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**ICT (INFORMATION AND COMMUNICATION
TECHNOLOGIES) AND ECONOMIC GROWTH**

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“BİT (BİLİŞİM VE İLETİŞİM TEKNOLOJİLERİ) VE EKONOMİK BÜYÜME”

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ÖZ

Bilişim ve İletişim Teknolojileri (BİT) günümüzde hayatımızın en önemli parçalarından olmuştur. Bu yüzden ekonomik açıdan da değerlendirilmektedir. Birçok işletme bu yönde yatırımlar yapmaktadır. Kimi işletmeler bu teknolojileri üretmekte, kimi işletmeler de kullanmaktadır. Bu yüzden mikroekonomi içerisinde giderek daha ağırlık kazanmaktadır. Bu sektörün makroekonomik açıdan ilk ele alınması ve uzun dönemde büyümeye nasıl bir etkisi olacağını tespit edilmelidir. Bu çalışma Romer yaklaşımındaki fikir üretim sürecinde BİT’in önemli bir faktör olarak ele alınarak modellenmesine yer vermektedir.

Anahtar Kelimeler: BİT, Uzun dönemde büyüme, Romer Yaklaşımı, OECD

“ICT (INFORMATION AND COMMUNICATION TECHNOLOGIES) AND ECONOMIC GROWTH”

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ABSTRACT

Information and Communication Technologies (ICT) are of great importance to our daily lives, which has led it to be a critical factor in economics. Most companies invest in ICT. Some companies produce ICT goods and others use them. This sector is gaining importance in microeconomics, and it should be examined from a macroeconomic perspective as well. What needs to be determined is if ICT contributes to long-term economic growth. This paper is inspired by Romer’s nonrivalrous ideas. ICT has a key role in this process and it is itself a nonrivalrous good to be examined.

Keywords: ICT, long-term growth, Romer Approach, OECD

PREFACE

This paper studies the effect of information technologies on the long run economic growth. Twentieth century started in industrial revolution era. The technology was assumed as machinery. Invention of electricity started a new age. Telegram was a beginning, afterwards electronics invented and the process got faster. Phone, radio and TV were the good news from future. Then computer was invented. First ones were huge, but today they are very little. People even carry them in their pockets. In 1980s, computers started to be a part of daily life. In Turkey, computer became popular during 1990s. At the beginning of that decade internet entered our life. Instant messaging, web journalism, e-mail came at first. Then search engines, wiki (what i know is) sites, social media trend arrived.

When we compare telegram and facebook wall it is rather easy to understand the change. E-commerce, e-mail, e-signature, e-government, e-business and so on we met up many “e”s in the last decade. Now we can easily reach the journals published all over the world and learn many things via internet. We used to research in libraries and it took hours to find what we were looking for. Today we can even search while travelling in the public transport bus, because smart phones can connect internet on 3G telecommunication technology.

After the smart phones nothing will be the same because plenty of software is in our hands and we can carry it everywhere. Most office programs have android and Iphone applications. Software engineering is one of the most popular jobs all over the world. These days you can see many people checking e-mails or ordering something via internet on their smart phones. Actually, that’s not all. Many large scale companies are using these applications for their internal approval processes. Therefore, business process improvement now has a new time span: Time span of smart phones.

Since the author of this study is a business analyst and project manager of IT projects, and witnessed an increase in business performance, he has decided to pursue an MA in economics and conduct research on the relationship between economic growth and IT investment.

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LIST OF ABBREVIATIONS

BI	: Business Intelligence
BPM	: Business Process Management
CAD	: Computer Aided Design
CAM	: Computer Aided Manufacturing
CERN	: The European Organization for Nuclear Research (Conseil Européen pour la Recherche Nucléaire)
CNC	: Computerized Numerical Control
CPU	: Central Process Unit
CRM	: Customer Relations Management
ERP	: Enterprise Resources Planning
GDP	: Gross Domestic Product
ICT	: Information and Communication Technologies
IT	: Information Technologies
JIT	: Just In Time
MFP	: Multifactor Productivity
MGI	: McKinsey Global Institute
OECD	: Organization for Economic Co-operation and Development
OLS	: Ordinary Least Squares
Op. Cit.	: Opus citatum
PLM	: Product Lifecycle Management
PPP	: Purchasing Power Parity
RAM	: Random Access Memory
R&D	: Research and Development
WWW	: World Wide Web

INTRODUCTION

Since we live in the Information Age, economists seek ways to understand the effect of information technologies (IT) on Long-run Economic Growth. Information Economics is a branch of microeconomics and investigates how information affects the economy and economic decisions.¹ Certainly, these efforts are not limited to firms or individuals. Economic research has a variety of areas in IT -- for instance, game theory, and uncertainty. Since IT has significant effects on either individuals' or firms' decisions, it has to be examined from a macroeconomic perspective.

Today, communication infrastructure is completely based on IT and it is nearly impossible to separate them. Therefore, it is common to term them Information and Communication Technologies (ICT) instead of IT. Although these terms seem to be different, they have the same meaning.

When we examine ICT from a macroeconomic perspective, it is clear that it might have an effect on long-term growth because neoclassical growth theories take technology as an input. Whether explicit or implicit input, it seems obvious that technology has an important role in long-term growth theories. Today people understand IT or ICT as technology because whenever they wonder about anything they google it. Many own mobile devices such as mobile phones, tablet PCs, notebooks, etc. They follow the stock exchange, complete banking operations and attend online meetings, to name a few, over these devices. There are many new things in our daily life, and our habits in our social life reflect our economic life as well.

The theorists of the Marshallian age were conditioned to define the economy as an evolutionary process.² Ibn Khaldun also, in his famous book "Muqaddimah" (Introduction), examines social life and describes growth. He also

¹ Brynjolfsson, E., Hitt, L.M., "Beyond Computation: Information Technology, Organizational Transformation and Business Performance", **Journal of Economic Perspectives**, Volume 14, Number 4, Fall 2000 p. 24.

² Jürg Niehans, **A History of Economic Theory Classical Contributions 1720-1980**, Baltimore and London, The John Hopkins University Press, 1990, p. 444.

emphasizes the effects of the macroeconomic forces of population growth, human capital development, and technological developments on economic development in the late 14th century.³ He puts an emphasis on urbanization because earlier societies were nomadic and goods they used were very limited. When people started to settle in villages and later in cities, they produced new goods. They lived in tents at first but later built houses, castles, temples and so on. They needed many new goods they did not in nomadic life. Since ideas were non-rivalrous, people carried them to new locations. For example, the invention of writing was a process; people carried this idea and developed it. New ideas on old ones led to the generation of a cycle of innovation. As a result, human beings now use various alphabets and communicate with them.

After the age of explorers, the mercantilist approach measured wealth in bullion (gold or silver stock). The amount of bullion a nation owned shows how wealthy it was, and if you gain, someone else has to lose. Adam Smith criticized this and proposed a new approach. Bullion was just a medium of exchange, regarding demand and supply in the market. Trade was not a zero-sum game to him. He defined an invisible hand operating in the market and was in favor of a free market economy.

Joseph Schumpeter proposed a new growth approach. He explained economic growth by innovation.⁴ According to Romer, innovation is a destructive process and entrepreneurs benefit from their innovation because they have the temporary advantage of a monopoly.⁵ Ford benefited from his production model, and Toyota did the same. Google, Microsoft, Apple and Intel are all very good examples of Schumpeterian Growth.

Long-term growth has been one of the most attractive topics of political economy for centuries.⁶ But it also generated one of the most important debates in the history of economic thought. Solow and Swan stated a model and explained

³ Ibn Khaldun, Muqaddimah

⁴ Joseph A. Schumpeter, **Capitalism, Socialism and Democracy**, London, Taylor & Francis e-Library, 2003, p. 83.

⁵ Romer, Paul, "The Origins of Endogenous Growth", **The Journal of Economic Perspectives**, Vol. 8, No. 1., Winter, 1994, p. 18.

⁶ Niehans, op.cit. p. 444.

growth with capital accumulation and production. Technology was exogenous in this model. Solow also examined how technology affects economic growth.

Paul Romer and Robert Lucas, Jr. improved Solow's neoclassical growth model in the 1980s. This model was different from Solow's, an endogenous model. Endogenous growth theory states that investment in human capital, innovation, and knowledge contribute to economic growth significantly.⁷ The concept of "idea" was introduced, because ideas are at the center of process. Romer gave a significant role to ideas in his model because ideas were non-rivalrous. If we omit copyrights, all economic agents can benefit from an idea. For example, the Just In Time production system (JIT) of Taichi Ohno made Toyota competitive in the automobile industry, today, on the other hand not only the manufacturing industry is benefitting from JIT, but also services sector companies do.

The idea generating process needs strong communication and collaboration because it is an evolutionary process. Rapid feedback mechanism provided by ICT makes this evolution more efficient. Knowledge and data are needed to create a new idea. These data and knowledge must be analyzed. Computers and global network systems have become a huge library and powerful analyzing tool.

Computers played a very critical role in the last decades. The US military invested in computers for security during the Cold War. Later, universities used computers to solve elaborate problems containing simulations and complex linear programming algorithms. Then people needed networks to tie these computers together. At first the US military built one, and then universities followed. Then Tim Berner-Lee, a scientist at CERN, offered a new idea, a worldwide web (WWW), in 1990.⁸ The commercialization of computers coincidentally rose at the same time. In just a few years the Internet became a global phenomenon. Some scientist did not believe computers would be commercial good in the 1970s. Today psychologists warn patients against Internet addiction.

⁷ Charles Irving Jones, **Introduction to Economic Growth**, New York, W.W. Norton & Company, 1998, p. 89.

⁸ John Farndon, **The World's Greatest Idea**, Trans. by Duygu Akın, Istanbul, NTV Publications, 2012, p. 289.

Since the 1990s, ICT goods we use have changed rapidly. First, we started with mobile phones, but now use smart phones. At first, phones did not have capable central process units (CPUs) or random access memory (RAM). But then computer scientists developed new architectures, and today computers can analyze billions of transactions. Data transfer is measured in megabits even for home users.

People all over the world are coming closer to each other day by day. The social media revolution strengthens democracy in some countries. Democracy is one of the parameters of the long run growth in some studies.⁹ Actually, the most important effect of information technologies is that people reach knowledge and information easier, cheaper and faster. This is a gift that Newton mentions as the standing on shoulders effect.¹⁰ Today everyone is standing on the giants' shoulders. Students, managers, and teachers; everyone has this privilege. ICT provides us with the tools we need.

Telemarketing and online shopping empower competition and force firms to produce higher quality and cheaper items. Firms generally need better decision processes. Therefore, they need better tools. Enterprise Resources Planning (ERP), Customer Relations Management (CRM), Workflow Management, Business Intelligence (BI), Performance Management, Data Warehousing, Data Mining and so on, all these processes need to be made more efficient because firms in markets have to answer customers' demands on time in order to make a profit. The competitive advantage of efficiency gained from ICT makes it attractive for companies. That is why many companies invest in IT infrastructure. Another important benefit is that the best practices of successful companies spread to others very fast. The spread of this know-how facilitates market entry and eliminates waste, all the while increasing further know-how.

Computers are not only capable of analyzing data or data transfer, but also good producers. Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) played a crucial role in production systems. Computerized

⁹ Barro, R.J., "Determinants of Economic Growth: A Cross-Country Empirical Study", **National Bureau of Economic Research**, 1996, p. 70.

¹⁰ This metaphor originates from the Latin expression "nanos gigantum humeris insidentes" which means previous discoveries let scientists build new discoveries.

Numerical Control (CNC) machines produced faster and supplied better quality goods. Robotic technology is also a computer miracle; manufacturing processes became much more efficient.

