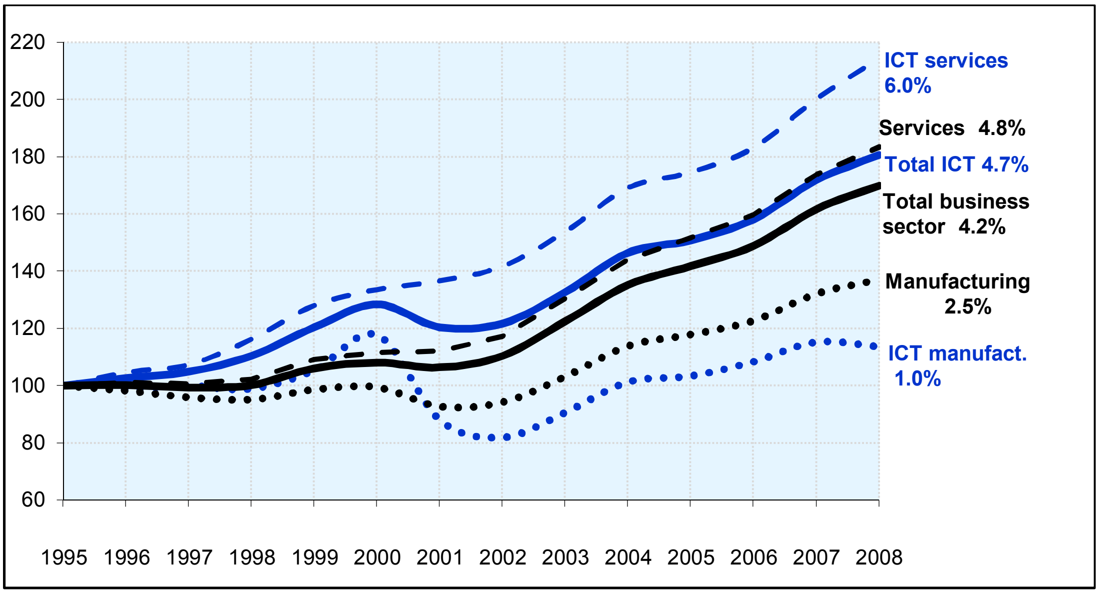
Source: OECD Statistics Database

Figure 3.3 Broadband total subscriptions per 100 inhabitants, 2009

Broadband is the dominant way of internet access recently and broadband penetration rates may give an idea about the level of ICT diffusion in OECD countries. Total broadband subscription per 100 inhabitants for the whole OECD area was 4.8 in 2002 while this value is increased to 23.3 in 2009. Together with being in different magnitudes, all OECD member countries proceeded significantly in this area since 2002. As Figure 3.3 depicts, by 2009, Netherlands is at the best position in terms of broadband subscription while Turkey is the country that has the longest way to make.

3.1.3. ICT Production in OECD Area

In addition to using ICT in a widespread manner, OECD countries are also strong at ICT production. 197 of top 250 ICT firms in the world belong to OECD countries and US is by far the best country with 75 ICT firms. As it is the case in ICT usage, ICT production in OECD area becomes more and more important. Between 1995 and 2008 ICT sector value added in OECD area grew 4.7 per cent annually and outpaced the growth in total business sector value added. By 2008, share of ICT value added in business sector value added in whole OECD area is about 8.2 per cent; Finland, Ireland and Korea are the leading countries in this respect.

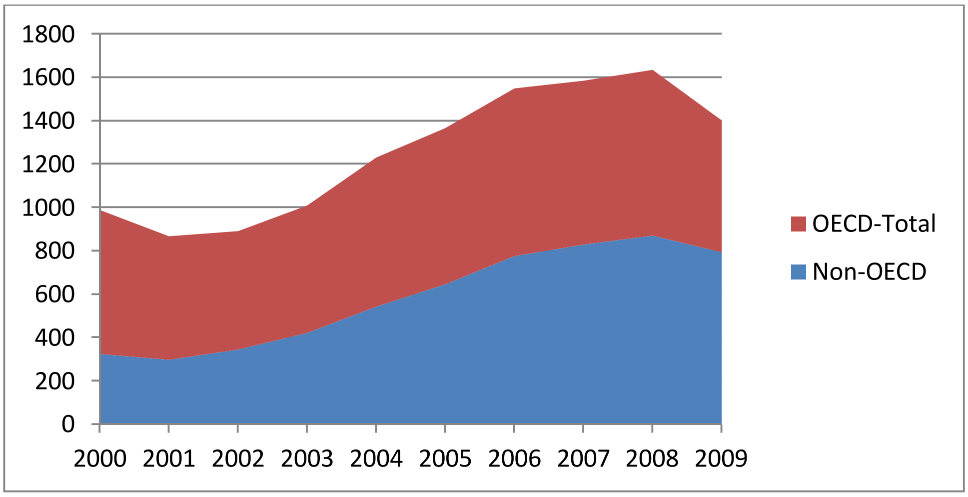


Source: OECD IT Outlook 2010

Figure 3.4 Growth of ICT sector and total value added in the OECD area, 1995-2008 (1995=100, Compound annual growth rate (%))

ICT services constitute an important part of ICT sector value added for OECD area and as Figure 3.4 shows it is the most rapidly growing segment. On the other hand, ICT manufacturing in OECD area grew least rapidly because of shift of ICT manufacturing to non-OECD countries, especially in Asia (OECD, 2010).

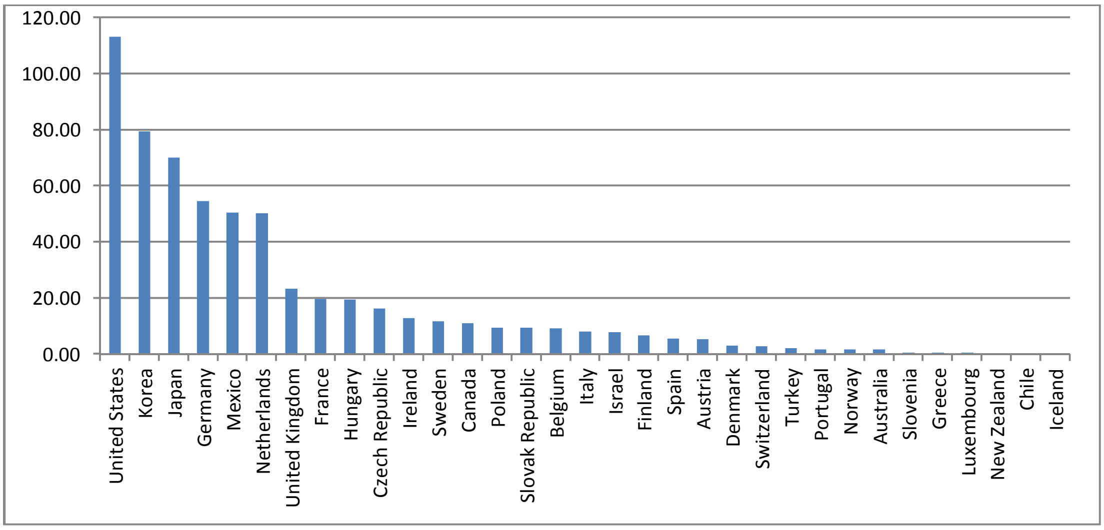
In terms of ICT exports there is a slightly upwards trend in total amount but share of OECD countries' total ICT goods exports in worldwide is decreasing. While in 2000 67 per cent of world's total ICT goods exports were from OECD countries, in 2009 this ratio decreased to 43 per cent. Figure 3.5 represents this evolution. That simultaneity of increasing ICT spending and production and decreasing share in worldwide ICT spending and exports of OECD member countries indicates that emerging non-OECD economies started to become serious rivals of OECD economies in ICT area.



Source: OECD Statistics Database

Figure 3.5 ICT goods exports (USD billions)

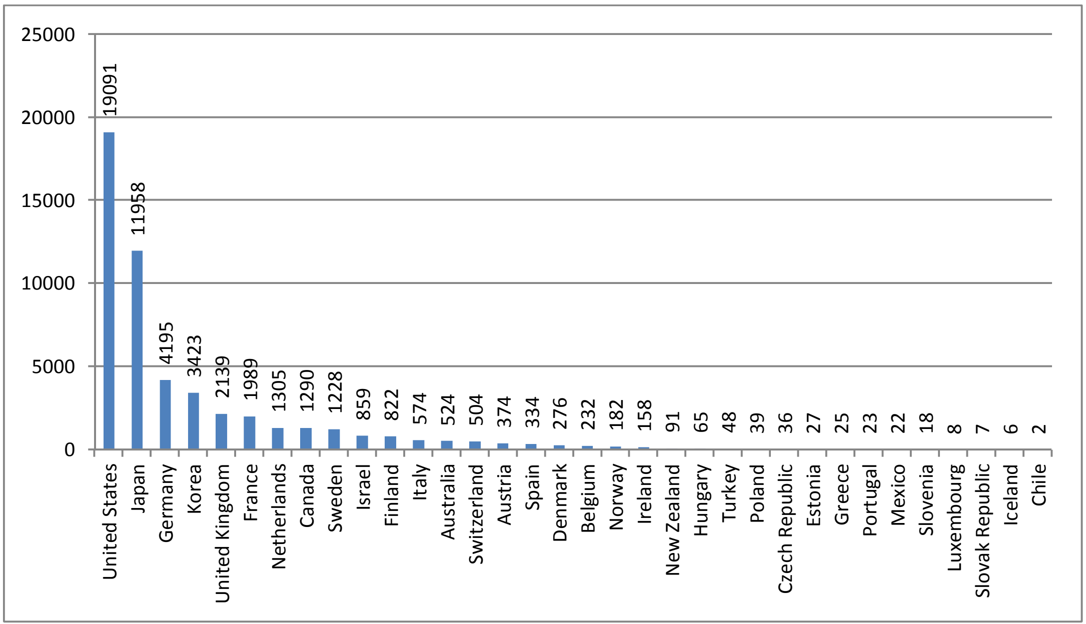
When we look at individual countries in terms of ICT good exports, as Figure 3.6 indicates, US, followed by Korea, Japan and Germany, is the leader country. On the other hand, Slovenia, Greece, Luxembourg, New Zealand, Chile and Iceland are the most lagging countries with ICT goods export less than USD 1 billion.



Source: OECD Statistics Database

Figure 3.6 ICT goods exports of OECD member countries by 2009 (USD billions)

Another meaningful point to investigate in order to gain insights about ICT production capacities of OECD member countries is R&D capabilities of them. Actually, OECD countries are quite active in this area. OECD member countries have about 52,000 patents in the ICT sector in 2007. As Figure 3.7 represents, ordering among OECD countries in this respect is very similar to that about ICT goods exports. US, Japan, Germany and Korea are the leading and Luxembourg, Slovak Republic, Iceland and Chile are the lagging countries.

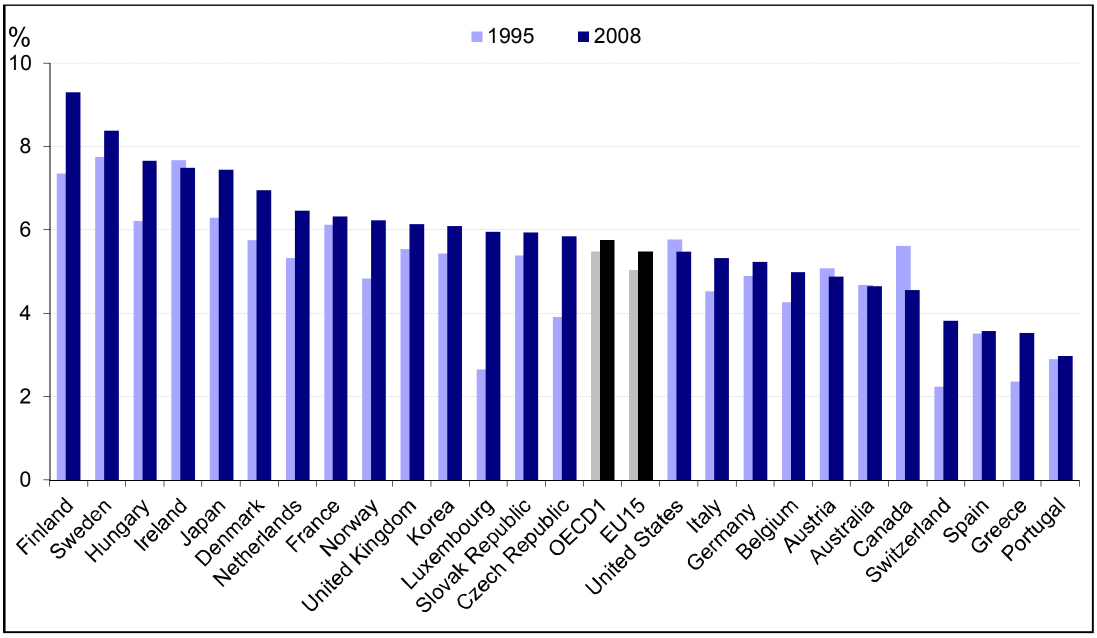


Source: OECD Statistics Database

Figure 3.7 Number of patents in the ICT sector, 2007

3.1.4. ICT Employment in OECD Area

Relationship between ICT and employment can be examined in several perspectives. First of all, although labor productivity in ICT sector is generally higher than other sectors and this fact limits the emergence of new vacancies, ICT sector employment has an important share in total employment in most countries. ICT is a sector where R&D activities, technical progress and innovation are very intensive. New ICT products and services are put on market continuously and there is an ever-growing demand for those from both individual and professional consumers. As a result, ICT sector is enlarging and new job opportunities are created within the sector. By 2008, approximately 16 million people were employed in the ICT sector in OECD countries and this value corresponds to 5.8 per cent of total business sector employment in OECD area. Figure 3.8 depicts the share of ICT employment in business sector employment in individual OECD member countries by revealing the evolution from 1995 to 2008. Finland and Sweden are the countries where shares of ICT sector employment in total business employment are the largest with values more than 8 per cent. On the other side, almost half of the ICT sector employment of OECD area is in the US (30 per cent) and Japan (19 per cent) (OECD, 2010).

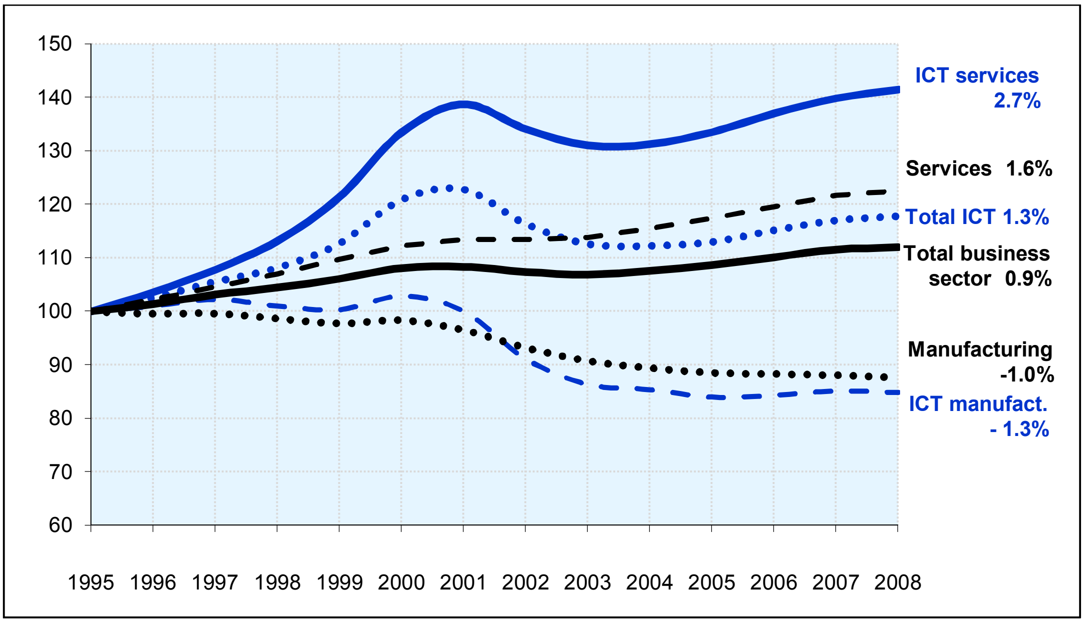


Source: OECD IT Outlook 2010

Figure 3.8 Share of ICT employment in business sector employment, 1995 and 2008

11 million of those 16 million people employed in ICT sector in OECD countries are employed in ICT services while remaining 5 million are in manufacturing. As Figure 3.9 represents, from 1995 to 2008, employment in ICT services grew on average 2.7 per cent annually and this growth rate is significantly higher than growth in employment of business services as a whole which is equal to 1.6 per cent. On the other hand, during the same period, employment in ICT manufacturing in OECD countries declined 1.3 per cent annually and this is a more rapid decrease than that in total manufacturing employment which is 1.0 per cent annually. Employment in ICT sector as a whole in OECD area grew on average 1.3 per cent annually between

1995 and 2008 and this is higher than growth in employment of total business sector which is 0.9 per cent annually.



Source: OECD IT Outlook 2010

Figure 3.9 Growth of ICT sector and total employment in OECD area, 1995-2008 (1995=100, Compound annual growth rate (%))

It is possible to categorize ICT employment as ICT specialists and ICT-using professions. By 2009, in most OECD countries approximately 3-4 per cent of total employment was ICT specialists, employers who deal with ICT systems directly as a fundamental part of their jobs. Besides, ICT-using professions (including ICT specialist) constitute about 20 per cent of total employment in most OECD countries. These two rates are generally lower in Eastern European countries (OECD, 2010).

3.2. ICT in Turkey

3.2.1. ICT Policies in Turkey

Turkey, as other OECD member countries, has been attributing great importance to ICT and paying considerable attention to this area, at least by writing down so in a great number of policy documents. Institutional structuring regarding ICT policies in Turkey is broadly constituted of Ministry of Development, formerly State Planning Organization (SPO), that was established in order to enabling efficient usage of the national resources and accelerating the development process, The Scientific and Technological Research Council of Turkey (TÜBİTAK) that was founded with the purpose of developing science and technology policies for raising and perpetuating the competitiveness and welfare of the country, The Supreme Council for Science and Technology (BTYK) that was assembled with the aim of determining science and technology policies in the direction of economic progress, social development and national security goals (Official Gazette, 1963; 1983; 1994). Ministry of Development gives consultation to the government in both determining and implementing policies regarding almost all areas including ICT. This institution also prepares policy documents and facilitates coordination among different public bodies. TÜBİTAK carries out and support R&D activities in science and technology and helps government in determining science and technology policies. BTYK is chaired by the Prime Minister and is the highest level policy coordination body for science and technology in Turkey. BTYK lends assistance to the government in designating long term strategies and policies, ascertains targets and priority areas and prepares legislative arrangements about science and technology (Official Gazette, 1989).

As it is the case in other policy areas in Turkey, the general frame for ICT policy is drawn in development plans. In addition, there are several important policy and strategy documents prepared by TÜBİTAK. Besides, there are various legislative arrangements which intend to put into practice the policies that are determined in those documents. A number of policy documents that belong to 1990s such as Sixth Five Year Development Plan (1990-1994), Turkish Science and Technology Policy 1993-2003, Seventh Five Year Development Plan (1996-2000) and Science and Technology Policy of Turkey prove the paid attention to the ICT area, at least to a certain extent. Transformation to an information society, raising computer literacy, extending the usage of computers and supporting R&D activities were primary ICT policy objectives in these documents.

In a similar vein to previous development plans and other relevant policy documents, Eighth Five Year Development Plan (2001-2005) of Turkey treats ICT as a strategic sector and prioritize the boosting the competitiveness of the Turkish ICT sector. Major policy concerns regarding ICT was stated as facilitating the competition in telecommunication sector, promoting electronic commerce, supporting R&D activities in ICT area, improving the Internet and mobile communication infrastructure, ensuring information security and giving weight to e-transformation of government (SPO, 2000). In 2001 with an intention about accelerating the technological progress in Turkey, Technology Development Zones Law was introduced. This law purposed conglomerating the advanced technology oriented firms by offering them financial support for land, infrastructure and construction costs and various tax exemptions (Official Gazette, 2001).

In 2003 "e-Transformation Turkey Project" was initiated under the coordination of SPO. This project aimed at rearranging policy and legislations about ICT within the framework of EU legal acquis, rendering public services more efficient, transparent and accountable by availing from ICT as much as possible, extending the usage of ICT, coordinating, monitoring and evaluating public investment projects in ICT area and guiding private actors in ICT sector (Prime Ministry Memorandum, 2003). After a while later a short term action plan, which proposed actions about information society strategy, technical and judicial infrastructure, information security, education, human resources, standards, e-government, e-health and e-commerce, was put into effect (SPO, 2003a). In 2004 Turkey's Information Society Transformation Policy document was accepted by e-Transformation Turkey Executive Board. According to this document Turkey's vision in this transformation was being a country that has become a focal point in the production of science and technology, that uses information and technology as an effective tool, that produces more value with information based decision making processes, that is successful in global competition and that has a high level of welfare (e-Transformation Turkey Executive Board, 2004). In 2005 a new action plan, which includes updated actions in the same areas with previous short term plan, was brought into force.

In 2004 National Science and Technology Policies 2003-2023 Strategy Document was published by TÜBİTAK. This document included a technology foresight study which attached gaining competence in science, technology and innovation to the 2023 vision of Turkish Republic. Grounding on this foresight study, national science and technology strategy was determined as dominating in strategic technology areas and transforming this dominance to economic and social benefits. Focusing on strategic areas, constituting cooperation networks among researchers and business world and management of focusing process with systematic coherence were stated as the three pillars of the national science and technology strategy. Being one of those strategic areas, ICT sector was expected to contribute to sustainable economic development by creating new products and technologies as well as putting more effective communication opportunities and richer information sources into service of other sectors (TÜBİTAK, 2004a).

Science and Technology Policies Application Plan 2005-2010 was accepted by BTYK in 2004. In this plan seven major action areas were stated as developing science and technology awareness and culture, educating scientists, supporting result oriented and qualified researches, activating national science and technology management, strengthening the performance of the private sector in science and technology, improving research environment and infrastructure and enabling national and international networks. Moreover, with this document Turkish Research Area (TARAL), which was a conceptual unity aiming to bring synergy among all actors in IT and R&D fields, was defined (TÜBİTAK, 2004b).

In the Ninth Development Plan (2007-2013) of Turkey, disseminating ICT was determined as one of the main strategic economic and social priorities in order to raise competitiveness of the country. Within this framework, improving ICT infrastructure by encouraging competition in the electronic communication sector, introducing alternative infrastructure and services, ensuring efficient, fast, secure, and widespread access to information at affordable costs; extending broadband coverage; increasing the usage of ICT by enterprises, citizens and institutions and using public procurement as an effective tool to foster development of ICT within the country were the major policy priorities in this document (SPO, 2006c).

In addition to previous efforts within the scope of e-Transformation Turkey Project, Information Society Strategy (2006-2010) and its annexed Information Society Strategy Action Plan were prepared by SPO with the contributions of other stakeholders in order to enable Turkey to benefit from ICT effectively and identifying the middle and long term strategies and targets for the realization of that transformation. In the Strategy, positions of citizens, public sector, firms and ICT sector and Turkey's potential for transformation into an information society by 2010 were evaluated. Also, targets for 2010 and required steps for accomplishment of those targets were set within the framework of the determined strategic priorities. Those strategic priorities were social transformation, ICT adoption by businesses, citizen-focused service transformation, modernization in public administration, a globally competitive IT sector, competitive, widespread and affordable telecommunications infrastructure and services and improvement of R&D and innovation (SPO, 2006a). The Action Plan covers the activities and projects that would be implemented to achieve the identified strategic objectives (SPO, 2006b).

In its fifteenth meeting in 2007 BTYK adopted National Innovation Strategy 2008-2010 to achieve desired progress by coordination and strategic management of all innovation elements and instruments within the country. Action areas proposed by this document can be summed up as encouraging entrepreneurship, innovativeness and productivity, using science and technology capacity of the country most efficiently, supporting existence of sustainable, strong and competitive markets, facilitating appropriate environment and infrastructure, enhancing international cooperation and improving management and coordination of the innovation system (TÜBİTAK, 2007b). Also another document named as International Science, Technology and Innovation Strategy Application Plan (2007-2010) was accepted in the same meeting. This document aims increasing science, technology and innovation competencies of Turkey in international arena by taking advantage of international cooperation with countries that were advanced in these areas (TÜBİTAK, 2007a).

In 2008, Law on Supporting R&D Activities and Electronic Communication Law were enacted. The former aimed to gain economic advantage through innovation and technology generation and brought various tax deductions, social security contribution aids, capital supports and grants for R&D activities of the private sector (Official Gazette, 2008b). Latter aspired to ensuring competition and efficiency in the electronic communication sector, extending electronic communication services throughout the country and encouraging technological development in this area (Official Gazette, 2008a).

Last but not the least, National Science, Technology and Innovation Strategy 2011-2016 was prepared by TÜBİTAK and adopted by BTYK in 2010. The vision drawn by this document for Turkey involved producing knowledge, developing new technologies and transforming these to innovative products, processes and services for the sake of the country and humanity. In this document, strategic goals were grouped into two as horizontal and vertical axes. Vertical axes were determined according to sectoral breakdown and ICT was a prioritized sector under the group for which R&D and innovation capacity of Turkey was deemed to be strong, comparatively. For this group it was intended to make detailed analyses and employ target oriented approaches to be able to actualize the above mentioned vision. Horizontal axes, which cover all prioritized sectors, were about improving human capital, commercialization of research outcomes, extending the culture of multi-stakeholder and multi-discipline R&D, strengthening the role of SMEs in national innovation system, increasing the contribution of research infrastructures to knowledge creation and making the international collaborations more effective (TÜBİTAK, 2010).