This paper seeks to discover if there is a correlation between ICT and long-term growth. The main argument is that the production process is becoming more efficient because of ICT. Romer's non-rivalrous goods match IT because computer codes can be used in different projects. For example, a sequencing algorithm is developed once but most software includes it. IT facilitates know-how transfer and best practice spread. In the last decade, new storage and server type is introduced: Cloud technology and it will revolutionize IT efficiency because entrepreneurs will be investing less in IT while simultaneously benefitting from it more.

This study consists of five chapters. The first chapter aims to show the rationale behind why ICT contributes to economic growth. The second chapter explains the concept of endogenous growth. The following chapter includes a model to understand the relationship between ICT and growth. The fourth chapter consists of recommendations to policy makers and briefly examines the Turkish case. The last chapter concludes the study. Data used in the model are included in the annex.

1. CHAPTER ONE: ICT CONTRIBUTION TO GROWTH

Idea creation process becomes more efficient with ICT. Because researchers need data, information and knowledge while producing new ideas. The spread of knowledge was increased by the invention of printing technology. ICT has a similar but more comprehensive role. Today, ICT is a basic element of all economic activities including trade, government services, education, health care, entertainment and so forth.¹¹ Finance and education sectors gain more profit with ICT technologies. These two areas has very crucial role in economic growth.

Diffusion of ICT means diffusion of information and knowledge. In the third chapter, regarding the knowledge accumulation Newton's famous "standing on shoulders effect" is explained. Instead of "standing on toes" or "standing on shoulders", ICT gives a tower to see further. Wiki sites, for instance, supply people to access simple knowledge faster and easier.

Most important of all, searching is a costly activity and great deal of time is needed. Before the information age, researchers needed great libraries and rather long time to find the relevant knowledge. Today, researchers can access information and knowledge by online journals or books. By entering keywords to the browser, researchers can find the data, information or knowledge they look for, however many researchers still use the traditional printed editions. Paper will maybe never come to an end but its usage will be more limited in the future.

Not only researchers benefit from this advantage, but also people working in operational activities of a firm. ERP or CRM systems, for instance, supply consistent and fast data to the top managers. Because these systems have controls while saving data to database and are faster than people. It would be impossible to manage a multinational company without ICT. Decision makers need accurate, fast information. This can be accomplished with relevant software and hardware such as ERP, CRM or PLM systems with databases and finally business intelligence tools.

¹¹ Yousefi A., "The impact of information and communication technology on economic growth: evidence from developed and developing countries", **Economics of Innovation and New Technology**, 20:6, 2011, p.581.

1.1. DEFINITION OF ICT

ICT has an important potential to foster economic growth and promote development evidently.¹² ICT (information and communications technology - or technologies) is a comprehensive and new term that consists of any communication device or application.¹³ The oldest form of ICT may be the telegraph, throughout the twentieth century radio, television, computer (both hardware and software), and satellite systems have been introduced and these systems have played significant role in our lives. The various services and applications related to these systems are also considered in ICT term, such as operating systems of computers or database softwares.

Since ICT is a very important aspect of society, there are many studies in particular contexts: for example ICTs in trade, provision of government services, education, health care, entertainment, and other activities around the world. ICT led people access to information at lower costs. Yousefi states that ICT facilitates innovation and reduces poverty because ICT is associated with easier and greater access to information and communication in underserved countries.¹⁴ It is believed that if developing countries utilize this tool to shrink faster the gap between rich and poor.¹⁵

Nasab suggests that social and cultural infrastructures and skilled labor is a must to benefit from ICT for OPEC member countries. Developing countries should promote the diffusion of ICT to catch up with the developed counties. This task can be accomplished by encouraging the institutes studying in the field of ICT and educate people to use ICT effectively.¹⁶

¹² Yousefi, op. cit. p.581.

¹³ Nasab Ebrahim H., Aghaei Majid, "The Effect of ICT on Economic Growth: Further Evidence", **International Bulletin of Business Administration**, 2009, p.50.

¹⁴ Yousefi, op. cit. p.581.

¹⁵ Yousefi, op. cit. p.586.

¹⁶ Nasab, Aghaei, op. cit. p. 54.

1.2. RATIONALE OF CONTRIBUTION OF ICT ON ECONOMIC GROWTH

Both exogenous and endogenous economic growth theories determine investment has a key role. It is an important point what sort of investment result in robust long run growth. While benchmarking various investment decisions, policy makers or top managers in companies should take into consideration of an answer to this question. That's why economists search for the effect of ICT investment on growth. Many empirical studies attempted to address this relation. But results are mixed due to the method utilized and country data set.¹⁷

Studies that analyze the impacts of ICT on business performance and economic growth suggest that there are exactly three important effects:¹⁸

1. As a capital good, ICT investment promotes overall capital deepening, and increases labor productivity and efficiency, consequently.
2. ICT investment corresponds to rapid technological improvement in the production processes of ICT goods and services. This also promotes multifactor productivity (MFP) growth in the ICT producing companies.
3. As ICT utility increases, firms also increase their overall efficiency, hence MFP increases. In addition to that, the more ICT usage may promote network effects, for example transaction costs decreases and innovation process becomes more efficient. As a result the overall efficiency of the economy rises.

In the next three sections these three effects will be examined by the help of studies which shows evidences.

¹⁷ Nasab, Aghaei, op. cit. p.46

¹⁸ OECD, "Seizing the Benefits of ICT in a Digital Economy", Meeting of the OECD Council Ministerial Level, 2003, p.11

1.2.1. THE IMPACT OF INVESTMENT IN ICT

Since ICT supplies good and services to the economy, firms in ICT sector invest in ICT infrastructure. These investments correspond to a share of the overall economic growth. ICT goods and services have distinctive property: technological progress in ICT is faster than other technologies. Before these goods are depreciated, their technology gets old. Therefore not only the firms in the ICT sector, but also the firms that need ICT invest in ICT permanently. Otherwise, they will lose competitive advantage.

In a macroeconomic perspective, there is evidence that ICT investment plays a significant role. Both Colecchia and Van Ark studies exhibit that investment of ICT has been very dynamic, because ICT investment is promoted as a result of decline in ICT prices. This led ICT be primarily invested assets. Although the amount of investment of ICT varies across OECD countries, an increasing trend appears in most of them.¹⁹

Over the 1995-2001 period, the amount of investment of ICT corresponds to 0.3 and 0.8 interval of percentage points of growth in GDP per capita in the countries which have available data. In the United States, Australia, the Netherlands and Canada rates are the highest. Japan and United Kingdom cases show moderate percentages. Lastly, Germany, France and Italy have smaller share of the overall growth. Software expenses, as an important component of ICT investment, are third of the overall contribution to economic growth in OECD countries.²⁰ There are several reasons for the differences in studies:

1. Many studies for any of these countries have confirmed the results of these cross-country studies; however these results are different in these studies because of various measuring methodologies. For example, the United States and France utilize “hedonic” deflators specially designed for computer related goods. Technological progress induces important quality changes such as faster

¹⁹ Colecchia, A., Schreyer, P., “The Contribution of Information and Communication Technologies to Economic Growth in Nine OECD Countries”, **OECD Economic Studies**, No: 34, 2002, p. 168.

²⁰ Colecchia, A., Schreyer, P., op.cit. p. 163.

processors and increasing disk capacity. In this case, these deflators are used to adjust prices. This methodology exhibits faster declines in computer prices in comparison to conventional price indexes which results in higher growth rates. That is why these countries have higher real growth in investment and production of ICT in comparison to those do not use “hedonic” deflators.²¹ As a result the amount of contribution of ICT will tend faster real growth performance.

2. To adjust these differences some methodologies were utilized.²² Therefore the result became more comparable than the results of individual national studies; however the national studies exhibit the same countries which represent a great impact of ICT investment on economic growth for instance, Australia, Canada, Korea, the United Kingdom and the United States. The share of ICT investment in economic growth did not come to an end with the slowdown in 2000's. While ICT investment slowed down in 2002, technological progress in the production of computers, such as new generation multi core computer processors, seems to continue for a long time.²³
3. Other ICT related areas such as communications technologies have rapid technological progress and this result in quality-adjusted ICT prices tend to decline. Hence investment of ICT will be promoted by lower prices and productivity growth will be accomplished.
4. The slowdown just after 2000, the level of ICT investment got lower. As a particular example, in the United States, some one-off investment peaks were observed such as the diffusion of the internet between 1995 and 2000.²⁴

²¹ Schreyer P., “The Contribution of Information and Communication Technology to Output Growth: A Study of G7 Countries”, **OECD Science, Technology and Industry Working Papers**, 2000, p. 10.

²² Colecchia and Schreyer, op. cit. p. 154.

²³ OECD, op. cit. p. 37.

²⁴ MGI, “How IT Enables Productivity Growth: The US Experience Across Three Sectors in the 1990s”, San Francisco, **McKinsey Global Institute**, November 2002, p. 8.

1.2.2. THE ROLE OF ICT-PRODUCING AND ICT-USING SECTORS

ICT-producing and ICT-using sectors relatively contribute to overall economic growth performance. Sectoral data indicates evidence on the impact of ICT. In some countries, the ICT-producing sector has particular interest. These countries exhibit higher rates of productivity growth and contribution of the ICT-producing sector to the aggregate growth performance at considerable shares.²⁵

In 1990s, the contribution of ICT manufacturing to productivity differs in the first and second half of the decade. The ICT manufacturing increasingly contributes to overall labor productivity growth in 1990s, in most OECD countries. The production of certain ICT goods partly attributed to more rapid technological progress. For example, semi-conductors have contributed to more rapid decline in prices and hence to higher real economic growth.²⁶

1.2.3. ICT-PRODUCING SECTORS

The production of ICT goods is differentiated in the types in different OECD countries. Some countries produce minor ICT goods which refer to much slower technological progress and this lead much less change in prices, consequently. The largest contribution ICT manufacturing to aggregate productivity growth is accounted in Finland, Ireland, Japan, Korea, Sweden and the United States. ICT manufacturing contributes 1 percentage point to aggregate productivity growth in Finland, Ireland and Korea in the 1995-2001 period.²⁷

Contribution of the ICT producing services sector to aggregate productivity growth is smaller than the ICT manufacturing sector, however it shows an increasing trend. The liberalization of telecommunications markets and rapid technological progress is one of the important engines of this increasing trend. In 1990s, this sector contributed to overall productivity growth at increasing amounts in several

²⁵ OECD, op. cit. p. 38.

²⁶ Jorgenson, Dale W., "Information Technology and the U.S. Economy", **The American Economic Review**, Vol. 91, No. 1, March, 2001, p.1.

²⁷ OECD, op. cit. p. 40.

countries, the most important examples are Canada, Finland, France, Germany and the Netherlands.²⁸

The emergence of the computer services industry also contributed to the growth in ICT producing services. The diffusion ICT accompanied this fact in OECD countries. While implementing ICT the development of these services has become crucial because the agents in this sector supplies important consultancy and training services. On the other hand, they develop relevant software to be utilized with the ICT hardware.²⁹

The productivity growth in some of OECD countries is accelerated by the ICT sector, especially in the United States, Japan, Korea, Sweden, Finland and Ireland. Because only few OECD countries represent rapid technological progress in ICT sector such as the production of electronic computers or semiconductors. High entry costs and large economies of scale in ICT sector resulted in highly concentrated production of ICT hardware. The cost of establishing a new semiconductor plant was about USD 100 million in early 1980s, but USD 1.2 billion in 1999. Since the cost of establishing a hardware plant is high, only a few countries can benefit their comparative advantages and invest in it. The terms-of-trade effects and an increased consumer surplus caused importing countries to share large part of the benefits of ICT production.³⁰

1.2.4. ICT-USING SECTORS

ICT is utilized in the production processes in a great deal of the economy. Some industries are intensive users of ICT and they are distinguished in many studies as

²⁸ Pilat, "The ICT Productivity Paradox: Insights from Micro Data", **OECD Economic Studies**, No. 38, 2004, p. 40.