3.2.2. Developments in ICT area in Turkey

ICT have been becoming widespread in all segments of the society in Turkey as it is the case in other OECD member countries. Main ICT indicators of Turkey that are represented in Table 3.1 show that usage of ICT has been increasing steadily. Apart from this increase in quantity, there are also significant improvements in terms of quality. Share of mobile communication which is obviously a higher level of technology application than public switched telephone network (PSTN) and share of broadband internet connection which provides much better service than dial-up network have risen significantly. In addition, share of information technology sector in ICT market has been enlarging though it is still much smaller compared to communications' share.

Table 3.1 Main ICT Indicators of Turkey

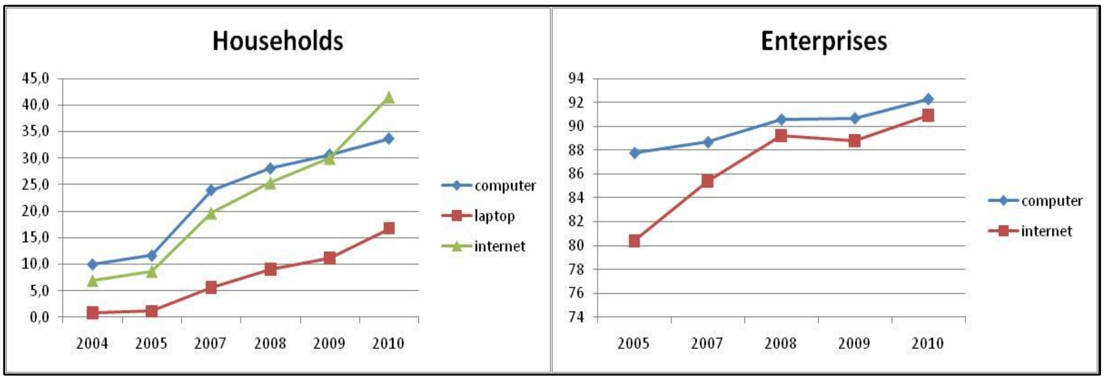
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011[1]
PSTN Penetration (%)	27	26.8	26.7	26.3	25.8	24.9	24.5	22.8	22	20.7
Mobile Penetration (%)	33.3	39.7	48.5	60.5	72.2	84.9	92.1	86.6	83.9	87.8
Broadband Penetration (%)	-	-	-	2.2	3.8	6	8.4	9.4	11.6	16.9
Internet Penetration (%)[2]	-	8.5	13.5	13.9	18	26.7	35.8	38.1	41.6	45
ICT Market Size (billion $)	-	10.3	11.9	15.8	17.9	21.7	23.8	22.2	25.4	24.2
*Telecommunications	-	8.5	9.6	12.4	13.8	17	16.7	15.5	17.8	16
*Information Technology	-	1.8	2.3	3.4	4.1	4.7	7.1	6.7	7.6	8.2

Source: Annual Programmes between 2004 and 2012

(1) Ministry of Development estimation

(2) The ratios cover 16-74 age groups

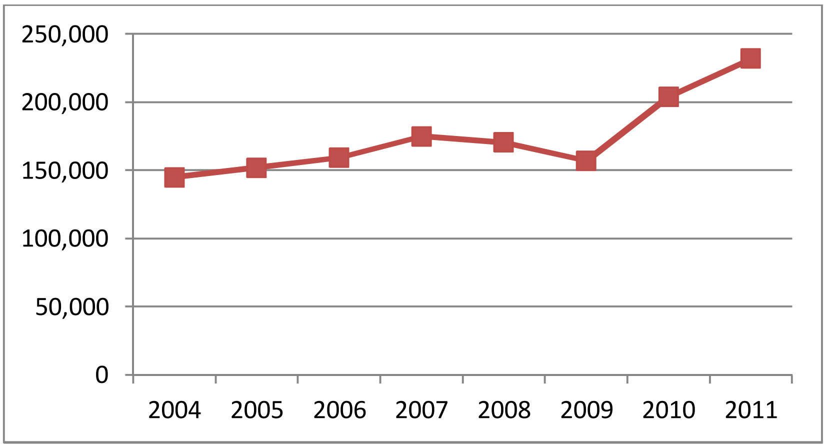
As it is seen in Figure 3.10 computer and internet ownerships have been fairly increasing in both enterprises and households since 2005. Increasing competition in telecommunication sector as a result of privatization of Türk Telekom and entry into force of Electronic Communication Law, various discounts and tax deductions for computer purchases and decreasing prices due to advancements in technology played an important role in this progress.



Source: TURKSTAT Information Society Statistics

Figure 3.10 ICT ownership in households and enterprises

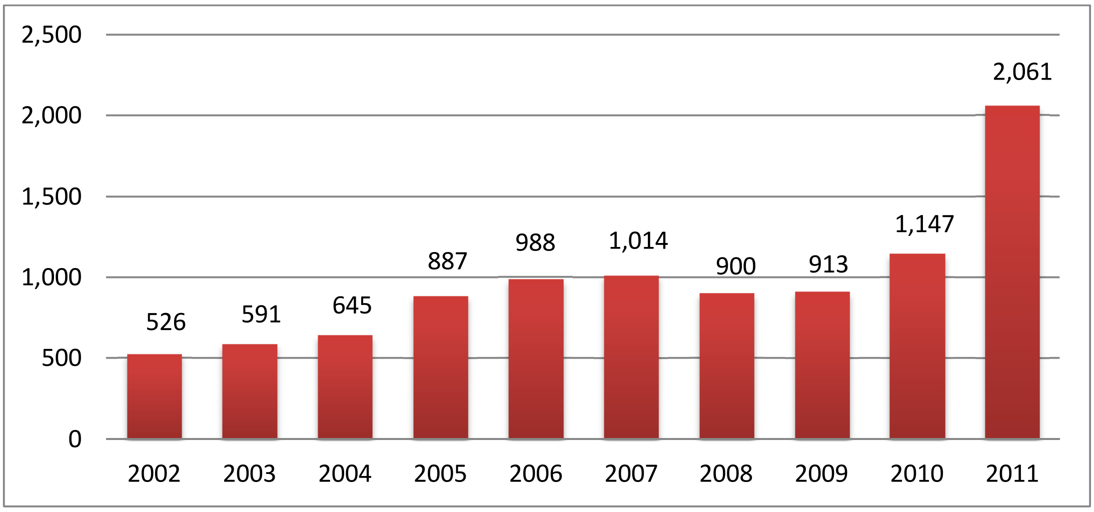
In parallel with the growing ICT diffusion in Turkey, there seems to be a positive trend also in terms of ICT employment. Figure 3.11 depicts this trend with the available data on employment in ICT services sector. While the employment in ICT services sector was about 145,000 people in 2004, it increased to 232,000 by the September 2011 with a 60 per cent raise in seven years. If this fact is taken into consideration together with the rise in total employment in Turkey for the same period just being 26 per cent, enlargement and employment creation potential of ICT sector becomes more apparent (TURKSTAT, 2012).



Source: TURKSTAT Labor Force Statistics

Figure 3.11 Employment in ICT Services Sector

As Figure 3.12 shows public ICT investment has also been following a similar trend and its value for 2011 is more than 2 billion Turkish liras and about fourfold of the 2002 level in real terms. But it should be noted that the upsurge in the last year is exceptional and due to initiation of a big project in the education sector (SPO, 2011). Thanks to these public funds allocated to ICT investments, usage of ICT in delivery of public services has increased as a result of several e-government projects in areas like judicial system, population and citizenship affairs, social security, tax collection and security issues. Likewise, computer and internet facilities in schools and curriculum have been developed in order to provide students with relevant ICT skills.



Source: SPO Public ICT Investments

Figure 3.12 ICT Investments of Turkish Government (2011 prices, Million TL)

Although these positive trends in ICT diffusion to both households and businesses as well as in the amount of public funds allocated to ICT do not guarantee productivity gains and economic returns directly, they are meaningful from the point of indirect effects of enhanced technology capabilities, digital literacy, living standards and technical infrastructure. On the other hand, despite these positive developments, as the previous sections reveal Turkey's position in ICT area by comparison with other OECD member countries is certainly not as favorable as desired.

3.3. Assessment

ICT has been treated as a strategic sector and among top priority policy areas in both OECD and Turkey for the last two decades. Depending on the present stage of the

ICT revolution in terms of technical, economic and social aspects, a number of special fields arouse more interest. Turkey mostly follows those policy trends in OECD albeit usually with a certain time lag. Governments generally see ICT as an effective tool to achieve sustainable economic and social development ever-increasingly. As a result of the special attention paid to ICT area, recent statistics usually show upwards trends in demand, production, investment, exports and employment regarding ICT sector for OECD area. Also Turkey makes way in similar direction for most of the indicators; however she is among stragglers in most of the comparative statistics. On the other hand, the general problem for the whole OECD area, despite continual improvements in absolute terms, is decreasing shares in worldwide ICT pie, both in demand and supply sides, due to the rivalry of non-OECD economies. Before speculating on the possible suggestions, next chapter questions whether ICT deserves that great attention by investigating macroeconomic gains of ICT revolution via econometric analyses.

CHAPTER 4

EMPIRICAL ANALYSES ON RELATIONSHIP BETWEEN ICT AND ECONOMIC GROWTH

As a modest contribution to the empirical studies that try to investigate economic effects of ICT revolution, this chapter carries out an econometric analysis in order to examine relationships between ICT usage and production and economic growth. Following sections present relevant information about the adopted methodology, employed econometric model, utilized data sets, estimation process, obtained results and evaluation of them.

4.1. Methodology

Before starting to implement econometric analyses, it is of vital importance to determine econometric framework properly to be able to obtain trustable results at the end of the estimation process. First of all, in this study, we carried out two different econometric estimations, one for sample of 30 OECD countries and one for only Turkey. For the sake of convenience, we will refer former as OECD case and for latter Turkey case through remainder of the text.

For the OECD case, we used a balanced panel data set which consists of 30 cross sections (countries) and 10 years time span and, thus, includes 300 observations. Panel data analysis is examining a specific subject by observing multiple experimental objects many times during a certain time span. In this regard, panel data analysis combines the time series and cross section analyzes and thus offers a number of advantages to the researchers. Panel data analysis allows for observing the dynamics of a change for even short time series. Thanks to the two-dimensional data structure in panel data sets, both quality and quantity of data points increase considerably (Yaffee, 2003). For Turkish case, we performed a time series analysis with 30 years time span.

For the OECD case, due to working with panel data we had to fix upon using fixed or random effects for cross sectional units in our model. In the fixed effects models, error term of the model is assumed to vary non-randomly over different units whereas that is assumed to vary randomly in random effects models. For our case, choosing fixed effects means that there are some unique attributes which vary non-stochastically among cross sections while the opposite is true for choosing random effects (Gujarati, 2004). Due to theoretical reasons we strongly think that fixed effects would be the right choice for our case. Because, according to us, it is highly possible that there exist differences in country-specific characteristic among cross sectional units. Thus, we used fixed effects in the model's estimation procedures.

In addition to these, to be able to increase the reliability of the results of empirical work, we took relevant precautions regarding the possible econometric troubles. In this context, we were doubtful about heteroskedasticity problem which occurs when the variance of the error terms is not constant. Especially for the OECD case, it is highly possible that error terms that are associated with different cross sectional units may have different variances. But unfortunately there is not any special tool to detect and fix heteroskedasticity problem beforehand in eViews. Instead, there are some special options which make eViews to run econometric models assuming the presence of heteroskedasticity and to make feasible estimations accordingly. In order to be in safe, for panel data we used "cross section weights" and for time series data we used "white heterokedasticity consistent covariance matrix estimator" options (Eviews, 2004).

Moreover, the autocorrelation problem was on our agenda. Because there is some risk for error terms not to be independently distributed over time. For the OECD case, this possibility is very low due to shortness of the investigated time period. Even so, to be able to clear the air, we used the "white period" option as coefficient covariance method in eViews. According to eViews Users Guide, "the white period robust coefficient variance estimator is designed to accommodate arbitrary serial correlation and time-varying variances in the disturbances". (Eviews, 2004, p. 866) Thus, we expect to obtain robust estimates against autocorrelation problem for the panel data analysis. For Turkish case, autocorrelation seems as a more serious problem because of comparative lengthiness of 30 years time span. Therefore, we carefully made autocorrelation test for all model alternatives that belong to Turkish case. Indeed, we encountered autocorrelation in some alternatives and fixed it by employing autoregressive model estimation technique. Results of autocorrelation tests and detailed explanation of performed operations to remove autocorrelation problem are represented in Appendix A.