²⁹ OECD, "The New Economy: Beyond The Hype, Final Report On The OECD Growth Project", Meetings of OECD Council Ministerial Level, 2001, p. 9.

³⁰ Bayoumi, T., Haacker, M., "It's Not What You Make, It's How You Use IT: Measuring the Welfare Benefits of the IT Revolution Across Countries", **Centre for Economic Performance**, 2002, p. 11.

an ICT-using sector.³¹ The role of ICT in aggregate performance can be understood by comparing the performance of the ICT-using and the non-ICT-using sectors over time. In services sectors there are key intensive ICT users like finance and business services. In 1990s, these key ICT-using services contributed to aggregate productivity growth increasingly. In some countries the contribution of ICT-using services is small for example Finland, Norway, Sweden and the Netherlands; however, some represents considerable contribution such as Australia, Ireland, Mexico, Canada, the United Kingdom and the United States. Some other studies have evidence that the United States have notable increase because of more rapid productivity growth in financial securities, wholesale and retail trade.³² It is confirmed that Australia had a strong increase in productivity growth by other studies.³³

ICT-using services contribute to aggregate productivity growth negatively, in some countries. In Switzerland, the banking sector has a low productivity growth in the first half of 1990s.

1.2.5. MULTIFACTOR PRODUCTIVITY (MFP)

The greater use of capital may result in stronger growth in labor productivity in both ICT-producing and ICT-using sectors. Estimates of multifactor productivity (MFP) growth represent whether overall efficiency of capital and labor utility is improved in ICT-using sectors and adjust for growth in capital stock. In case, aggregate MFP growth is analyzed in its sectoral contributions show how changes in MFP growth should be attributed to ICT-using sectors to ICT manufacturing or to other sectors. The OECD STAN database currently supplies the contribution of all activities to aggregate MFP growth for which estimates of capital stock at the industry level for seven countries.³⁴

³¹ McGuckin, R. H., Stiroh, K. J., “Do Computers Make Output Harder to Measure?”, **Journal of Technology Transfer**, Volume 26, 2001, p. 308.; Pilat, op. cit. p. 45.

³² MGI, op. cit. p. 16.; Triplett, J. E., Bosworth, B. P., “Productivity Measurement Issues in Services Industries: “Baumol’s Disease” Has Been Cured”, **Economic Policy Review**, 2002, p. 27.

³³ Parham, D., Roberts, P., Sun, H., “Information Technology and Australia’s Productivity Surge”, **Commonwealth of Australia**, 2001, p. 73.

³⁴ OECD(2003) op. cit. p. 43.

In Finland, ICT manufacturing notably contributed to the acceleration in production growth. In Denmark and Finland, the MFP estimates indicate increasing contributions to aggregate productivity for ICT using services. Through the 1990s, MFP contradicted in the ICT using services in several other countries. The United States capital stock data does not yet exist in the OECD STAN, thus MFP estimates for the United States cannot be obtained from this source. Non-ICT producing sectors contribution to US MFP growth show different results in several studies. One represents no contribution³⁵, another study shows a relatively small contribution³⁶ and another study shows much more considerable contribution.³⁷

Some studies contain two main problems: First all non-ICT producing industries are combined together and secondly the contribution of the non-ICT producing industries to aggregate MFP growth is estimated as a residual.³⁸

This residual is actually small in a more detailed study for the United States, however, financial securities, wholesale and retail trade contributed to MFP growth positively. On the other hand, other service sectors contributed negatively. Triplett and Bosworth's study shows relatively strong rate in MFP growth in certain parts of the US services sector.³⁹ In this study, MFP growth is estimated accelerated from 1.1% to 2.4% annually from 1987-1995 to 1995-2000 in wholesale trade sector. In retail trade sector, MFP growth risen from 0.4% to 3.0% annually. In financial securities sector it is from 2.9% to 11.2%. Considering the relatively large share of these sectors in the economy, it can be concluded that in ICT-using services there is a notable contribution to more rapid aggregate MFP growth. Therefore this study shows that there is evidence of strong MFP growth in the United States in ICT-using services. A comprehensive study may clarify the effects of ICT use in productivity in any country.

³⁵ Oliner S. D., Sichel D. E., "Information Technology and Productivity: Where Are We Now and Where Are We Going?", **Finance and Economics Discussion Series**, 2002, p. 28.

³⁶ Jorgenson D. W., Ho M. S., Stiroh K. J., "A Retrospective Look at the U.S. Productivity Growth Resurgence", Federal Reserve Bank of New York Staff Reports, no. 277, 2007, p. 18.

³⁷ Baily M. N., "The New Economy: Post Mortem or Second Wind?", **Journal of Economic Perspectives**, Vol. 16, No. 2, Spring 2002, p. 24.

³⁸ Oliner, Sichel, op. cit. p. 5.

³⁹ Triplett, J.E., Bosworth B.B., "Baumol's Disease Has Been Cured: IT and Multifactor Productivity in US Services Industries", paper prepared for Brookings workshop on services industry productivity, Brookings Institution, September 2002, p. 27.

Since companies like Wal-Mart developed innovative applications especially in ICT utilizing in order to have larger share in the market, important deal of rise in productivity growth can be attributed to retail trade.⁴⁰ Losing market share to these productive companies, due to their higher average production levels, made other firms improved their performance to gain competitive advantage. Financial securities also had a large part in productivity growth in the 1990s, in other ICT-using services.

Stronger competition, effective use of ICT and strong financial markets combination resulted in a strong productivity growth performance.⁴¹ ICT has a strong impact on MFP which primarily originates from the efficiency of labor and capital usage gained by the use of ICT in the services sector. The use of ICT in a company has a positive spillovers on the whole economy, thus these impacts do not originate from network effects. Probably, spillover effects has a role but, since ICT investment was stronger and started earlier in the United States rather than most of OECD countries.⁴² Furthermore, the US economy should have succeeded greater benefits from the use of ICT, because it had the essential elements before other OECD countries, as represented in 2001 OECD report.⁴³ It is the fact that the US economy have benefited earlier from ICT investment in OECD countries. The US economy represented high level of competition in the 1980s and regulatory reforms in the 1980s and 1990s made this competition stronger. The telecommunications sector became liberal earlier and comprehensively in the US. Therefore dynamic segments of the ICT market got more competitive. The US success story can be explained by macroeconomic policies, well-functioning institutions and markets and finally a competitive economic environment.⁴⁴

⁴⁰ MGI, op.cit. p. 16.

⁴¹ MGI, op. cit. p. 20.

⁴² Colecchia, Schreyer, op. cit. p. 426

⁴³ OECD(2003), op. cit. p. 45.

⁴⁴ OECD(2003), op. cit. p. 45.

In European countries, these results and attributes are relatively low due to restrictive labor and product market regulations. As a result companies could not benefit from their ICT investment.⁴⁵

Australian firms also benefited from ICT investments. Structural reforms encouraged firms to invest in ICT in order to increase productivity.⁴⁶ Wholesale and retail trade and financial intermediation sectors which cover most of the Australian productivity gains are represent evidence in the second half of the 1990s.

1.2.6. ICT AND COMPETITIVE EFFECTS

Competitive effects are one of the most important explanations for the contribution of ICT-producing sectors to growth and productivity such as new firm entries. OECD 2001 study explains that aggregate productivity growth has several components: the growth in existing companies, new firm entries and the exit of closing firms and lastly more productive firms which gain market share. In different sectors the importance of these components distinguishes.⁴⁷

New firm entries are much more important in ICT-related manufacturing sectors more than in other manufacturing industries. Entry of new firms has a crucial role in sectors which have rapid technological change. Because just like ICT manufacturing sectors, ICT related services sector also has high entry rates such as in telecommunications and computer services sectors. The rapid employment expansion of new firms can be attributed to the dynamic character of the ICT-producing sector. The growth rate of these new firms is higher than firms in other sectors in the economy. In the United States, firms represent higher growth rates in

⁴⁵ Gust, C., Marquez J., "International Comparisons of Productivity Growth: The Role of Information Technology and Regulatory Practices", **International Finance Discussion Papers**, No. 727, Federal Reserve Board, May 2002. p. 25.

⁴⁶ Parham et al., op. cit. p.4.

⁴⁷ OECD(2003), op. cit. p. 46.

comparison to other OECD countries⁴⁸, on the other hand, these new firms in the ICT sector supplied important contribution to growth.

Europe and the United States have been typically distinguished on firm turnover according to the OECD study.⁴⁹ The European Union and the United States show these differences:

1. In the United States, entering firms are smaller in size in comparison to sector average,
2. The European Union has higher labor productivity level of new firms relative to average
3. The United States has a much stronger employment expansion for new firms that successfully entered in the initial years.

Statistical factors and business cycle differences may partly explain these firms' performance differences.⁵⁰ In the United States, new firms have a greater degree of experimentation. Companies in the United States make decision for potentially higher results and take higher risks in investing new technologies; however, companies in the European Union make decision for more predictable outputs and take fewer risks. These differences may be attributed to distinguishing business environment of these two regions. Since barriers are relatively low in the United States, entrepreneurs in the business environment experience entry and exit more in comparison to many European countries.

⁴⁸ Scarpetta, S., Hemmings P., Tresselt T. and J. Woo, "The Role of Policy and Institutions for Productivity and Firm Dynamics: Evidence from Micro and Industry Data", **OECD Economics Department Working Papers**, No. 329, 2002, p. 7.

⁴⁹ OECD(2003), op. cit. p. 47.

⁵⁰ Bartelsman, E., Bassanini A., Haltiwanger J., Jarmin R., Scarpetta S. and Schank T., "The Spread of ICT and Productivity Growth – Is Europe Really Lagging Behind in the New Economy?", **Fondazione Rodolfo DeBenedetti**, 2002, p. 45.

1.2.7. THE IMPACT OF ICT ON AGGREGATE PRODUCTIVITY GROWTH

As explained above, productivity growth has been affected by ICT in the second half of the 1990s and into 2001. These effects can be addressed by three components:

1. ICT investment has supplied labor productivity growth with strong growth performance most obviously in the United States, Canada and Australia. While ICT investment was recovering slowly, these impacts did not disappear, according to the available evidence.
2. In some countries, aggregate labor and multi-factor productivity growth have been contributed by ICT production significantly, especially in Ireland, Korea and Finland.
3. In the United States and Australia, there is evidence service sectors invested in ICT heavily, such as logistics and financial securities, and more rapid MFP growth could be succeeded correspondingly. The correlation between MFP growth and ICT utility can be seen at the aggregate level. The greatest increase in MFP growth over the 1990s has been succeeded in the countries that have had high ICT investment in the 1990s.⁵¹

Since there are many factors affecting aggregate trends in productivity,⁵² the contribution of ICT is generally referred to a structural improvement in some countries, for example in Australia and the United States, ICT is evaluated as significant investment.

Labor productivity (GDP per hour worked) changes are evident for key OECD countries. Some countries including Canada, Denmark, Australia, the United States, Ireland and Sweden considerably increased their labor productivity growth from the

⁵¹ OECD(2003), op. cit. p. 48.

⁵² OECD(2003), op. cit. p. 49.

1980s to the 1990s; however some countries like France, Italy, Japan and Germany represented considerably decline in labor productivity growth at the same period.⁵³

Labor productivity growth increased over the 1990s in Australia, the United States and Ireland, too. France and Germany show more rapid labor productivity growth in the 1990s but cyclical conditions increased it from the first half to the second half of the decade.⁵⁴

As output growth contradicted in 2001, labor productivity growth dips in 2001 in most OECD countries. Some countries like Australia and Ireland, on the other hand, represented a strong growth in labor productivity in 2001. The United States and Canada both experienced an increase in labor productivity growth in 2002 after a fall in 2001.⁵⁵

For many countries including Turkey, estimates of multifactor productivity growth are not available. OECD studies are confirmed by these estimates for example structural improvement in MFP growth from 80s to 90s in the United States, Australia, Canada, Ireland, New Zealand and the Nordic countries.