For the OECD case, above mentioned possible problematic issues led us to use generalized least squares (GLS) method which is known to be robust against statistical problems like heteroskedasticity and autocorrelation (Gujarati, 2004). In addition, following Erdil, et al. (2010) we also made trials by employing generalized method of moments (GMM) estimation method. However, none of the estimates which are obtained by GMM is statistically meaningful. For Turkish case, we used ordinary least squares (OLS) method.

4.2. The Model

As we are curious about the connection between economic growth and ICT, unsurprisingly our dependent variable in our econometric model is the aggregate output. We have two traditional factors of production, capital and labor, in the model as independent variables. Besides them, in parallel with our aim, there are two other explanatory variables as ICT usage and ICT production. Thus, we relate change in output (GDP) with the changes in capital, labor, ICT usage (ICTUSG) and ICT production (ICTPRD) as represented by equation (9) where the coefficients reveal the proportional change in output with the changes in independent variables. However, due to lack of data that goes back to 30 years for Turkey regarding ICT production variable, we could not include the ICTPRD to the econometric model that is used in Turkey case.

$$\dot{GDP} = C(0) + C(1) \cdot \dot{CAPITAL} + C(2) \cdot \dot{LABOR} + C(3) \cdot \dot{ICTUSG} + C(4) \cdot \dot{ICTPRD} \quad (9)$$

As the literature review in Chapter 2 demonstrates, evolution of GDP over time is accepted as the foremost indicator for the course of economy. We also take the change in GDP in order to follow economic growth of countries by using two different proxies for this variable as total GDP and GDP per capita. Both GDP data are calculated according to expenditure approach and in US dollars, constant prices and constant exchange rates of the base year, 2005. Even though we think that GDP per capita is a more accurate measure of a country's economic position, we also use GDP as dependent variable in some model alternatives.

For the capital variable, which is one of the two conventional inputs for economic output, we use gross capital formation data that is calculated in US dollars, constant prices and constant PPPs of the base year, 2005. According to the glossary of our data source, "gross capital formation is measured by the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables" (OECD, 2012a). Here, "gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non- produced assets realized by the productive activity of institutional units" (OECD, 2012b). Considering that gross capital formation data is closely related to the investment, we use this proxy in a similar vein to a number of studies that use investment data for the capital variable such as Pohjola (2000), Yoo (2003) and Nasab and Aghaei (2009). As a matter of course we expect capital variable to have a positive coefficient in our econometric model.

For the other traditional factor of production, labor, we have two different proxies. First, similar to Röller and Waverman (2001) that use total labor force, we have total civilian labor force as a proxy for labor variable. Our second proxy is obtained by multiplying total civilian labor force data and labor productivity index. This new data set may be treated as effective units of labor as in Solow Growth Model. We also expect a positive sign for the coefficient of labor variable in either case.

We believe that ICT diffusion in all segments of the economic and social life results in desirable influences in terms of economic growth. Our analyses on different aspects of the ICT revolution in section 2.2 support this view. In addition, most of the literature that is mentioned in section 2.3 reach similar findings by employing empirical methods. Hence, in order to verify our hypothesis about positive relationship between ICT diffusion and economic growth, we add an explanatory variable as ICT usage in our econometric model anticipating a positive coefficient for it. As a proxy for ICT usage variable, similar to Breitenbach, et al. (2005) and Erdil, et al. (2010), we employ communication access channels (total of analogue lines, ISDN lines, DSL, cable modem and mobile subscribers) and corresponding value of this statistics per 100 inhabitants.

As seen in section 2.3, most of the studies that investigate the economic impacts of ICT revolution focus on ICT demand side. But a few of them such as Jorgenson and Stiroh (1999), Oliner and Sichel (2000), Colecchia and Schreyer (2001) and Jalava and Pohjola (2005) also interrogate direct effects of ICT production on economic growth along with ICT usage. Likewise, current study suspects optimistically about existence of significant positive impacts of ICT production capabilities and volumes of countries on their economic growths. In order to test this, we have an ICT production variable on the right hand side. Total ICT goods exports in constant US dollars and number of patents in the ICT sector are used as proxies for this variable.
Undoubtedly, there may exist more accurate proxies for all variables in our model. But we are not free from a common obstacle, data availability problem, for this kind of econometric studies, especially which need suitable data regarding ICT area. Therefore, we have to be contented with above described proxies. A summary of the variables and associated proxies is represented in Table 4.1.

Table 4.1 Description of Variables in the Model

Variable	Description
GDP	Total GDP or GDP per capita that are calculated according to expenditure approach and in US dollars, constant prices and constant exchange rates of the base year, 2005.
CAPITAL	Gross capital formation that is calculated in US dollars, constant prices and constant PPPs of the base year, 2005.
LABOR	Total civilian labor force or Total civilian labor force*Labor productivity index.
ICTUSG	Communication access channels or Communication access channels per 100 inhabitants.
ICTPRD	Total ICT goods exports or Number of patents in ICT sector

4.3. Data

For the OECD case, data sets that are employed in our econometric analyses belong to 30 OECD member countries that became so before 2010. We could not involve the latest OECD member countries, Chile, Estonia, Israel and Slovenia, due to severity of data availability problems for them. A list of the studied countries is represented in Appendix B. Time span of our empirical study is the period between 1999 and 2008. This period actually coincides with the time span for which effects of ICT revolution are expected to be felt precisely. Furthermore, not surprisingly, data availability problems are influential on this determination. For Turkish case, our time series regression involves 30 observations between 1980 and 2009. We use a single data source, OECD Statistics Database, for all proxies and hoping to benefit from this fact in terms of compatibility and consistency of our data sets.

To be able to stabilize the variation in the data sets we took logarithms for all of them. Further, suspecting about non-stationary nature of data sets, we performed unit root tests for all variables. Ultimately, as the test results in Appendix C indicate, it is seen that there is a unit root problem for all data series. We overcame this problem by taking first order difference of data sets for the OECD case. For Turkish case unit root problem in ICT usage data remained despite first order differencing. Therefore we had to take second order differences. Although these operations decreased the number of observations to 270 for the OECD case and to 28 for the

Turkey case, they strengthen the reliability of econometric analyses. Consequently, our econometric model for the OECD case became the one represented by equation (10) where "DLOG" means difference of the logarithms of associated variable in time t and t-1. Likewise, employed econometric model for Turkish case is displayed by equation (11). Here because we had to take second order differences for data sets that belong to Turkish case, equation (11) actually relates the changes in growths of variables.

$$\mathrm{DLOGGDP} = \mathrm{C}(0) + \mathrm{C}(1) \cdot \mathrm{DLOGCAPITAL} + \mathrm{C}(2) \cdot \mathrm{DLOGLABOR} + \mathrm{C}(3) \cdot \mathrm{DLOGICTUSG} + \mathrm{C}(4) \cdot \mathrm{DLOGICTPRD} \quad (10)$$

$$\mathrm{DDLOGGDP} = \mathrm{C}(0) + \mathrm{C}(1) \cdot \mathrm{DDLOGCAPITAL} + \mathrm{C}(2) \cdot \mathrm{DDLOGLABOR} + \mathrm{C}(3) \cdot \mathrm{DDLOGICTUSG} \quad (11)$$

Another probable troubled issue regarding data sets is reverse causality problem which is also taken into account by Norton (1992) and Röller and Waverman (2001). We were also cautious about the influence of GDP growth on growths in capital, labor, ICT usage and ICT production. For this reason, we carried out pairwise Granger causality tests for all data series and proved that there is not any reverse causal relationship between independent variables and dependent variable statistically. Results of Granger causality tests are presented in Appendix D.

4.4. Estimation and Results

As it is explained in the second section of this chapter, we have two different proxies for each of GDP, LABOR, ICTUSG and ICTPRD variables and for the OECD case and we used both GLS and GMM methods separately for all proxy combinations. Besides, we made additional trials by including lagged value of dependent variable to the model. These facts result in 64 different estimation combinations for the OECD case. Results of all these combinations are represented in Appendix E. Here, we provide the outputs belonging to four best efficient estimations in terms of significance of variables. Table 4.2 displays the coefficients of each variable in each model as well as associated t-values in parentheses and adjusted R^2 statistics for the OECD case.

Table 4.2 Results of Selected Estimations for the OECD case

Variable	Model-1	Model-2	Model-3	Model-4
CAPITAL	**0.137**** (12.013)	**0.137**** (12.028)	**0.135**** (11.194)	**0.135**** (11.252)
LABOR	**0.397**** (10.037)	**0.397**** (10.035)	**0.411**** (9.508)	**0.410**** (9.526)
ICTUSG	**0.028**** (2.776)	**0.028**** (2.782)	**0.030**** (2.733)	**0.031**** (2.745)
ICTPRD	**0.008*** (1.997)	**0.008*** (1.996)	**0.008*** (2.165)	**0.008*** (2.159)
CONSTANT	**0.009**** (6.844)	**0.009**** (7.209)	**0.001** (0.885)	**0.001** (1.019)
Adj. R2	0.806	0.806	0.798	0.798

* Significant at the 5 per cent level

** Significant at the 1 per cent level

In all of the above mentioned four models for the OECD case, gross capital formation, effective labor (total civilian labor force multiplied by labor productivity index) and number of patents in ICT sector are used as proxies for CAPITAL, LABOR and ICTPRD respectively. For GDP as the dependent variable, we use total GDP in models (1) and (2) and GDP per capita in models (3) and (4). Proxies for ICTUSG variable are total access channels in models (1) and (3) and total access channels per 100 inhabitants in models (2) and (4).

Concerning the significance of variables, all of them are significant at the 1% level in all four models except the intercept term which is not significant in models (3) and (4) as well as ICTPRD variable which is significant at the 5% level in all models. Moreover, coefficients of independent variables do not vary markedly among alternative models.

Apart from these, in order to be able to observe the marginal contribution ICT production variable to estimations, we performed additional trials for above mentioned 4 models by taking the ICTPRD variable out for the OECD case. As it is represented in Table 4.3, exclusion of ICTPRD variable resulted in a slight increase in the contribution of capital and ICT usage variables to GDP growth.

Table 4.3 Results of Selected Estimations for the OECD case without ICTPRD

Variable	**Model-1**	**Model-2**	**Model-3**	**Model-4**
CAPITAL	**0.143**** (11.941)	**0.143**** (11.957)	**0.142**** (11.164)	**0.142**** (11.205)
LABOR	**0.399**** (9.973)	**0.398**** (9.986)	**0.412**** (9.135)	**0.411**** (9.142)
ICTUSG	**0.030*** (2.541)	**0.030*** (2.546)	**0.032*** (2.467)	**0.033*** (2.482)
CONSTANT	**0.009**** (6.531)	**0.009**** (6.954)	**0.001** (0.920)	**0.002** (1.063)
Adj. R2	0.761	0.761	0.758	0.758

* Significant at the 5 per cent level

** Significant at the 1 per cent level

For Turkish case, using two different proxies for each of GDP, LABOR and ICTUSG variables and making additional trials by including lagged value of dependent variable to the model for each proxy combination we had 16 different estimations. Results of all these combinations are represented in Appendix F. Here, we provide the outputs belonging to four best efficient estimations in terms of significance of variables. Table 4.4 displays the coefficients of each variable in each model as well as associated t-values in parentheses and adjusted R^2 statistics for Turkish case.

Table 4.4 Results of Selected Estimations for Turkish case

Variable	Model-1	Model-2	Model-3	Model-4
CAPITAL	**0.101*** (6.288)	**0.101*** (6.282)	**0.101*** (6.391)	**0.100*** (6.389)
LABOR	**0.602*** (10.334)	**0.602*** (10.338)	**0.604*** (10.612)	**0.604*** (10.611)
ICTUSG	**-0.038** (-0.96)	**-0.038** (-0.973)	**-0.030** (-0.816)	**-0.030** (-0.826)
CONSTANT	**-0.001** (-0.552)	**-0.001** (-0.543)	**-0.001** (-0.305)	**-0.001** (-0.297)
Adj. R2	0.950	0.950	0.951	0.951

* Significant at the 1 per cent level

In all of the above mentioned four models for Turkish case, gross capital formation and effective labor (total civilian labor force multiplied by labor productivity index) are used as proxies for CAPITAL and LABOR respectively. For GDP as the dependent variable, we use total GDP in models (1) and (2) and GDP per capita in models (3) and (4). Proxies for ICTUSG variable are total access channels in models (1) and (3) and total access channels per 100 inhabitants in models (2) and (4).

Concerning the significance of variables, CAPITAL and LABOR are significant at the 1% level in all four models whereas the intercept term and ICTUSG are not significant in any models. Furthermore, coefficients of independent variables do not vary markedly among alternative models.

4.5. Assessment

As it is already clear to the reader, there are substantial differences regarding empirical analyses for the OECD and Turkish cases in terms of employed econometric method, time span of data sets and number of observations. Inherently, it is possible to reach findings that differ in terms of reliability and message for these two cases. Hence, we will evaluate the results of econometric analyses for the OECD and Turkish cases separately.