According to OECD, ICT will be affecting productivity and will be a key factor for overall growth performance.⁵⁶

⁵³ OECD(2003), op. cit. p. 50.

⁵⁴ OECD(2003), op. cit. p. 50.

⁵⁵ OECD(2003), op. cit. p. 51.

⁵⁶ OECD(2003), op. cit. p. 51.

2. CHAPTER TWO: ECONOMIC GROWTH THEORY

Economic growth has attracted social scientists' attention since the age of geographical discoveries. Mercantilists, Physiocrats and Classicals attempted to explain it. Economic growth can be defined as the increase in the amount of the production by an economy over time.⁵⁷ Production term refers to generated goods and services.

First approaches were visionary theories. These theories were trying to explain growth without any economic model. Schumpeterian innovation centered growth explanation is one of the famous visionary economic growth theories. The economic models era brought new approaches: growth models. Roy-Harrod model, Solow-Swan model and Romer model of economic growth are the prior ones.⁵⁸

Solow-Swan model was a neoclassical economic growth and his capital accumulation and production function explanation later called the golden rule.

Neoclassical economic growth theory generated a debate: exogenous growth versus endogenous growth. This debate basically refers to technology. Solow-Swan model is an exogenous economic growth model because in this model technology is exogenous. Romer model is an endogenous model because in this model technology is endogenous.⁵⁹

In this chapter, firstly, Solow-Swan model will be introduced briefly. Secondly, Romer model will be discussed in detail.

⁵⁷ Turkan Turan, **Introduction to Economic Growth Theory**, Istanbul, Yalın Publications, 2008, p. 11.

⁵⁸ Turan, op. cit. p. 27.

⁵⁹ Romer(1994), op. cit. p. 3.

2.1. SOLOW GROWTH MODEL

One of the most famous papers on economic growth was written by Robert Solow of Massachusetts Institute of Technology entitled “A Contribution to the Theory of Economic Growth” in 1956. Solow growth model has become widely accepted because it is able to explain roughly well cross-country differences in growth rates of per capita income. In addition to that it is augmented by the inclusion of other productive factors in addition to private capital and labor.⁶⁰ Solow was awarded the Nobel Prize in economics in 1987 due to his contribution to economics.

2.2. THE BASIC SOLOW MODEL

In Solow growth model, technology is exogenous and there is no international trade. In order to make the model easier there is only one good produced and consumed. This good is either an investment good or consumption good like wheat or corn. As most of the economic models theorized by economists, to understand economic growth Solow uses an easier environment.

Solow built his model on two equations; the production function and the capital accumulation equation. The production function has a Cobb-Douglas form⁶¹;

$$Y = F(K, L) = K^{\alpha} L^{1-\alpha}$$

Where variables or inputs are K(capital) and L(labor). α is some number between 0 and 1, therefore, this function indicates constant returns to scale. This means if all the inputs are doubled, output, Y, will exactly double. If production function is rewritten in terms of output per worker, $y \equiv Y/L$, and capital per worker, $k \equiv K/L$:

$$y = k^{\alpha}$$

⁶⁰ Bajo-Rubio, Oscar. "A further generalization of the Solow growth model: the role of the public sector." **Economics Letters**, 2000, pp. 79-80

⁶¹ Solow R. M., “A Contribution to the Theory of Economic Growth”, **The Quarterly Journal of Economics**, Vol. 70, No. 1., Feb., 1956, p. 76.

Another key function in Solow model is capital accumulation function. Since the production function is rewritten in capital per worker it is needed to describe how capital is accumulated. The capital accumulation equation is as follows;

$$\dot{K} = sY - dK$$

As the equation interpreted, increase or decrease in the capital stock, $\dot{K}$, is equal to the amount of gross investment, sY , minus the amount of depreciation dK that is the possible result of the production process. When the equation is written in per worker terms;

$$\dot{k} = sy - (n + d)k$$

According to Solow workers/consumers save a constant ratio (marginal propensity to save), s , of their combined and rental income $Y = wL + rK$. It is a closed economy, therefore saving equals investment, and the only use of investment in the economy is to accumulate capital. The standard functional form used here implies that a constant fraction, d , of the capital stock depreciates every period. As an example, it is generally assumed that $d = 0.05$, therefore 5% of the machines and plants in our model will be useless for next year. The population growth rate is indicated by the parameter, n .⁶²

2.2.1. THE SOLOW DIAGRAM

As mentioned earlier there are two equations in Solow model; a production function and a capital accumulation equation. These equations are derived in terms of output per worker and capital per worker as follows;

$$y = k^\alpha \tag{1}$$

and

$$\dot{k} = sy - (n + d)k \tag{2}$$

⁶² Solow(1956), op. cit. p.67

Let an economy start out with a given stock of capital per worker, k_0 , and a given population growth rate, n , depreciation rate, d , and investment rate s . How does output per worker change over time in this economy? How does the economy grow? How does output per worker compare in the long run between two economies that have different investment rates? In order to analyze the answers given to these questions Solow introduces the Solow diagram in figure 3.1. This diagram consists of two curves, plotted as functions of the capital-labor ratio, k . The first curve is the amount of investment per person,

$$sy = sk^{\alpha}.$$

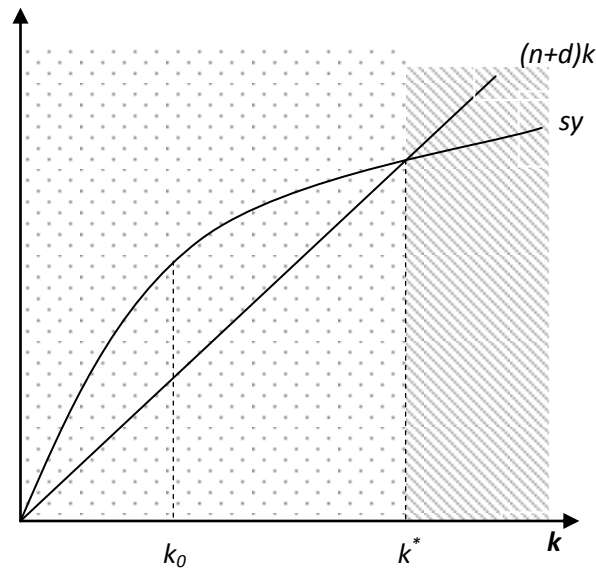


Figure 3.1. The basic Solow diagram⁶³

This curve has the same shape as the production function, the difference is, it is sloped down by the factor s . The second curve is the line $(n+d)k$, and it corresponds to the amount of new investment per person needed to sustain the amount of capital per worker constant. The change in the amount of capital per worker is the difference between these two curves.

⁶³ Solow(1956), op. cit. p. 70.

In figure 3.1. the dotted area this change is positive and capital per worker in the economy is increasing which is called capital deepening. But in the dashed area there is no change in capital per worker but the actual capital stock K is still increasing which is called capital widening.⁶⁴ This term is used, because population growth rate is equal with growth rate of capital stock K .

Under the circumstances of an economy which has capital, k_0 , what would be expected? At k_0 , the amount of investment per worker is more than the amount needed to sustain capital per worker constant. In this case capital deepening appears and k increases over time. This capital deepening will end at the point $k = k^*$, in other words when $sy = (n+d)k$, which means $\dot{k} = 0$. At this point, the amount of capital per worker stays constant, and this point is named as the *steady state*.⁶⁵

In case that an economy begins with a capital stock per worker larger than k^* , which corresponds to the dashed area in figure 3.1., the amount of the investment per worker supplied by the economy is less than the amount needed and capital-labor ratio would not be constant. If the term $\dot{k}$ is less than zero, the amount of capital per worker begins to decline in this economy. This decline occurs until the amount of capital per worker falls to k^* . If the term $\dot{k}$ is greater than zero, the process will reverse.⁶⁶

2.2.2. TECHNOLOGY AND THE SOLOW MODEL

Technology is exogenous in Solow model. In order to add it to the model, a technology variable is added to the production function. By doing so, the technology variable, A , is said to be “labor augmented” or “Harrod-neutral”. If technological development occurs A increases over time.⁶⁷

$$Y = F(K, AL) = K^\alpha (AL)^{1-\alpha}$$

⁶⁴ Solow(1956), op. cit. p. 70, Jones, op. cit. p. 25.

⁶⁵ Solow(1956), op. cit. p. 70.

⁶⁶ Jones, op. cit. p. 25.

⁶⁷ Solow R. M., “Technical Change and the Aggregate Production Function”, **The Review of Economics and Statistics**, Vol. 39, No. 3., Aug., 1957, p. 317.

Under the assumption that there is technological progress and if it is considered as A is growing at a constant rate;

$$\frac{\dot{A}}{A} = g \leftrightarrow A = A_0 e^{gt}$$

In this equation g is a parameter which corresponds to the growth rate of technology. The capital accumulation equation in the Solow model with technology would be the same;

$$\frac{\dot{K}}{K} = s \frac{Y}{K} - d$$

When we write the production function to see the growth implications of the model with the technology;

$$y = k^\alpha A^{1-\alpha}$$

In order to analyze logs are taken and differentiated,

$$\frac{\dot{y}}{y} = \alpha \frac{\dot{k}}{k} + (1 - \alpha) \frac{\dot{A}}{A}$$

Eventually, if Y/K is constant, the capital accumulation equation that the growth rate of K will be constant. If Y/K is constant then y/k is also constant and as a result, most important of all, y and k will be increasing at the same rate. That case which capital, output, consumption and population are growing at constant rates is named as a balanced growth path.

Let g_x denote the growth rate of any variable x , along the balanced growth path. On the balanced growth path, $g_y = g_k$ according to the balanced growth path definition. When this relationship is substituted into equation above and recalling that $\dot{A}/A = g$, it can be concluded that,

$$g_y = g_k = g$$

In the Solow model, along the balanced growth path, output per worker and capital per worker both increase at the rate of exogenous technological progress, g . When

technology is annexed to the model, the technological progress becomes the source of sustained per capita growth.⁶⁸

2.3. ROMER MODEL

Another important contribution was made by Romer in early 1980s. Economics of technology was introduced to economic growth theory by his model.

As a key term, technology has a very specific definition in the economics of growth and development. It covers the ways or methodologies in production processes which transforms inputs into outputs. For instance, when production process is defined by production function like $Y = F(K, L, \bullet)$, the function $F(\bullet)$ is technology function and it demonstrates the way or the methodology of the transformation of inputs into outputs. While explaining the Solow model, the Cobb-Douglas production function utilized, in this function $Y = K^\alpha (AL)^{1-\alpha}$, A represents the index of technology.

Ideas are very important for production because it advances technology. Ideas are engines of innovation and innovations allow firms or individuals to be more productive and more efficient. This means that more and better goods or services could be produced without increasing the amount inputs like labor and capital.

Paul Romer explains an idea via the magnetic tape technology, in 1990.⁶⁹ Lighting technology is a good example, too. People used to light their houses by setting fire. Afterwards, candles and oil lamps were used in order to light residents for a long time. After the invention of electricity Thomas Edison invented and introduced first light bulbs. Another new idea is fluorescent lamps which were more efficient because of lower electricity consumption and longer life. Now light emitting diodes (LEDs) are in use which do not contain mercury as fluorescent lamps do and have much longer life. LEDs also consume nearly one tenth of energy that fluorescent

⁶⁸ Jones, op. cit. p.34.