4.5.1. Assessment of the findings of the OECD case

According to results of our econometric analyses that belong to the OECD case, all of capital, labor, ICT usage and ICT production variables have a positive impact on the economic growth in compliance with our expectations. Even though all of those effects are significant in statistical terms, their magnitudes differ substantially.

We find out that ICTUSG variable has a coefficient about 0.03 which indicates that a 1% rise in ICT capital results in 0.03 percentage increase in GDP growth. This value is pretty lower than Erdil et al. (2010)'s estimate which is approximately 0.1. However, Röller and Waverman (2001), which investigates just OECD countries as we do, reached a value of 0.045 for the coefficient of independent variable associated with ICT diffusion. Yet more, Röller and Waverman (2001) comment that their estimate is a little bit large. Thus, our result regarding the effect of ICT usage on economic growth seems reasonable and can also be a supportive argument for the growth-friendly results of ICT revolution.

Coefficient of ICTPRD variable, 0.008, shows that a 1% rise in ICT production results in 0.008 percentage increase in GDP growth. Although this effect seems to be very small, it still provides some insights about the positive relationship between ICT production capabilities and GDP growth. In literature, favorable consequences of ICT revolution are mostly linked with the increase in ICT usage in economy and society wide levels instead of rise in ICT production volumes. When considered from this point of view, it is quite natural to obtain a smaller coefficient for the variable associated with ICT production than the ICT usage variable. Our findings about ICTPRD variable do not put away our affirmative opinion regarding the positive relationship between ICT production and economic growth; instead they encourage us to continue arguing so.

According to our results, coefficients of capital and labor variables are approximately 0.14 and 0.4, respectively. When well accepted economic growth theories are taken into consideration, these strong positive connections between capital and labor and output are no wonder. In fact, we can find some foot prints of ICT in shares of GDP growth attributed to capital and labor. Firstly, our proxy for CAPITAL, gross capital formation, includes the changes in ICT capital stocks. Moreover, as we previously explained, ICT diffusion improves labor productivity considerably. Therefore, our proxy for labor that is calculated by total civilian labor force multiplied by labor productivity index also involves indirect effects of ICT revolution. These facts constitute further support for the positive relationship between ICT revolution and economic growth.

Taking everything into account, results of our econometric analyses indicate that there exists a positive link between ICT revolution and economic growth, at least when 30 OECD countries between 1999 and 2008 are considered within our empirical framework. This conclusion validates computationally the explanations about economics of ICT in Chapter 2 as well as supporting the findings of most of the researchers mentioned in the literature review part. Undoubtedly, more precise and comprehensive results can be obtained by working with more generous data sources.

4.5.2. Assessment of the findings for Turkish case

Before starting to evaluate the results of econometric analyses for Turkish case, we should state that these analyses are much weaker than those made for the OECD case. Because, number of observations in the former is approximately one tenth of the latter's and this fact reduces the power of analyses considerably. Therefore, it is better to be more attentive while drawing conclusions depending on the results of econometric analyses for the Turkey case, especially those contradict with the OECD case.

According to results of our econometric analyses that belong to Turkish case, capital and labor variables have a positive impact on the economic growth in compliance with our expectations. However, contrary to both our expectations and findings of the econometric analyses for the OECD case, ICT usage variable has not any significant positive effect on the economic growth in Turkey during the period between 1980 and 2009. As Table 4.3 indicates, ICTUSG is not a statistically significant variable in any models. This points out that there is not any remarkable linkage between ICT usage and economic growth. We think that, besides the methodological weakness due to fewness of data points, this result can be explained by the particular conditions of Turkey.

As the findings of many studies that investigate different group of countries for different time periods such as Jorgenson and Stiroh (1999), Röller and Waverman (2001), Oliner and Sichel (1994), Parham, et al. (2001), Ramlan, et al. (2007), Kim (2002), Jorgenson and Motohashi (2005), Whelan (2000), Oliner and Sichel (2000), Oulton (2001), Armstrong, et al. (2002), Van Ark (2001) and Daveri (2002) suggest, positive impacts of ICT revolution occur with a certain time lag after widespread diffusion of ICT. Furthermore, those desirable impacts are felt increasingly with the passing of time thanks to spillover and network effects. Accordingly, lack of significant relationship between ICT usage and economic growth in Turkey for the 1980-2009 period can be explained by the fact that ICT diffusion in Turkey have not gone beyond the critical threshold yet or early enough. In addition to this, in a similar vein to Pohjola (2000) and Dewan and Kraemer (2000), we think that existence of complementary physical and social infrastructures in a country plays an important role in terms of exploitation of ICT revolution in that country and case in Turkey may be affected by also this circumstance. Moreover, weakness of proxies that were employed for ICTUSG variable might not be appropriate enough to reflect contribution of ICT usage to economic growth for Turkish case. Further research that works with better proxies as well as sectoral level data will be useful in terms of understanding the dynamics of ICT revolution in Turkey.

Lastly, our findings indicate that coefficients of capital and labor variables are approximately 0.1 and 0.6, respectively. Similar to the OECD case, these strong positive relationships between capital and labor and economic growth are quite expectable. It is seen that growth in effective labor is more influential on economic growth for Turkish case compared to the OECD case. May be, positive impact of ICT revolution that we could not be confirmed statistically with ICT usage variable is hidden in growth effect of labor to some extent for Turkish case.

CHAPTER 5

CONCLUSION

Great developments in ICT during recent years caused radical transformations in terms of both social and economic aspects. ICT sector has emerged as a major and rapidly growing one. Both economic volume and employment capacity of the sector expanded significantly. Direct effects of ICT revolution occur via all kinds of economic activities regarding the ICT sector like production, marketing, trading and distribution of ICT products and services, employment within the sector, financial interactions between the ICT sector and other industries. Apart from all these, more importantly because ICT is a general purpose technology and with the widespread usage of it in other sectors, those radical developments affected all segments of the economy and the society in general. Dissemination of ICT altered the personal lives, social structure, business climate, public sector and scientific activities deeply. These alterations are generally treated as desirable ones and diffusion of ICT is strongly linked to the productivity gains in terms of both multifactor productivity and labor productivity improvements throughout the economy. In order to test and quantify the positive impacts of ICT revolution for the economy on overall, empirical studies that search for a positive relationship between economic growth and ICT usage and production are carried out.

5.1. Simultaneous Evaluation of Theoretical and Experimental Results

ICT has become one of the major sectors of the modern economies. With high R&D and innovation capabilities of the sector and continuous and growing demand to its products by both individuals and other sectors of the economy, ICT sector has been expanding steadily. Worldwide ICT spending, value added in ICT sector, ICT sector's employment and global ICT trade have been raising considerably. Ability of ICT sector to refresh itself and introduce novel products and solutions continuously, have made it one of the driving forces behind national economies.

With the widespread ICT diffusion and emergence of Internet as a network that spreads the entire globe, dynamics of the knowledge creation process has changed substantially. Thanks to ICT, information can be produced, stored, shared and accessed more easily and faster. ICT also becomes influential on work environment. Organizational structures, hierarchical relationships, types, numbers and methods of tasks change due to ICT revolution. Easier flow of information, more effective supply chain management and more flexible organization of workplace environment bring about considerable cost reductions, productivity gains and efficiency improvements for the firms.

Transfer of many daily life applications to the virtual environment and dissemination of electronic services such as e-banking, e-health, e-learning, etc. provide easiness for people by removing some of the traditional constraints, especially geographical barriers, as well as making great time and money savings possible. E-commerce transforms the marketplace by changing the way business is conducted, paving the way for new products and markets, string up new and closer relationships between firms and customers, changing the organization in work and introducing a work environment with more knowledge diffusion, human interactivity, openness and flexibility. E-commerce increases efficiency and effectiveness of economic activities and processes, decrease a number of costs and promote productivity in certain areas through several channels in different layers of the economy.

With the ICT revolution, demand for ICT experts and ICT literate staff grows significantly. As new tasks and processes appear in work environment or complexity of existing ones increases due to involvement of ICT, some new job descriptions and professions emerge. ICT revolution leads the separation of work from physical environments completely or partly thanks to applications like tele-working. Thanks to e-government applications public institutions can perform their tasks in an automated way with a higher speed and more accurately and reliably. This improves their performance while reducing transaction costs. Transparency, accountability and trustability of government bodies improve, necessities of citizens can be understood better and their satisfaction increases.

ICT revolution also changes habits, way of entertaining and networking, distribution of expenditures, education and training forms of individuals. These contribute to achievement of easier sell-fulfillment, increased personal prosperity, advanced standards of living and grown social welfare. Quality of services is improved and they are generalized throughout the country equally. Disadvantageous segments of the society, especially disabled people, who cannot or can only limitedly benefit from services become more active and integrated to the society. These contribute the advancement of social development.

All in all, ICT revolution has various direct and indirect positive impacts on the economy. However, it is not so easy to test and quantify the exact magnitude and scope of all consequences of that revolution. Even so, it is possible to achieve these in aggregated terms by investigating the macroeconomic effects of ICT. To that end, we looked at the relationships between GDP growth path, which seems as a somewhat acceptable gauge for the overall direction of an economy and contains the results of all those effects that are mentioned above more or less in the long run, and ICT usage and production variables econometrically. In the empirical part of the thesis, we performed two distinct sets of analyses. For the first one, the OECD case, we worked with data sets that belong to 30 OECD member countries and period between 1999 and 2008. For the second set of analyses, Turkish case, we utilized data only for Turkey and 30 years between 1980 and 2009. Naturally, due to fewness of number of observations in the latter, relevant results were weaker.

For the OECD case, results of our econometric analyses indicate that both ICT usage and production have a positive effect on the economic growth. We find out that ICT usage variable has a coefficient about 0.03 which indicates that a 1% rise in ICT capital results in 0.03 percentage increase in GDP growth. Besides, coefficient of ICT production variable, 0.008, shows that a 1% rise in ICT production results in 0.008 percentage increase in GDP growth. As a consequence, our empirical findings support that there exists a positive link between ICT revolution and economic growth, at least when 30 OECD member countries between 1999 and 2008 are considered within our empirical framework. This conclusion validates computationally our theoretical analyses regarding economics of ICT.

On the other hand, for Turkish case, contrary to both our expectations and findings of the econometric analyses for the OECD case, we could not reach any significant positive effect of ICT usage on the economic growth. ICT usage variable in our econometric model was not statistically significant. This points out that there is not any remarkable linkage between ICT usage and economic growth in Turkey between 1980 and 2009. We think that, besides the methodological weakness due to fewness of data points, this result can be explained by the particular conditions of Turkey. As the findings of many similar studies suggest, positive impacts of ICT revolution occur with a certain time lag after widespread diffusion of ICT. Furthermore, those desirable impacts are felt increasingly with the passing of time thanks to spillover and network effects. Accordingly, lack of significant relationship between ICT usage and economic growth in Turkey for the 1980-2009 period can be explained by the fact that ICT diffusion in Turkey have not gone beyond the critical threshold yet or it is early to measure its impacts. In addition to this, we think that existence of complementary physical and social infrastructures has an influence on emergence of positive results of ICT revolution. Our findings for Turkish case may also root in insufficiency of those complementary infrastructures in Turkey.

5.2. Policy Suggestions

As our theoretical discussions and empirical findings reveal, there seems to be a positive relationship between ICT and economic growth, especially for developed countries. Although our econometric findings for Turkish case fail to back up the optimism about ICT due to above explained reasons, growth friendly results of ICT revolution can still be championed quite easily and securely thanks to the general tendency of relevant literature as well as other empirical and theoretical findings of this thesis. Concordantly, OECD countries, including Turkey, have treated ICT as an important issue and paid special attention to it in order to foster economic growth. When the policy documents of last two decades are investigated, it is seen that ICT has been regarded as a strategic sector and among top priority policy areas in both OECD and Turkey. As a result of this particular attention towards ICT area, recent statistics usually show upwards trends in demand, production, investment, exports and employment regarding ICT sector for OECD area. Similar trends are also observed in Turkey; but she is among stragglers in most of the comparative statistics among OECD countries.

We think that Turkey should certainly get her share of ICT revolution. Because, as it is discussed throughout this study, ICT bring forth various economic and social advantages for those that can take necessary steps in an appropriate and timely manner. In this regard, the main aim of Turkish ICT policy should be "utilizing ICT as an effective tool to foster economic and social development".

To be able to reach this target, one of the priorities of ICT policy should be dealing with the ICT demand side. Turkey should not content itself with advancements in absolute terms regarding ICT diffusion. Instead, believing the growth friendly results of ICT usage, it should make some steps to improve its comparative position against other countries. In other words, following the general trends may not be enough to break through in economic progress, but proactive actions regarding ICT area may be more helpful to make a difference. On the other hand, just making more and more ICT investment and, thus, increasing ICT diffusion to whole economy and society cannot be the ultimate goal. Surely, qualitative improvements in ICT usage should accompany those developments. ICT spending should be directed to more productive aims; ICT investments should serve for increasing the efficiency, effectiveness and value added capacity of the economic activities. In addition to these, necessary precautions should be taken to channel individual users to benefit from ICT for more meaningful purposes.

In order to enhance ICT diffusion throughout the economy and society, various financial instruments in the hands of the government can be mobilized. In the simplest term, taxes on ICT should be decreased by stretching the budgetary constraints. This reduction should be put into practice fractionally. Taxes on certain ICT products and services, which are determined as the most rewarding ones in terms of economic and social outcomes, should be cut more compared to others or even remove completely. Thus, both quantitative and qualitative improvements regarding ICT diffusion could be attained. Moreover, people that belong to disadvantageous segments of the society in terms of income, education, age, geographical location and physical or mental disabilities should be encouraged to own and effectively use ICT by the relevant tools. Tax reductions could be advanced specifically for these groups of people and also direct financial support for their ICT purchases can be provided. In addition to these, powerful precautions should be taken regarding the computer literacy and competencies of both citizens and businesses. Undergoing efforts to provide computer skills to students should continue increasingly. These efforts should also involve other civilians, especially employees. In this sense, firms may be encouraged financially to gain required computer competencies to their personnel. Further to that, economic and social opportunities and advantages that are brought by ICT, especially Internet, should be put across to relevant bodies effectively.

We strongly think that ICT revolution is not just an intensive usage of ICT in various segments of economic and social lives; it has also a supply side. Thanks to continuous and growing demand to its mostly value-added products, ICT sector matter a lot for modern economies. Therefore, Turkey should urge upon ICT production without loss of time. Thus, she can succeed more sustainable economic growth and proceed in solving the unemployment problem.

In accordance with this purpose, certain sub-fields in ICT area should be determined and all kinds of meaningful efforts in those fields should be encouraged and supported by the government by all available means. Designating the ICT as strategic sector as a whole is not sufficient and efficient enough. Instead, Turkey should focus on particular ICT products with the aim of constituting a worldwide perception as "that product can be produced best in Turkey". For this assertive target, government should mobilize all financial, technical, legislative, administrative and regulatory possibilities. Although private sector mostly follows the new technological trends in the world better than the public sector, firms may suffer from lack of enough courage and scale. Government should bring together and lead forth actors from private sector and academia to develop new business in promising ICT fields. As the most extreme possibility, government may become a partner of such enterprises. What is more, with its gradually increasing ICT spending budget, government is an important customer of ICT sector. This fact should be used to strengthen domestic ICT firms as far as they satisfy the quality requirements. Besides opting for the existing products and services of domestic ICT firms, government can make them to produce new ICT products and services that fulfill its necessities by giving guarantee of purchase.

As ICT diffuses and influence deeply to other sectors, ICT policy should also be highly integrated with policies in other topics like education, industry, foreign trade, labor, energy, transportation, environment, etc. As it is mentioned before, gaining sufficient computer skills to citizens and training qualified ICT professionals should be among priorities of education policy. Curriculums on computer related subjects in both vocational and higher education systems should be developed and transformed in line with technological trends and requirements of the real sector. Furthermore, while designing and implementing industry and foreign trade policies, high-value added ICT products should certainly be given primacy.

Moreover, opportunities and risks of ICT revolution should be kept in mind for labor policies. People, who do not have necessary skills required by the ICT revolution, face with threat of losing their jobs or retrogression in terms of income statue. Labor policy should ensure either updating competencies of this kind of people in order to help them to retain their current employment or retraining them to find new jobs in different areas. Besides, working forms like teleworking may be used as a tool for actualizing flexible employment policies. Labor policy instruments can be developed to make it possible for people, who cannot find an ordinary full time job, to earn money by accomplishing certain tasks via internet.

Eco-friendly or green ICT products and services offer tremendous opportunities for cutting energy costs and decreasing carbondioxide emissions by enabling energy efficiency improvements especially in manufacturing, buildings, transport systems and electric grids. Policies regarding energy, transportation, environment, construction and manufacturing sectors should pay attention to those innovative ICT solutions. Firms that operate in these sectors should be encouraged to adapt energy efficient ICT applications to their business and, thus, gain competitive advantage by cutting their costs.

Lastly, Turkey should strengthen its physical and social infrastructures in order to reap the benefits of ICT revolution fully. ICT makes factors of production more productive, but this positive impact is highly dependent on both quantity and quality of those factors. As well, because ICT diffuse in all aspects of economic and social lives, its effects occur in mutual interaction with economic and social conditions. Actually, measures to improve physical and social infrastructures comprise a very wide range of practices and this issue is a much more top level one compared to ICT policy. Generally speaking, Turkey should allocate proportionately more funds to long-termed physical and social infrastructure investments to benefit from ICT revolution properly as well as increasing living standards of its citizens.

5.3. Concluding Remarks

In this thesis, we investigated the positive impacts of ICT revolution on economic growth. Our empirical findings that rely on experience of 30 OECD member countries during 1999-2008 period support the optimistic results of our theoretical discussions regarding the positive linkage between ICT revolution and economic progress. Thus, we recommend Turkey to continue paying attention to ICT but by taking distinguishing steps and by not ignoring the supply side.

Naturally, our empirical analyses have some limitations. If the number of observations can be increased by working with data sets that cover more countries and longer time periods, strength of empirical analyses will also rise significantly. In addition, utilizing more accurate ICT proxies, especially for the ICT production variable, will undoubtedly lead more reliable conclusions. Further research should also focus on sectoral impacts of ICT revolution by employing micro data. By this way, eventual results of ICT revolution in different fields and on different aspects can be evaluated precisely.

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APPENDIX A

AUTOCORRELATION TESTS FOR TURKISH CASE

In order to detect autocorrelation in second order differenced data sets that belong to Turkey, we performed Breusch-Godfrey Serial Correlation LM Test in eViews. "Obs*R-squared" is the test statistics for the null hypothesis of this test which is that there is no autocorrelation up to a predetermined lag order, 6 in our case. Initial results of autocorrelation for all 16 model alternatives are represented in Table A.1. As the low probability values indicate, there were autocorrelation problem for all models except 11,12,15,16 numbered ones.

Table A.1 Initial results of autocorrelation test for Turkish case

Model	Obs*R-squared	Probability
1	11.686	0.069
2	11.670	0.070
3	12.627	0.049
4	12.547	0.051
5	11.806	0.066
6	11.793	0.067
7	11.005	0.088
8	10.913	0.091
9	18.898	0.004
10	18.887	0.004
11	6.529	0.367
12	6.499	0.370
13	18.803	0.005
14	18.785	0.005
15	6.260	0.395
16	6.224	0.399

To be able to overcome autocorrelation problem, we included various combinations of autoregressive terms with different orders to the problematic models. At the end, we succeed to solve autocorrelation problem by adding AR(4) term to the models 1,2,5,6 and AR(1) term to the models 3,4,7,8. However, we could not get rid of the autocorrelation in models 9,10,13,14. Table A.2 displays the final results of Breusch-Godfrey Serial Correlation LM Test.

Table A.2 Final results of autocorrelation test for Turkish case

Model	Obs*R-squared	Probability
1	7.691	0.262
2	7.744	0.257
3	10.210	0.116
4	10.204	0.116
5	8.335	0.215
6	8.366	0.212
7	8.874	0.181
8	8.839	0.183
9	18.898	0.004
10	18.887	0.004
11	6.529	0.367
12	6.499	0.370
13	18.803	0.005
14	18.785	0.005
15	6.260	0.395
16	6.224	0.399

APPENDIX B

COUNTRIES THAT ARE INVOLVED TO EMPIRICAL ANALYSES FOR THE OECD CASE

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Japan
Korea
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

APPENDIX C

UNIT ROOT TESTS

In order to check if there exist unit root problem in data set, we carried out Breitung unit root test in eViews for logarithmic data sets. Table C.1 summarizes the results of initial unit root tests for logarithmic data sets whilst Table C.2 represents the results of unit root tests after first order differencing operation for data sets that belong to the OECD case. Null hypothesis of the unit root test is that there is unit root in the data set.

Table C.1 Results of unit root test for logarithmic data sets of the OECD case

	Statistic	**Probability**
loggdp1	6.828	1.000
loggdp2	6.235	1.000
logcapital	3.163	0.999
loglabor1	0.354	0.639
loglabor2	3.248	0.999
logict1	0.500	0.692
logict2	0.552	0.709
logict3	1.128	0.870
logict4	0.433	0.668

Table C.2 Results of unit root test for first order differenced logarithmic data sets of the OECD case

	Statistic	**Probability**
dloggdp1	-1.816	0.035
dloggdp2	-2.277	0.011
dlogcapital	-2.456	0.007
dloglabor1	-1.879	0.030
dloglabor2	-7.562	0.000
dlogict1	-3.710	0.000

	Statistic	Probability
dlogict2	-3.646	0.000
dlogict3	-3.996	0.000
dlogict4	-4.662	0.000

For the Turkey case, Table C.3 displays the results of initial unit root tests for logarithmic data sets; Table C.4 shows the results of unit root tests after first order differencing operation and Table C.5 represents the results of unit root tests after second order differencing operation.

Table C.3 Results of unit root test for logarithmic data sets of Turkish case

	Statistic	Probability
loggdp1	-1.221	0.652
loggdp2	-0.913	0.769
logcapital	-1.807	0.370
loglabor1	-1.068	0.715
loglabor2	-0.985	0.745
logict1	-1.892	0.331
logict2	-1.603	0.469

Table C.4 Results of unit root test for first order differenced logarithmic data sets of Turkish case

	Statistic	Probability
dloggdp1	-5.311	0.000
dloggdp2	-5.467	0.000
dlogcapital	-7.089	0.000
dloglabor1	-5.591	0.000
dloglabor2	-5.515	0.000
dlogict1	-2.562	0.113
dlogict2	-2.660	0.094

Table C.5 Results of unit root test for second order differenced logarithmic data sets of Turkish case

	Statistic	Probability
ddloggdp1	-9.393	0.000
ddloggdp2	-9.394	0.000

	Statistic	**Probability**
ddlogcapital	-6.975	0.000
ddloglabor1	-5.716	0.000
ddloglabor2	-9.479	0.000
ddlogict1	-5.941	0.000
ddlogict2	-5.936	0.000

APPENDIX D

GRANGER CAUSALITY TESTS

Akaike information criterion (AIC) is used to determine lag length to include Granger Causality Test. Lag length corresponding to the minimum AIC value is preferred. Table D.1 and Table D.2 show minimum AIC values, selected lag lengths, F-Statistic and Probability values for all dependent and independent variable pairs that belong to the OECD and Turkey cases respectively. Null hypothesis of the Granger Causality Test is that there is no reverse causality between in question dependent and independent variables pair.

Table D.1 Results of Granger causality test for the OECD case

Dependent Variable	Independent Variable	Min. AIC	Selected Lag	Statistic	Probability
dloggdp1	dlogcapital	-10.052*	2	1.744	0.177
dloggdp1	dloglabor1	-12.393*	6	1.284	0.275
dloggdp1	dloglabor2	-11.585*	1	1.646	0.201
dloggdp1	dlogict1	-9.801*	8	1.876	0.151
dloggdp1	dlogict2	-9.845*	7	1.182	0.332
dloggdp1	dlogict3	-7.367*	3	1.476	0.223
dloggdp1	dlogict4	-6.289*	8	1.532	0.237
dloggdp2	dlogcapital	-10.227*	2	1.683	0.188
dloggdp2	dloglabor1	-12.423*	1	1.386	0.240
dloggdp2	dloglabor2	-11.550*	1	0.435	0.510
dloggdp2	dlogict1	-9.971*	8	1.977	0.132
dloggdp2	dlogict2	-10.020*	7	0.908	0.509
dloggdp2	dlogict3	-7.296*	3	1.432	0.235
dloggdp2	dlogict4	-6.400*	8	1.374	0.293

Table D.2 Results of Granger causality test for Turkish case

Dependent Variable	Independent Variable	Min. AIC	Selected Lag	Statistic	Probability
dloggdp1	dlogcapital	-6.530*	8	0.365	0.887
dloggdp1	dloglabor1	-7.974*	8	2.333	0.262
dloggdp1	dloglabor2	-8.751*	8	1.786	0.344
dloggdp1	dlogict1	-6.626*	8	0.599	0.750
dloggdp1	dlogict2	-6.633*	8	0.632	0.732
dloggdp2	dlogcapital	-6.865*	8	0.384	0.876
dloggdp2	dloglabor1	-8.127*	8	2.582	0.235
dloggdp2	dloglabor2	-8.476*	8	1.296	0.458
dloggdp2	dlogict1	-6.686*	8	0.588	0.756
dloggdp2	dlogict2	-6.688*	8	0.619	0.739

APPENDIX E

ESTIMATION RESULTS FOR THE OECD CASE

Table E.1 represents the details of outputs that belong to 64 estimation combinations for the OECD case. Table E.2 displays which variables and methods are used in each estimation while Table E.3 explains the proxies that correspond to variables in Table E.2. Also, S/D choice in Table E.2 indicates that a lagged value of dependent variable is added to right hand side of the equation for models that are assigned a "D", meaning dynamic and others a "S", meaning static. Those models that were mentioned in Chapter 4 as the four best efficient estimations in terms of significance of variables for the OECD case in models numbered 37, 45, 53 and 61, respectively.