⁶⁹ Romer P. M., "Endogenous Technological Change", **Journal of Political Economy**, Vol. 98, no. 5, 1990, p. 72.

lamps do. In this case light is 4000 times cheaper than it was in 1800, as William Nordhaus estimates.⁷⁰

There are many examples of ideas and technological improvements. Internet, smart phones, tablet PCs and LED 3D TVs are phenomenon of the last decade. Ideas are by no means limited to feats of engineering, however. Taichi Ohno's creation of the Just in Time approach to production is no less an idea than advances in semiconductor technology. The BİM's retail approach and bank credit cards are innovations that allowed firms to combine inputs in new ways that consumers, according to revealed preference, have found very attractive. Outsourcing approach reduced many companies' production costs and increased their quality. Firms only dealt with their main activity and they made better decisions. That led them to be more efficient and profitable. Social media is another idea which played a crucial role in the social life. People started to share their moods, ideas, photos and so on. In the context of the production function above, a new idea promotes an increase in the technology index, A .⁷¹

Early in the mid-1980s, Paul Romer noticed that there was a relationship between the economics of ideas and economic growth. This relationship can be formulized as in the following way:⁷²



Figure 3.2. Romer's Economics of Ideas⁷³

Romer states that a distinctive characteristic of ideas is that they are nonrivalrous. This nonrivalry implies the presence of increasing returns to scale. And to model these increasing returns in a competitive environment with intentional research necessarily requires imperfect competition.⁷⁴

⁷⁰ Jones, op. cit. p. 72

⁷¹ Romer(1994), op. cit. p.4., Romer(1990), op. cit. p.79.

⁷² Jones, op. cit. p. 73

⁷³ Romer(1990), op. cit. p. 71

⁷⁴ Romer(1990), op. cit. pp. 73-74

2.3.1. NONRIVALRY AND EXCLUDABILITY

Romer observed that ideas are quite different from most of other economic goods. Because most goods are rivalrous: such as books, doctor's consultation or dental care services. This means that if anyone reads a book, sees a doctor or dentist he also blockade that good or service and nobody can do it at the same time. Most economic goods have the same property: if someone uses one good or service no one else can use it at the same time.⁷⁵ If hundred people need doctors consultation at the same time there should be hundred doctors or they should wait each other.

But ideas are different from these goods, they are nonrivalrous. A computer engineer using C++ programming language syntax and libraries does not preclude any other computer engineer to develop codes. This intellectual capital can be used by thousands or millions of code developers all over the world and no more resources would be needed different from rivalrous goods. It could be claimed for computer programs, too. If any software is developed once, it can be used by many computers at the same time. This software can be rivalrous, if it needs to be licensed. But free software is nonrivalrous. Anyone who has a compatible computer with this program can use it.

Another observation is that ideas have another distinctive characteristic. As most of the economic goods, ideas are excludable.⁷⁶ Excludability is not totally possible for ideas. The degree of excludability of ideas is related with ownership. If the owner of the idea can charge a fee for its use then it can be considered as excludable. A software company would secure their operating system project before they decide to kill the project. Copyrights and patent systems prevent unauthenticated utilities of software; however software can be cracked nevertheless.

⁷⁵ Romer(1990), op. cit. p.73.

⁷⁶ Romer(1990), op. cit. p.74.

2.3.2. THE BASICS OF THE ROMER MODEL

In Romer model, technological progress is endogenized. Researchers search for new ideas in order to profit from new inventions. In this section, the basic elements of the model and their implications for economic growth will be examined.

The advanced countries perform sustained economic growth. Therefore the model is designed to find out an explanation. Different from the Solow's neoclassical model which is applicable for every country, this model assumes that all the advanced countries as one country. Research and development (R&D) activities in the advanced world are the engine of the technological progress.

The Romer model has two main components in order to explain endogenous technological change: the production function which explains the relationship between inputs and output in an economy and a set of equations to exhibit the evolution of the inputs in the production function. The central equations are similar with the Solow model but there is a crucial exception.

In the Romer model, the aggregate production function exhibits the transformation of input components; the capital stock (K) and the labor (L_Y) into output (Y). The crucial exception is the stock of ideas (A):

$$Y = K^{\alpha}(AL_Y)^{1-\alpha}$$

where α is a parameter between 0 and 1.

Assuming that the production function is given, it needs to be discussed what are the market structure and the microfoundations of the economy that explain the aggregate production function.

The production function illustrates constant returns to scale in K and L_Y , if A is a given level of technology. But in this model ideas (A) is not only a constant, but also an input into the function, then it has to be increasing returns. For instance, when Larry Page and Sergey Brin developed Google's web search algorithm this source code wouldn't be needed to be developed again. In order to serve more

people or double the hits of their website they only needed to double their bandwidth, servers' capacity, databases etc and certainly a larger garage just like Jobs and Wozniak.

As explained in the example the production function results in constant returns to scale related with the inputs: labor and capital. When all three inputs: capital, labor and the stock of the ideas are taken into account, the production function expected to be increasing returns. In the Google example, if Page and Brin double their infrastructure and improve their source code, their website hits would rise more than double. The nonrivalry property of ideas is the reason of this expectation.

Capital accumulation in the model is the same as in the Solow model. Capital accumulation process is explained with households' savings at a given rate s_K and it depreciates at a rate d exogenously:

$$\dot{K} = s_K Y - dK$$

Population is taken account as it corresponds to labor and grows at some constant and exogenous rate n , exponentially:

$$\frac{\dot{L}}{L} = n$$

The equation that figures technological progress is critical and new if it is compared with the neoclassical model. The productivity term A increases exogenously at a constant rate in the neoclassical model. But in the Romer model growth of A is endogenous.

In order to accomplish that the Romer model suggest a function $A(t)$ which exhibits the stock of knowledge or the number of ideas that have been invented over the time period t . $\dot{A}$ represents the number of new ideas created at any time. In order to make the model simpler, $\dot{A}$ is equal to the population of people or researchers studying to discover or invent new ideas, L_A , and multiplied by the rate at which they discover new ideas, $\bar{\delta}$:

$$\dot{A} = \bar{\delta} L_A$$

This means that labor is divided into two parts: first creating new ideas (L_A) and producing output (L_Y), so the labor market in the economy is explained by the following equation:⁷⁷

$$L_A + L_Y = L$$

Researchers could create new ideas simply at the constant rate or the stock of ideas that have been invented may result in an increasing or a decreasing function of A . For instance, in the present, creativity or efficiency of researches might be increased by the inventions or discoveries made in the past. Therefore, $\bar{\delta}$ represents an increasing function of A . The discovery of electricity, the invention of transistor and the development of computer science are examples of ideas that have increased the creativity of sequential research. But the opposing thought might be true, too. What if the most obvious ideas are discovered earlier and it is more difficult to create new ones. Therefore, $\bar{\delta}$ represents a decreasing function of A .

Because of this debate, it is suggested that ideas are created at the rate as follows

$$\bar{\delta} = \delta A^\phi$$

where δ and ϕ are constants. The interpretation of this equation is, if $\phi > 0$ then the productivity of research increases with the stock of ideas that have already been discovered; if $\phi < 0$ then corresponding case is the "fishing out" in which the fish become harder to catch over time. Eventually, if $\phi = 0$ then the tendency for the most obvious ideas to be discovered first exactly offsets the fact that old ideas may facilitate the discovery of new ideas — i.e., the productivity of research is independent of the stock of knowledge.

The number of people working in research and development processes at any time period could possibly be the determinant of the average productivity level. As an example, if a pharmacy company recruits more pharmacists in order to increase amount of effort to invent new drugs. In order to represent this possibility in the production function L_A^λ would be utilized instead of L_A which stands for new ideas,

⁷⁷ Romer(1990), op. cit. p.97-98.

where λ is some parameter between 0 and 1. If these two equations combined into one, it should be in the following form:

$$\dot{A} = \delta L_A^\lambda A^\phi$$

In order to make reasons obvious, it is assumed that $\phi < 1$

This is a crucial aspect of the modeling economic growth represented in these equations. Compared to the economy as a whole, individual researchers have a little share so $\bar{\delta}$ is assumed given and they have constant returns to research. This means that an individual working on R&D role could create $\bar{\delta}$ new ideas. Despite this assumption, the production function for ideas could not be accepted as constant returns to scale in the whole economy. Efforts of a researcher can change $\bar{\delta}$ by only a tiny amount, but total efforts of the researchers' society will vary $\bar{\delta}$ clearly.

For instance, in case of $\lambda < 1$ might result in an externality because of duplication: the reason is simple: an individual researcher may create an idea repeatedly and it is not going to be new to the economy. This is similar to congestion on internet network. Internet users omit the fact that they raise the traffic on the network and preclude other users to access web sites which they are trying to browse. The effect of a single internet user seems to be tiny, but the total traffic caused by all internet users precludes accessing a particular web site.

The stock of ideas has a similar case; A^ϕ is considered as external by the individuals. In case that $\phi > 0$, exhibiting a positive knowledge overflow in research. Economists benefited from the game theory far more than John Nash himself benefited from his own theory. He created a knowledge overflow for researchers in the future. It is obvious that Nash also used the knowledge accumulated by the predecessors like Antoine Augustin Cournot or John von Neumann. Isaac Newton describes this cycling process in his famous statement:

"If I have seen farther than others, it is because I was standing on the shoulders of giants."⁷⁸

⁷⁸ Newton's famous quote is in his letter to his friend Robert Hooke in 1676.

The externality associated with the case $\phi > 0$ might be named the "standing on shoulders" effect, in addition to that, the externality resulted from the case $\lambda < 1$ can be called the "stepping on toes" effect.⁷⁹

2.3.3. GROWTH IN THE ROMER MODEL

Along the balanced growth path the growth rate needs to be explained for the Romer model. If constant ratio of the population works on producing ideas, the model expected to be the same as the neoclassical model in estimating that all per capita growth is derived from technological progress. When per capita growth is denoted by lower-case letter and g_x denotes the growth rate of any variable x along the balanced growth path, the growth rates represent the relation following:

$$g_y = g_k = g_A$$

This equation shows that per capita output, the capital-labor ratio and the stock of ideas have to grow at the identical rate along a balanced growth path. Provided that there is not any technological progress, there is no growth in the model.

As a result, the rate of technological progress along a balanced growth path is an important component. In order to clarify, the production function for ideas can be rewritten.

Dividing both sides of this equation by A following equation is obtained:

$$\frac{\dot{A}}{A} = \delta \frac{L_A^\lambda}{A^{1-\phi}}$$

$\frac{\dot{A}}{A} \equiv g_A$ is constant value, along a balanced growth path. Provided the numerator and the denominator of the right-hand side of equation grow identically, this growth rate will remain constant. After taking logs and differentiating of both sides of this equation,

⁷⁹ Jones, op. cit. p. 93

$$0 = \lambda \frac{\dot{L}_A}{L_A} - (1 - \phi) \frac{\dot{A}}{A}$$

The numbers of researchers and the population have to grow at the same rate along a balanced growth path. Even if the numbers of researchers grow at a higher rate, researchers will overflow the population in the end. But this is impossible.

That is, $\dot{L}_A/L_A = n$. By substituting this into equation above yields

$$g_A = \frac{\lambda n}{1 - \phi}$$

It is concluded that the parameters of the production function for ideas and the rate of growth of researchers which is derived from the population growth rate are the determiners of the long-run growth rate.

In order to understand the properties of this equation it is needed to be examined if there is an intuition that the equation is rational. Supposing the special case where $\lambda = 1$ and $\phi = 0$ which is annexed to the condition the productivity of researchers is constant δ . In this case, no duplication will occur in research and the productivity of a researcher is not affected by the stock of ideas that have been created before. Therefore, the equation would seem like this:

$$\dot{A} = \lambda L_A$$

If the number of people employed for idea creating process is held constant, then δ will be constant consequently. It is excepted that constant number of ideas δL_A , will be created for a given time period in this case.⁸⁰

To be more specific, considering $\delta L_A = 200$ and this economy initiates with the stock of ideas A_0 , discovered or invented in the past. At the beginning, 200 may correspond to a large fraction of the present stock A_0 , per period, but as the stock grows over time, 200 new ideas will be tiny small fraction of the present stock. As a result, the growth rate of the stock of ideas declines over time and finally becomes zero. But on the other hand, technological progress never ends because the

⁸⁰ Romer(1990), op. cit. p. 98

economy sustains generating 200 new ideas for every period. So, the accumulated stock of ideas becomes greater in comparison with the newly created 200 ideas.

To perform growth of this economy, the number of new ideas should not stay constant, it has to increase. This can be succeeded if the number of researchers is increasing. Sustaining growth of number of researchers corresponds to increasing number of ideas and this would result in sustained growth in the model. Therefore population growth means more researchers and more researchers generate more ideas. That is why the model includes population growth.

In the neoclassical model, population growth plays a different role in comparison to the Romer model. As an example, a higher population growth rate results in a fall in the level of income along a balanced growth path. Increasing number of people means capital will not be sufficient to keep K/L at the same amount because capital exhibits diminishing returns. The Romer model has a distinctive effect at that point. People play an important role in idea creation process. The more people an economy has, the more ideas they generate.⁸¹ Since the ideas are nonrivalrous, everyone benefits.

In order to prove that the per capita growth rate of the world economy is correlated with population growth, there should be some evidence. Admittedly, it is not an easy issue to test the model for this particular implication. One of the assumptions of the model indicates that the engine of growth is explained by the advanced countries of the world taken as a whole. So countries which have population growth cannot supply evidence to test the model. Rapid and sustained population growth and rapid and sustained growth in per capita output are both rather recent aspects. The Industrial Revolution roughly coincided with increases, witnessed over most of history, in the rate of population from very low rate.

It would not be a coincident that if the population or the number of the researchers do not exhibit sustained growth, the long-run growth would not correspondingly. Because the growth rate of the economy is tied to the growth rate of the population. This forecast can be rewritten as if research effort in the world do not change over

⁸¹ Romer(1990), op. cit. p.95.

time, economic growth rate will approach zero in the end. The Romer model implies that, because the same amount of research effort would not proportionally sustain increases in the stock of ideas needed to perform long-run growth.

There exists a special case in which a constant research effort can sustain the long-run growth, indeed. This is another important aspect derived from the Romer model. Romer considers the production function for ideas in case which $\lambda = 1$ and $\phi = 1$ and function becomes:

$$\dot{A} = \delta L_A A$$

When both sides divided by A , a new version of the Romer model will result in sustained growth with a given constant research effort:⁸²

$$\frac{\dot{A}}{A} = \delta L_A$$

This special case implies that the productivity of research is proportional to the existing stock of ideas: $\delta = \delta A$. It is assumed that the productivity of researchers or research effort grows over time, although the number of researchers does not increase.

Although this case seems to be advantageous, it can be also considered as a defect in the model. Through the last forty years or the last century, world research effort has risen at enormous amounts, so L_A has grown rapidly in this period of time. The Romer model suggests that the advanced economies should also exhibit a growth rate which has risen rapidly over the last forty years or the last century. But this prediction is not consistent with the reality. For example, the average growth has been almost 1.8 percent per year in the U.S. for the last hundred years.⁸³ But this conclusion is not enough to reject the models' prediction, because in case that ϕ is less than one, the results associates with the equation and the model cannot be blamed to be invalid.

⁸² Romer(1990), op. cit. p. 83.

⁸³ Jones, op. cit. p. 96

In this reasoning, there is no rejection to increasing returns in research or positive knowledge spillover.⁸⁴ ϕ ; The knowledge spillover parameter expected to be larger than zero and quite large. The empirical observations make the model rejected just in case of $\phi = 1$.

The neoclassical growth model and the Romer's endogenous growth model give similar results in one important way. The neoclassical model predicts that changes in the government policy or the changes in the investment rate do not affect long-run economic growth. There is no astonishment for this result, because all growth was due to exogenous technological progress.

The Romer model is endogenous, however, it concludes to an identical result. The long-run growth rate is not affected by changes in the investment rate or in the share of the population that creates ideas. None of the parameters in the function is affected, if the investment rate or the R&D share of labor changes. Policy makers cannot change the long-run growth rate in the endogenous growth model by utilizing conventional policies.

⁸⁴ Romer(1990), op. cit. p.89.

3. CHAPTER THREE: AN EMPIRICAL ANALYSIS OF SOME OECD COUNTRIES

There are numerous theoretical and empirical studies on the determinants of growth. Our model base on Yousefi's model⁸⁵ inspired from Romer Model and in the time span between 1980 and 2008, for ten OECD countries; United States, United Kingdom, Germany, Japan, France, Spain, Italy, Sweden, Belgium and Canada were studied. Data is obtained from World Bank and Penn World Table.

There are two approaches to understand the relation between growth and ICT investment; the production function and the growth accounting. Since the Romer Model as is in the Solow model basically depends on the Cobb-Douglas production function, we stated our model on production function approach.

In the second part of the study details are discussed and we will not be explaining the Yousefi model again, but the meaning of variables will be discussed.

Yousefi's Model is including a human capital variable different from Solow model. It is denoted by H in the equation.

$$Y = AH^{\gamma}K^{\alpha}L^{1-\alpha}$$

When we get logarithm of both sides, we get;

$$\ln Y = \ln A + \gamma \ln H + \alpha \ln K + (1 - \alpha) \ln L$$

Finally when we rewrite the equation as follows

$$\ln Y - \ln L = \ln A + \gamma \ln H + \alpha(\ln K - \ln L)$$

Y is the dependent variable and corresponds to real GDP. H is an independent variable and corresponds to ICT investment. K is an independent variable and corresponds to non ICT investment and eventually L is an independent variable and corresponds to population of each country in the time span.

⁸⁵ Yousefi A., op. cit. p. 587.

For these ten countries World Bank data is used to understand the relationship. Data covers non-residential ICT investment in these countries. The reason beyond this choice is non-residential data means these investments are financed by firms not individuals. Since the innovation infrastructure is built by these firms it is more explanatory to use these data. In the model, variable H stands for human capital. But it is assumed that non-residential ICT investment data is used in the linear regression.

Instead of using labor data, population is taken account as L. Because the infrastructure is built by firms but the innovation is made by all people in the country. Certainly children or old people may not participate in this innovation process. But population is more explanatory than labor data. In the near future that assumption is assumed to be more correct because technological improvements make everyone more participated. Population data is obtained from Penn World Table 7.2.

Capital is an important element of Romer model. In this model K stands for capital. Data used in the linear regression is obtained from non-residential ICT investment data of World Bank. In this data ICT and non-ICT investment is separated and all data is in different currencies. Some of them are pound, some are euro. Since the Penn World Table contains exchange rate to US dollars, all the data is converted into dollars.

Dependent variable Y which corresponds to GDP is obtained from Penn World table 7.2, too. Tcgrp data which means total Purchasing Power Parity over GDP (ppp) Converted GDP⁸⁶, G-K method, at current prices. Ppp converted is used instead of real in Penn World Data. All other data set is chosen from real data, because the Long-run growth model is a neoclassical model.

⁸⁶ Penn World Table 7.0

3.1. EMPIRICAL RESULTS

The model is tested with developed countries, because the most of these countries have either ICT producing and ICT consuming industries. Especially, the United States of America has superior importance for the model, due to having greatest ICT-producing firms including software producers, GSM operators and ICT-consuming industries.

It would be helpful to compare the developed countries and developing countries for the contribution of ICT investment to the Long-run growth, but it is omitted for this study.

3.1.1. UNITED STATES OF AMERICA

USA data set covers the time span between 1980 and 2008. Figure 4.1. shows GDP is increasing and figure 4.2. shows non-residential ICT investment in the same time period. Both data have increasing trend.

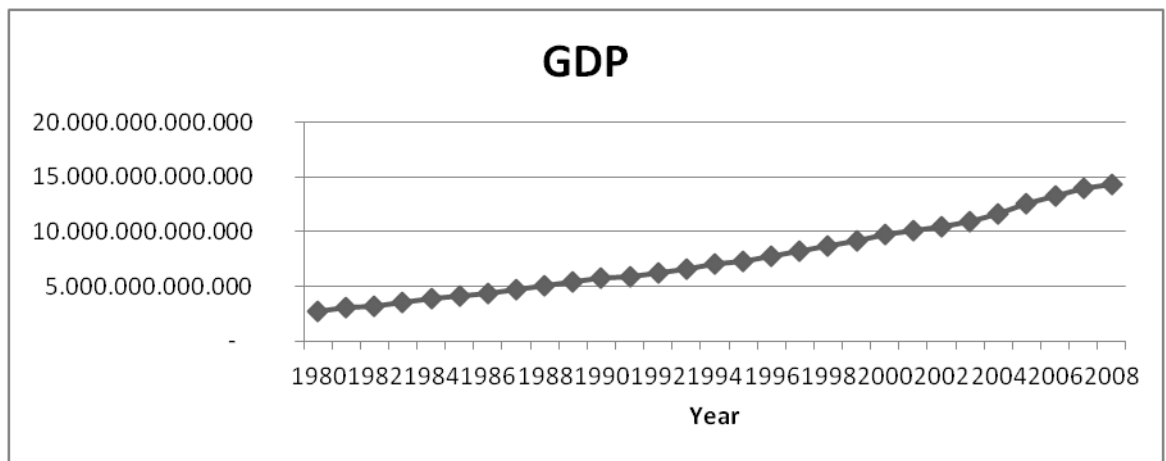


Figure 4.1. USA GDP between 1980 and 2008⁸⁷

⁸⁷ Penn World Table

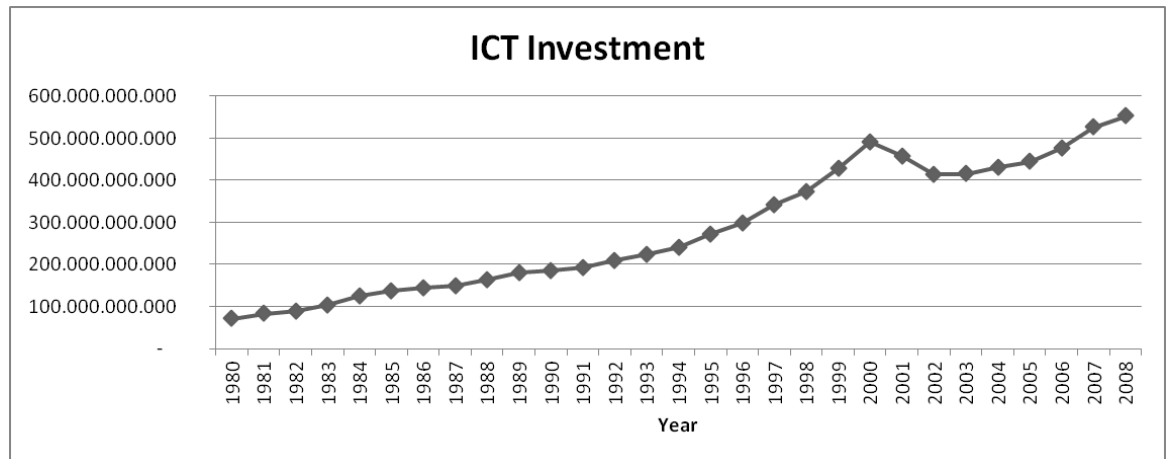


Figure 4.2. USA ICT Investment between 1980 and 2008⁸⁸

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0,990	0,981	0,979	0,0569	0,981	657,275	2	26	0,000	0,308

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.1. The United States Model Summary

Coefficients(a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	-4,278	0,810		-5,279	0,000	-5,944	-2,612					
x1	0,442	0,064	0,692	6,949	0,000	0,311	0,572	0,987	0,806	0,190	0,075	13,286
x2	0,363	0,118	0,307	3,080	0,005	0,121	0,605	0,972	0,517	0,084	0,075	13,286

a Dependent Variable: y

Table 4.2. The United States Coefficients

⁸⁸ World Bank(2008), Non-Residential ICT Investment

Adjusted R square is 0,979 and coefficients alpha is 0,36 and gamma is 0,44. This shows that model fits to USA and ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.2. UNITED KINGDOM

UK data set covers the time span between 1980 and 2007. Figure 4.3. shows GDP is increasing and figure 4.4. shows non-residential ICT investment in the same time period. Both data have increasing trend.