Table E.1 Outputs of estimations that belong to the OECD case

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG	ICTPRD
1	Coefficient	0.019	0.183		0.117	0.030	0.003
	t-value	8.518	13.258		1.302	1.446	0.844
	p-value	0.000	0.000		0.194	0.149	0.400
2	Coefficient	0.017	0.120	0.179	0.016	0.013	0.002
	t-value	10.594	3.551	13.922	0.257	1.043	0.700
	p-value	0.000	0.001	0.000	0.798	0.298	0.485
3	Coefficient	1.200	-0.634		-17.847	-9.988	-1.592
	t-value	0.042	-0.028		-0.039	-0.041	-0.045
	p-value	0.967	0.978		0.969	0.968	0.964
4	Coefficient	-0.095	-0.376	0.179	4.535	0.593	0.346
	t-value	-0.389	-0.177	0.354	0.625	0.445	0.319
	p-value	0.697	0.860	0.724	0.533	0.657	0.750
5	Coefficient	0.018	0.176		0.114	0.029	0.013
	t-value	10.493	14.620		1.399	1.771	2.661
	p-value	0.000	0.000		0.163	0.078	0.008
6	Coefficient	0.017	0.108	0.179	0.025	0.016	0.005
	t-value	10.685	3.152	16.832	0.420	1.311	1.630
	p-value	0.000	0.002	0.000	0.675	0.191	0.105

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG	ICTPRD
7	Coefficient	-0.001	0.181		0.929	0.138	0.015
	t-value	-0.024	0.718		1.205	0.319	0.448
	p-value	0.981	0.474		0.230	0.750	0.654
8	Coefficient	0.013	0.090	0.149	0.416	0.021	0.009
	t-value	0.468	0.221	0.988	0.236	0.112	0.832
	p-value	0.640	0.826	0.325	0.814	0.911	0.406
9	Coefficient	0.019	0.183		0.119	0.030	0.003
	t-value	9.067	13.257		1.325	1.452	0.851
	p-value	0.000	0.000		0.186	0.148	0.396
10	Coefficient	0.017	0.120	0.178	0.018	0.013	0.002
	t-value	11.116	3.567	13.931	0.275	1.043	0.710
	p-value	0.000	0.001	0.000	0.784	0.298	0.479
11	Coefficient	0.443	0.060		-7.631	-3.727	-0.603
	t-value	0.125	0.030		-0.110	-0.118	-0.157
	p-value	0.901	0.976		0.912	0.907	0.875
12	Coefficient	-0.129	-0.397	0.128	5.771	0.796	0.478
	t-value	-0.294	-0.148	0.163	0.449	0.319	0.265
	p-value	0.769	0.883	0.871	0.654	0.750	0.792
13	Coefficient	0.019	0.176		0.117	0.029	0.013
	t-value	11.136	14.624		1.427	1.780	2.668
	p-value	0.000	0.000		0.155	0.076	0.008
14	Coefficient	0.017	0.108	0.179	0.027	0.016	0.005
	t-value	11.209	3.161	16.917	0.447	1.313	1.629
	p-value	0.000	0.002	0.000	0.656	0.191	0.105
15	Coefficient	-0.001	0.174		0.985	0.141	0.015
	t-value	-0.020	0.710		1.163	0.315	0.429
	p-value	0.984	0.478		0.246	0.753	0.668
16	Coefficient	0.014	0.093	0.148	0.403	0.017	0.009
	t-value	0.524	0.241	1.034	0.235	0.093	0.825
	p-value	0.601	0.810	0.303	0.814	0.926	0.411
17	Coefficient	0.012	0.189		0.056	0.036	0.002
	t-value	5.146	14.863		0.618	1.568	0.457
	p-value	0.000	0.000		0.537	0.118	0.648
18	Coefficient	0.010	0.139	0.188	-0.071	0.022	0.001
	t-value	6.343	3.987	14.920	-1.129	1.549	0.373
	p-value	0.000	0.000	0.000	0.260	0.123	0.710
19	Coefficient	1.051	-0.485		-15.937	-8.769	-1.398
	t-value	0.042	-0.025		-0.040	-0.041	-0.045
	p-value	0.967	0.980		0.968	0.967	0.964
20	Coefficient	-0.079	-0.418	0.253	3.682	0.500	0.220

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG	ICTPRD
	t-value	-0.407	-0.247	0.595	0.664	0.489	0.256
	p-value	0.684	0.806	0.553	0.508	0.626	0.798
21	Coefficient	0.012	0.181		0.053	0.033	0.012
	t-value	6.176	15.558		0.623	1.780	2.493
	p-value	0.000	0.000		0.534	0.076	0.013
22	Coefficient	0.010	0.128	0.187	-0.063	0.025	0.005
	t-value	6.297	3.756	17.212	-1.064	1.768	1.504
	p-value	0.000	0.000	0.000	0.289	0.079	0.134
23	Coefficient	-0.004	0.233		0.559	0.124	0.012
	t-value	-0.093	0.772		0.645	0.379	0.489
	p-value	0.926	0.441		0.520	0.705	0.625
24	Coefficient	-0.002	-0.092	0.211	0.872	0.090	0.012
	t-value	-0.045	-0.190	1.222	0.396	0.335	1.177
	p-value	0.964	0.850	0.223	0.693	0.738	0.241
25	Coefficient	0.012	0.189		0.059	0.037	0.002
	t-value	5.391	14.808		0.658	1.613	0.428
	p-value	0.000	0.000		0.511	0.108	0.669
26	Coefficient	0.010	0.138	0.188	-0.068	0.023	0.001
	t-value	6.556	3.929	15.359	-1.092	1.597	0.358
	p-value	0.000	0.000	0.000	0.276	0.112	0.721
27	Coefficient	0.387	0.124		-6.982	-3.280	-0.530
	t-value	0.126	0.072		-0.117	-0.119	-0.161
	p-value	0.900	0.943		0.907	0.905	0.872
28	Coefficient	-0.106	-0.424	0.209	4.651	0.663	0.330
	t-value	-0.312	-0.200	0.318	0.481	0.348	0.233
	p-value	0.756	0.842	0.751	0.631	0.728	0.816
29	Coefficient	0.012	0.180		0.056	0.035	0.012
	t-value	6.439	15.504		0.662	1.813	2.477
	p-value	0.000	0.000		0.509	0.071	0.014
30	Coefficient	0.010	0.127	0.187	-0.061	0.027	0.005
	t-value	6.540	3.703	17.530	-1.022	1.810	1.510
	p-value	0.000	0.000	0.000	0.308	0.072	0.133
31	Coefficient	-0.004	0.227		0.607	0.125	0.012
	t-value	-0.090	0.782		0.654	0.393	0.483
	p-value	0.928	0.435		0.514	0.695	0.630
32	Coefficient	-0.001	-0.076	0.206	0.832	0.083	0.012
	t-value	-0.013	-0.175	1.321	0.401	0.325	1.156
	p-value	0.990	0.861	0.188	0.689	0.746	0.249
33	Coefficient	0.009	0.141		0.402	0.029	0.002
	t-value	6.356	10.869		10.064	2.419	0.636

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG	ICTPRD
	p-value	0.000	0.000		0.000	0.016	0.525
34	Coefficient	0.005	0.192	0.147	0.385	0.005	0.003
	t-value	2.048	4.751	14.441	9.042	0.356	0.916
	p-value	0.042	0.000	0.000	0.000	0.722	0.361
35	Coefficient	0.108	-0.640		1.332	-0.882	-0.429
	t-value	0.064	-0.047		0.207	-0.074	-0.130
	p-value	0.949	0.962		0.836	0.941	0.897
36	Coefficient	0.366	-3.383	2.427	-3.470	-0.855	-1.790
	t-value	0.095	-0.094	0.100	-0.056	-0.142	-0.106
	p-value	0.925	0.925	0.920	0.955	0.887	0.916
37	Coefficient	0.009	0.137		0.397	0.028	0.008
	t-value	6.844	12.013		10.037	2.776	1.997
	p-value	0.000	0.000		0.000	0.006	0.047
38	Coefficient	0.005	0.179	0.145	0.382	0.005	0.006
	t-value	2.396	4.745	13.535	9.201	0.399	1.646
	p-value	0.018	0.000	0.000	0.000	0.690	0.101
39	Coefficient	-0.523	3.913		6.391	2.839	0.049
	t-value	-0.045	0.048		0.048	0.046	0.048
	p-value	0.964	0.962		0.962	0.963	0.962
40	Coefficient	-0.004	0.283	0.003	1.103	-0.150	0.011
	t-value	-0.110	1.190	0.015	0.891	-1.279	0.596
	p-value	0.913	0.236	0.988	0.374	0.203	0.552
41	Coefficient	0.009	0.140		0.401	0.029	0.002
	t-value	6.742	10.868		10.077	2.428	0.655
	p-value	0.000	0.000		0.000	0.016	0.513
42	Coefficient	0.005	0.192	0.147	0.385	0.005	0.003
	t-value	2.115	4.742	14.423	9.039	0.359	0.914
	p-value	0.036	0.000	0.000	0.000	0.720	0.362
43	Coefficient	0.055	-0.178		1.094	-0.471	-0.293
	t-value	0.130	-0.059		0.241	-0.179	-0.469
	p-value	0.897	0.953		0.810	0.858	0.640
44	Coefficient	0.272	-2.346	1.772	-3.181	-0.598	-1.149
	t-value	0.136	-0.135	0.147	-0.081	-0.223	-0.158
	p-value	0.892	0.893	0.883	0.935	0.824	0.874
45	Coefficient	0.009	0.137		0.397	0.028	0.008
	t-value	7.209	12.028		10.035	2.782	1.996
	p-value	0.000	0.000		0.000	0.006	0.047
46	Coefficient	0.005	0.179	0.145	0.382	0.005	0.006
	t-value	2.488	4.735	13.515	9.200	0.401	1.648
	p-value	0.014	0.000	0.000	0.000	0.689	0.101

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG	ICTPRD
47	Coefficient	0.347	-1.781		-4.538	-1.646	-0.030
	t-value	0.095	-0.085		-0.084	-0.091	-0.060
	p-value	0.925	0.932		0.933	0.927	0.952
48	Coefficient	-0.005	0.276	0.006	1.084	-0.140	0.011
	t-value	-0.137	1.167	0.033	0.882	-1.351	0.610
	p-value	0.891	0.245	0.974	0.379	0.178	0.543
49	Coefficient	0.001	0.143		0.414	0.032	0.000
	t-value	0.912	10.828		9.209	2.402	-0.137
	p-value	0.363	0.000		0.000	0.017	0.891
50	Coefficient	-0.002	0.195	0.149	0.397	0.013	0.001
	t-value	-1.083	4.685	14.281	9.165	0.824	0.331
	p-value	0.280	0.000	0.000	0.000	0.411	0.741
51	Coefficient	0.027	0.018		1.049	-0.284	-0.231
	t-value	0.053	0.004		0.427	-0.077	-0.220
	p-value	0.958	0.997		0.670	0.939	0.826
52	Coefficient	0.143	-1.547	1.263	-1.100	-0.329	-0.864
	t-value	0.148	-0.160	0.185	-0.055	-0.254	-0.197
	p-value	0.883	0.873	0.854	0.956	0.800	0.844
53	Coefficient	0.001	0.135		0.411	0.030	0.008
	t-value	0.885	11.194		9.508	2.733	2.165
	p-value	0.377	0.000		0.000	0.007	0.031
54	Coefficient	-0.002	0.187	0.145	0.397	0.014	0.006
	t-value	-1.112	5.060	12.715	9.392	0.890	1.674
	p-value	0.267	0.000	0.000	0.000	0.374	0.096
55	Coefficient	-0.303	2.386		3.660	1.665	0.030
	t-value	-0.043	0.048		0.046	0.045	0.050
	p-value	0.966	0.962		0.964	0.964	0.960
56	Coefficient	-0.005	0.214	0.040	0.850	-0.093	0.012
	t-value	-0.235	1.387	0.373	1.146	-1.362	0.778
	p-value	0.815	0.167	0.710	0.253	0.175	0.438
57	Coefficient	0.002	0.143		0.413	0.033	0.000
	t-value	1.052	10.849		9.221	2.419	-0.142
	p-value	0.294	0.000		0.000	0.016	0.887
58	Coefficient	-0.002	0.195	0.149	0.396	0.015	0.001
	t-value	-1.138	4.678	14.283	9.147	0.931	0.332
	p-value	0.257	0.000	0.000	0.000	0.353	0.741
59	Coefficient	0.013	0.125		0.996	-0.184	-0.197
	t-value	0.086	0.088		0.533	-0.166	-0.610
	p-value	0.932	0.930		0.595	0.869	0.543
60	Coefficient	0.134	-1.346	1.130	-1.389	-0.292	-0.700