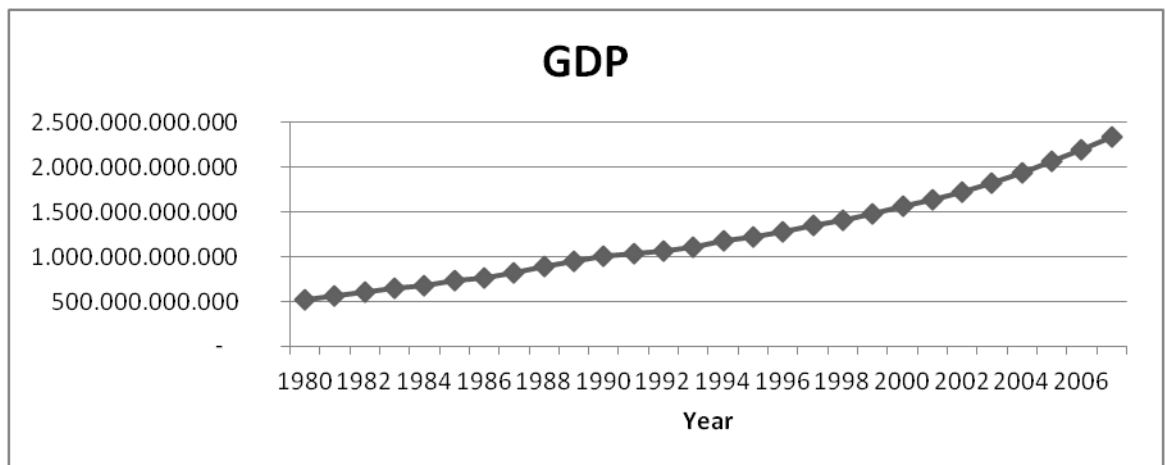


Figure 4.3. United Kingdom GDP between 1980 and 2007⁸⁹

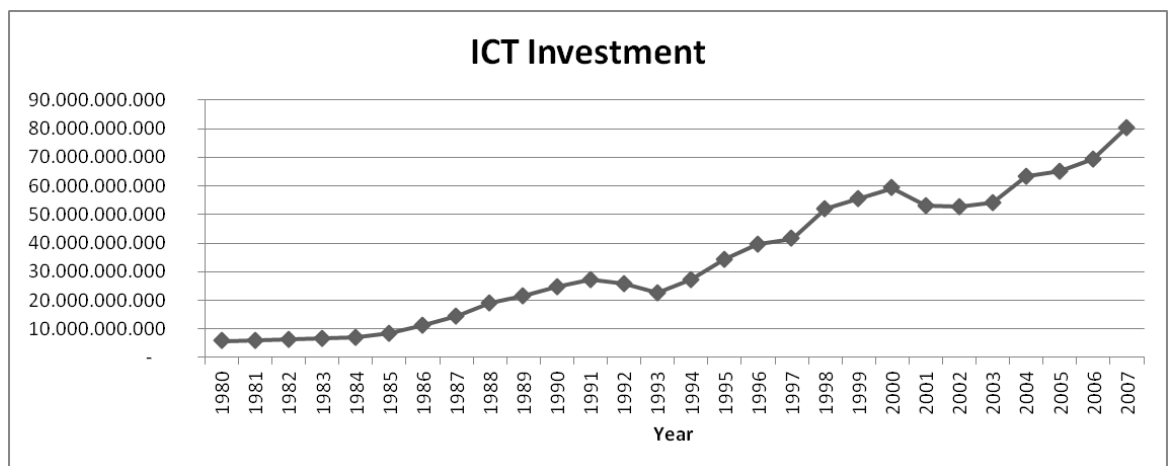


Figure 4.4. United Kingdom ICT Investment between 1980 and 2007⁹⁰

⁸⁹ Penn World Table

⁹⁰ World Bank(2008), Non-Residential ICT Investment

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,977	0,955	0,951	0,0897	0,955	265,330	2	25	0,000	0,312

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.3. United Kingdom Model Summary

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-1,112	0,736		-1,510	0,144	-2,629	0,405					
	x1	0,449	0,068	0,947	6,627	0,000	0,310	0,589	0,977	0,798	0,281	0,088	11,336
	x2	0,030	0,132	0,032	0,225	0,824	-0,242	0,302	0,936	0,045	0,010	0,088	11,336

a Dependent Variable: y

Table 4.4. United Kingdom Coefficients

Adjusted R square is 0,951 and coefficients alpha is 0,03 and gamma is 0,45. This shows that model fits to UK and ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.3. SWEDEN

Sweden data set covers the time span between 1980 and 2006. Figure 4.5. shows GDP is increasing and figure 4.5. shows non-residential ICT investment in the same time period. Both data have increasing trend.

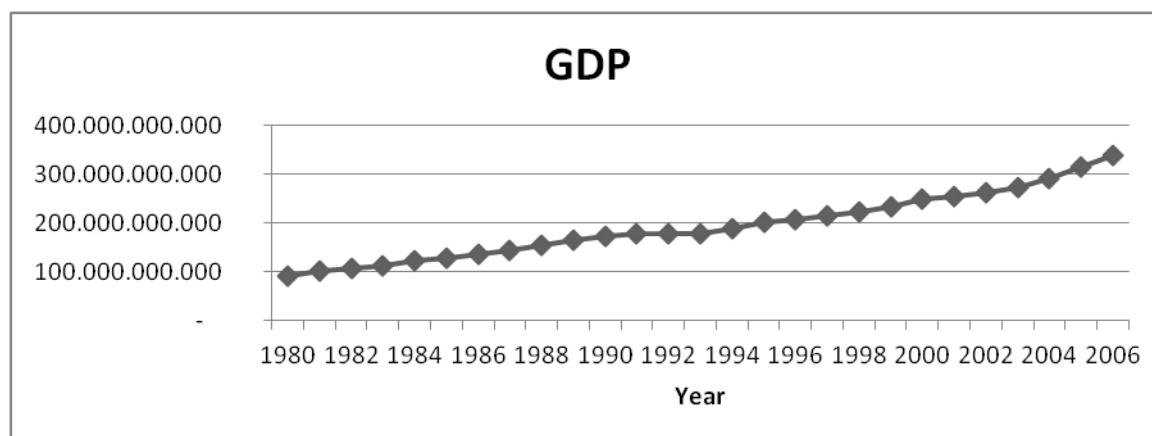


Figure 4.5. Sweden GDP between 1980 and 2006⁹¹

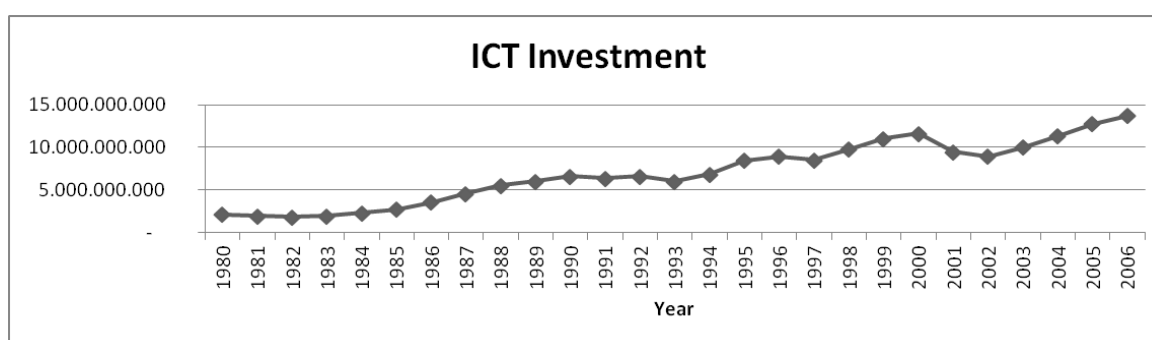


Figure 4.6. Sweden ICT Investment between 1980 and 2006⁹²

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,962	0,925	0,918	0,0945	0,925	147,494	2	24	0,000	0,259

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.5. Sweden Model Summary

⁹¹ Penn World Table

⁹² World Bank(2008), Non-Residential ICT Investment

Coefficients(a)													
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std.	Beta			Lower	Upper	Zero-	Partial	Part	Tolerance	VIF
1	(Constant)	-1,149	0,650		-1,767	0,090	-2,491	0,193					
	x1	0,535	0,044	1,038	12,25	0,000	0,445	0,625	0,959	0,929	0,686	0,437	2,289
	x2	-0,119	0,096	-0,105	-1,240	0,227	-0,317	0,079	0,674	-0,245	-0,069	0,437	2,289

a Dependent Variable: y

Table 4.6. Sweden Coefficients

Adjusted R square is 0,918 and coefficients alpha is -0,119 and gamma is 0,535.

This shows that model does not successfully fit to Sweden, but ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.4. SPAIN

Spain data set covers the time span between 1980 and 2006. Figure 4.7. shows GDP is increasing and figure 4.8. shows non-residential ICT investment in the same time period. Both data have increasing trend.

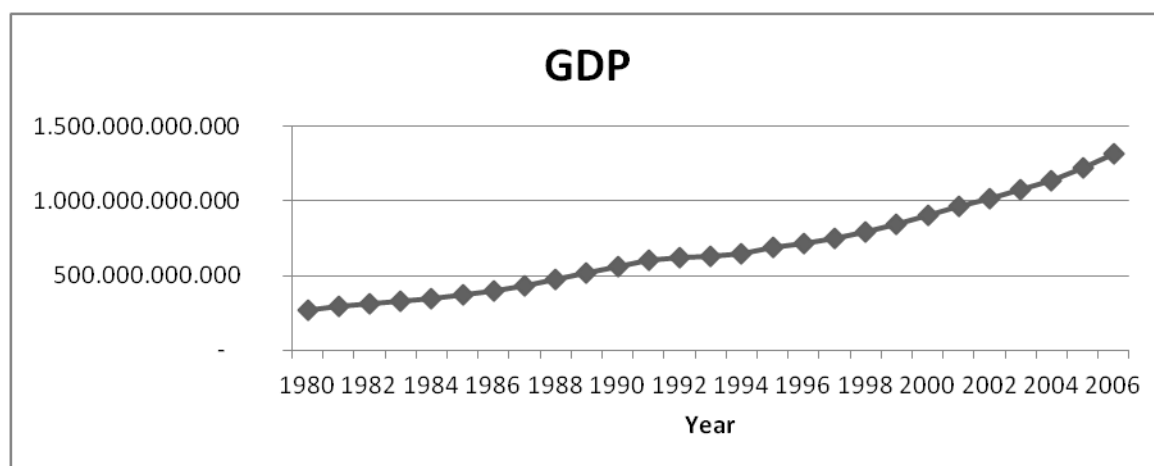


Figure 4.7. Spain GDP between 1980-2006⁹³

⁹³ Penn World Table

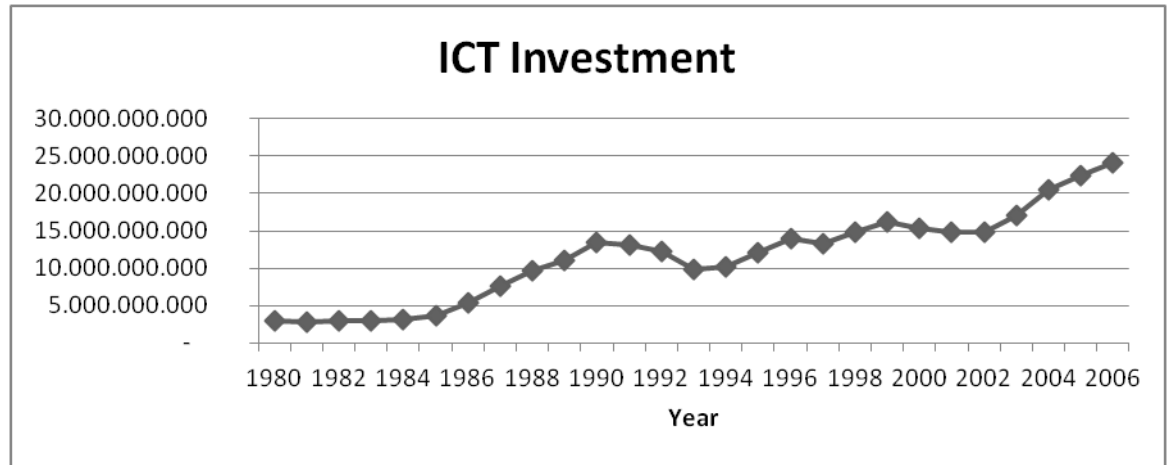


Figure 4.8. Spain ICT Investment between 1980 and 2006⁹⁴

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,954	0,910	0,902	0,1336	0,910	120,766	2	24	0,000	0,304