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG	ICTPRD
	t-value	0.176	-0.192	0.224	-0.080	-0.308	-0.243
	p-value	0.860	0.848	0.823	0.936	0.759	0.809
61	Coefficient	0.001	0.135		0.410	0.031	0.008
	t-value	1.019	11.252		9.526	2.745	2.159
	p-value	0.309	0.000		0.000	0.007	0.032
62	Coefficient	-0.002	0.186	0.145	0.396	0.016	0.006
	t-value	-1.172	5.050	12.722	9.379	1.005	1.677
	p-value	0.243	0.000	0.000	0.000	0.316	0.095
63	Coefficient	0.204	-0.927		-2.703	-0.946	-0.016
	t-value	0.100	-0.079		-0.090	-0.094	-0.058
	p-value	0.920	0.937		0.928	0.925	0.954
64	Coefficient	-0.006	0.214	0.038	0.857	-0.087	0.012
	t-value	-0.285	1.342	0.343	1.144	-1.374	0.778
	p-value	0.776	0.181	0.732	0.254	0.171	0.438

Table E.2 Details of estimation combinations for the OECD case

NO	GDP	LABOR	ICTUSAGE	ICTPROD	METHOD	S/D
1	GDP1	LABOR	ICT1	ICT3	GLS	S
2	GDP1	LABOR	ICT1	ICT3	GLS	D
3	GDP1	LABOR	ICT1	ICT3	GMM	S
4	GDP1	LABOR	ICT1	ICT3	GMM	D
5	GDP1	LABOR	ICT1	ICT4	GLS	S
6	GDP1	LABOR	ICT1	ICT4	GLS	D
7	GDP1	LABOR	ICT1	ICT4	GMM	S
8	GDP1	LABOR	ICT1	ICT4	GMM	D
9	GDP1	LABOR	ICT2	ICT3	GLS	S
10	GDP1	LABOR	ICT2	ICT3	GLS	D
11	GDP1	LABOR	ICT2	ICT3	GMM	S
12	GDP1	LABOR	ICT2	ICT3	GMM	D
13	GDP1	LABOR	ICT2	ICT4	GLS	S
14	GDP1	LABOR	ICT2	ICT4	GLS	D
15	GDP1	LABOR	ICT2	ICT4	GMM	S
16	GDP1	LABOR	ICT2	ICT4	GMM	D
17	GDP2	LABOR	ICT1	ICT3	GLS	S
18	GDP2	LABOR	ICT1	ICT3	GLS	D
19	GDP2	LABOR	ICT1	ICT3	GMM	S

NO	GDP	LABOR	ICTUSAGE	ICTPROD	METHOD	S/D
20	GDP2	LABOR	ICT1	ICT3	GMM	D
21	GDP2	LABOR	ICT1	ICT4	GLS	S
22	GDP2	LABOR	ICT1	ICT4	GLS	D
23	GDP2	LABOR	ICT1	ICT4	GMM	S
24	GDP2	LABOR	ICT1	ICT4	GMM	D
25	GDP2	LABOR	ICT2	ICT3	GLS	S
26	GDP2	LABOR	ICT2	ICT3	GLS	D
27	GDP2	LABOR	ICT2	ICT3	GMM	S
28	GDP2	LABOR	ICT2	ICT3	GMM	D
29	GDP2	LABOR	ICT2	ICT4	GLS	S
30	GDP2	LABOR	ICT2	ICT4	GLS	D
31	GDP2	LABOR	ICT2	ICT4	GMM	S
32	GDP2	LABOR	ICT2	ICT4	GMM	D
33	GDP1	ELABOR	ICT1	ICT3	GLS	S
34	GDP1	ELABOR	ICT1	ICT3	GLS	D
35	GDP1	ELABOR	ICT1	ICT3	GMM	S
36	GDP1	ELABOR	ICT1	ICT3	GMM	D
37	GDP1	ELABOR	ICT1	ICT4	GLS	S
38	GDP1	ELABOR	ICT1	ICT4	GLS	D
39	GDP1	ELABOR	ICT1	ICT4	GMM	S
40	GDP1	ELABOR	ICT1	ICT4	GMM	D
41	GDP1	ELABOR	ICT2	ICT3	GLS	S
42	GDP1	ELABOR	ICT2	ICT3	GLS	D
43	GDP1	ELABOR	ICT2	ICT3	GMM	S
44	GDP1	ELABOR	ICT2	ICT3	GMM	D
45	GDP1	ELABOR	ICT2	ICT4	GLS	S
46	GDP1	ELABOR	ICT2	ICT4	GLS	D
47	GDP1	ELABOR	ICT2	ICT4	GMM	S
48	GDP1	ELABOR	ICT2	ICT4	GMM	D
49	GDP2	ELABOR	ICT1	ICT3	GLS	S
50	GDP2	ELABOR	ICT1	ICT3	GLS	D
51	GDP2	ELABOR	ICT1	ICT3	GMM	S
52	GDP2	ELABOR	ICT1	ICT3	GMM	D
53	GDP2	ELABOR	ICT1	ICT4	GLS	S
54	GDP2	ELABOR	ICT1	ICT4	GLS	D
55	GDP2	ELABOR	ICT1	ICT4	GMM	S

NO	GDP	LABOR	ICTUSAGE	ICTPROD	METHOD	S/D
56	GDP2	ELABOR	ICT1	ICT4	GMM	D
57	GDP2	ELABOR	ICT2	ICT3	GLS	S
58	GDP2	ELABOR	ICT2	ICT3	GLS	D
59	GDP2	ELABOR	ICT2	ICT3	GMM	S
60	GDP2	ELABOR	ICT2	ICT3	GMM	D
61	GDP2	ELABOR	ICT2	ICT4	GLS	S
62	GDP2	ELABOR	ICT2	ICT4	GLS	D
63	GDP2	ELABOR	ICT2	ICT4	GMM	S
64	GDP2	ELABOR	ICT2	ICT4	GMM	D

Table E.3 Legend of proxies for the OECD case

Variable	Proxy
GDP1	Total GDP
GDP2	GDP per capita
CAPITAL	Gross Capital Formation
LABOR	Civilian Labor Force
ELABOR	Civilian Labor Force * Labor Productivity Index
ICT1	Access Channels
ICT2	Access Channels per 100 Inhabitants
ICT3	Total ICT Exports
ICT4	Number of ICT Patents

APPENDIX F

ESTIMATION RESULTS FOR TURKISH CASE

Table F.1 represents the details of outputs that belong to 16 estimation combinations for Turkish case. Table F.2 displays which variables and methods are used in each estimation while Table F.3 explains the proxies that correspond to variables in Table F.2. Also, S/D choice in Table F.2 indicates that a lagged value of dependent variable is added to right hand side of the equation for models that are assigned a "D", meaning dynamic and others a "S", meaning static. Those models that were mentioned in Chapter 4 as the four best efficient estimations in terms of significance of variables for Turkish case in models numbered 3, 4, 7 and 8, respectively.

Table F.1 Outputs of estimations that belong to Turkish case

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG
1	Coefficient	-0.003	0.196		-0.372	-0.075
	t-value	-0.337	13.226		-3.286	-1.634
	p-value	0.740	0.000		0.004	0.119
2	Coefficient	-0.003	0.196		-0.372	-0.075
	t-value	-0.333	13.232		-3.291	-1.652
	p-value	0.743	0.000		0.004	0.115
3	Coefficient	-0.001	0.101		0.602	-0.038
	t-value	-0.552	6.288		10.334	-0.960
	p-value	0.586	0.000		0.000	0.348
4	Coefficient	-0.001	0.101		0.602	-0.038
	t-value	-0.543	6.282		10.338	-0.973
	p-value	0.592	0.000		0.000	0.341
5	Coefficient	-0.003	0.196		-0.372	-0.069
	t-value	-0.268	13.272		-3.383	-1.501
	p-value	0.792	0.000		0.003	0.150
6	Coefficient	-0.003	0.196		-0.372	-0.068
	t-value	-0.263	13.280		-3.389	-1.513
	p-value	0.795	0.000		0.003	0.147

Model		CONSTANT	CAPITAL	CAPITAL(-1)	LABOR	ICTUSG
7	Coefficient	-0.001	0.101		0.604	-0.030
	t-value	-0.305	6.391		10.612	-0.816
	p-value	0.763	0.000		0.000	0.423
8	Coefficient	-0.001	0.100		0.604	-0.030
	t-value	-0.297	6.389		10.611	-0.826
	p-value	0.769	0.000		0.000	0.418
9	Coefficient	-0.002	0.089	0.193	-0.348	-0.090
	t-value	-0.323	0.641	5.432	-2.750	-0.992
	p-value	0.750	0.528	0.000	0.012	0.332
10	Coefficient	-0.002	0.089	0.193	-0.348	-0.089
	t-value	-0.315	0.638	5.413	-2.748	-0.984
	p-value	0.756	0.530	0.000	0.012	0.336
11	Coefficient	-0.002	0.149	0.120	0.641	-0.115
	t-value	-0.668	2.366	8.422	10.661	-2.306
	p-value	0.511	0.027	0.000	0.000	0.031
12	Coefficient	-0.002	0.150	0.120	0.641	-0.114
	t-value	-0.644	2.385	8.442	10.686	-2.331
	p-value	0.526	0.026	0.000	0.000	0.029
13	Coefficient	-0.001	0.090	0.193	-0.343	-0.082
	t-value	-0.230	0.646	5.372	-2.749	-0.906
	p-value	0.820	0.525	0.000	0.012	0.375
14	Coefficient	-0.001	0.090	0.193	-0.342	-0.081
	t-value	-0.222	0.642	5.349	-2.747	-0.895
	p-value	0.826	0.528	0.000	0.012	0.380
15	Coefficient	-0.001	0.153	0.120	0.643	-0.108
	t-value	-0.494	2.534	8.506	10.932	-2.231
	p-value	0.626	0.019	0.000	0.000	0.036
16	Coefficient	-0.001	0.154	0.120	0.643	-0.107
	t-value	-0.470	2.550	8.518	10.954	-2.253
	p-value	0.643	0.018	0.000	0.000	0.035

Table F.2 Details of estimation combinations for Turkish case

NO	GDP	LABOR	ICTUSAGE	S/D
1	GDP1	LABOR	ICT1	S
2	GDP1	LABOR	ICT2	S
3	GDP1	ELABOR	ICT1	S
4	GDP1	ELABOR	ICT2	S

NO	GDP	LABOR	ICTUSAGE	S/D
5	GDP2	LABOR	ICT1	S
6	GDP2	LABOR	ICT2	S
7	GDP2	ELABOR	ICT1	S
8	GDP2	ELABOR	ICT2	S
9	GDP1	LABOR	ICT1	D
10	GDP1	LABOR	ICT2	D
11	GDP1	ELABOR	ICT1	D
12	GDP1	ELABOR	ICT2	D
13	GDP2	LABOR	ICT1	D
14	GDP2	LABOR	ICT2	D
15	GDP2	ELABOR	ICT1	D
16	GDP2	ELABOR	ICT2	D

Table F.3 Legend of proxies for Turkish case

Variable	Proxy
GDP1	Total GDP
GDP2	GDP per capita
CAPITAL	Gross Capital Formation
LABOR	Civilian Labor Force
ELABOR	Civilian Labor Force * Labor Productivity Index
ICT1	Access Channels
ICT2	Access Channels per 100 Inhabitants

APPENDIX G

TEZ FOTOKOPİSİ İZİN FORMU

METU
LIBRARY

TEZ FOTOKOPİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ■

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : KARAGÖL
Adı : BURAK
Bölümü : İKTİSAT

TEZİN ADI (İngilizce) : MACROECONOMIC EFFECTS OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN TURKEY AND OTHER OECD MEMBER COUNTRIES

TEZİN TÜRÜ : Yüksek Lisans ■ Doktora ☐

1. Tezimin tamamı dünya çapında erişime açılsın ve kaynak gösterilmek şartıyla tezimin bir kısmı veya tamamının fotokopisi alınsın. ☐
2. Tezimin tamamı yalnızca Orta Doğu Teknik Üniversitesi kullanıcılarının erişimine açılsın. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ☐
3. Tezim bir (1) yıl süreyle erişime kapalı olsun. (Bu seçenekle tezinizin fotokopisi ya da elektronik kopyası Kütüphane aracılığı ile ODTÜ dışına dağıtılmayacaktır.) ■

Yazarın imzası .... Tarih ....