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.7. Spain Model Summary

Coefficients(a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	-1,309	2,367		-0,553	0,585	-6,195	3,576					
x1	0,412	0,155	0,662	2,663	0,014	0,093	0,730	0,951	0,478	0,163	0,061	16,416
x2	0,201	0,168	0,298	1,198	0,243	-0,145	0,547	0,940	0,238	0,074	0,061	16,416

a Dependent Variable: y

Table 4.8. Spain Coefficients

Adjusted R square is 0,902 and coefficients alpha is 0,20 and gamma is 0,41. This shows that model fits to Spain and ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

⁹⁴ World Bank(2008), Non-Residential ICT Investment

3.1.5. JAPAN

Japan data set covers the time span between 1990 and 2007. Figure 4.9. shows GDP is increasing and figure 4.10. shows non-residential ICT investment in the same time period. Both data have increasing trend.

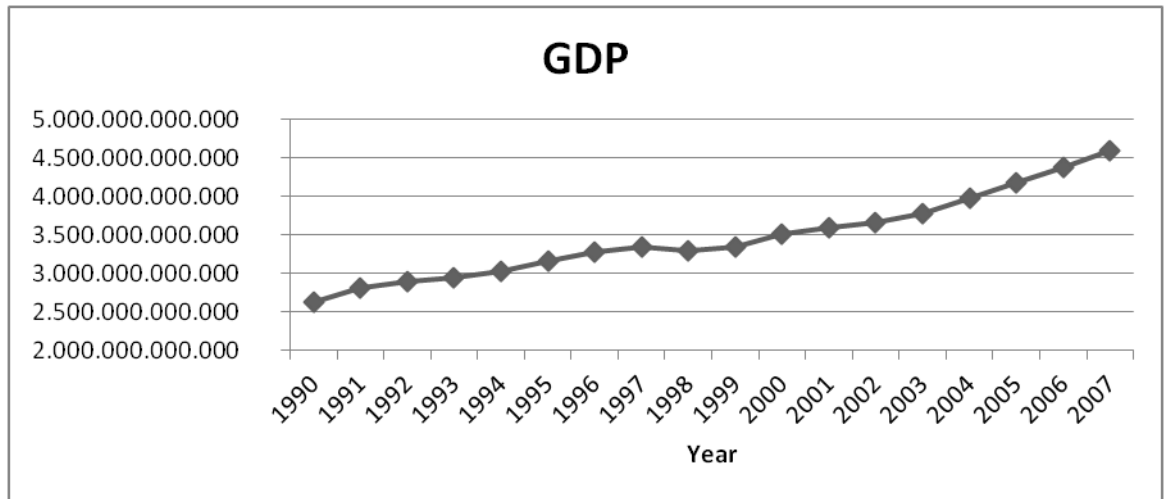


Figure 4.9. Japan GDP between 1990-2007⁹⁵

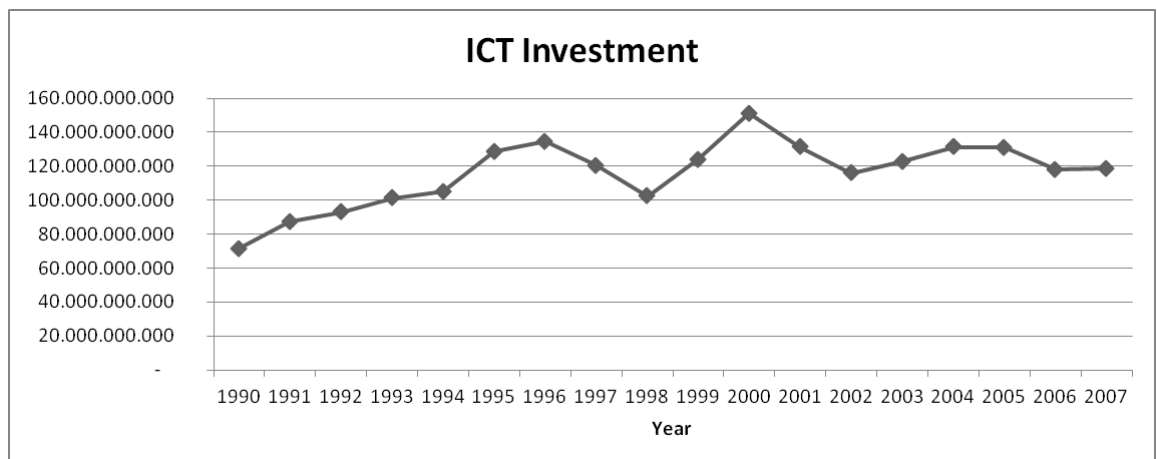


Figure 4.10. Japan ICT Investment between 1990 and 2007⁹⁶

These data is analyzed by SPSS in OLS and the results are as follows:

⁹⁵ Penn World Table

⁹⁶ World Bank(2008), Non-Residential ICT Investment

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,804	0,647	0,600	0,0923	0,647	13,744	2	15	0,000	0,241

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.9. Japan Model Summary

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1,709	3,464		0,493	0,629	-5,673	9,091					
	x1	0,523	0,123	0,652	4,248	0,001	0,260	0,785	0,644	0,739	0,652	1,000	1,000
	x2	-0,547	0,174	-0,482	-3,140	0,007	-0,918	-0,176	-0,471	-0,630	-0,482	1,000	1,000

a Dependent Variable: y

Table 4.10. Japan Coefficients

Adjusted R square is 0,600 and coefficients alpha is -0,54 and gamma is 0,52. This shows that model does not fit to Japan, but ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.6. ITALY

Italy data set covers the time span between 1980 and 2006. Figure 4.11. shows GDP is increasing and figure 4.12. shows non-residential ICT investment in the same time period. Both data have increasing trend.

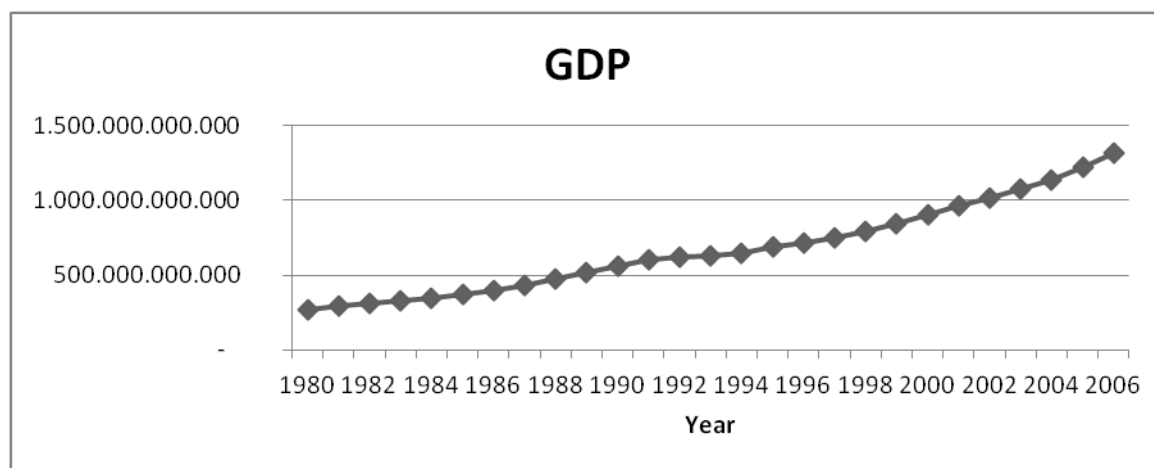


Figure 4.11. Italy GDP between 1980-2006⁹⁷

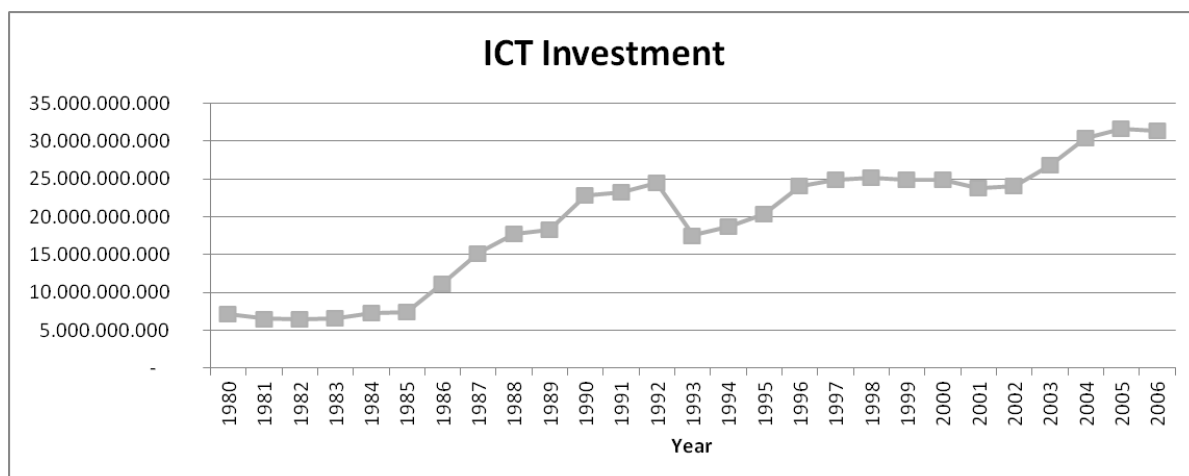


Figure 4.12. Italy ICT Investment between 1980 and 2006⁹⁸

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,949	0,901	0,893	0,1158	0,901	109,060	2	24	0,000	0,453

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.11. Italy Model Summary

⁹⁷ Penn World Table

⁹⁸ World Bank(2008), Non-Residential ICT Investment

Coefficients(a)												
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	-5,195	2,311		-2,248	0,034	-9,964	-0,426					
x1	0,655	0,163	1,008	4,022	0,000	0,319	0,990	0,949	0,635	0,258	0,066	15,198
x2	-0,051	0,210	-0,061	-0,242	0,811	-0,484	0,382	0,913	-0,049	-0,016	0,066	15,198

a Dependent Variable: y

Table 4.12. Italy Coefficients

Adjusted R square is 0,893 and coefficients alpha is -0,05 and gamma is 0,66. This shows that model fits to Italy and ICT industry highly contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.7. GERMANY

Germany data set covers the time span between 1991 and 2008. Figure 4.13. shows GDP is increasing and figure 4.14. shows non-residential ICT investment in the same time period. Both data have increasing trend.

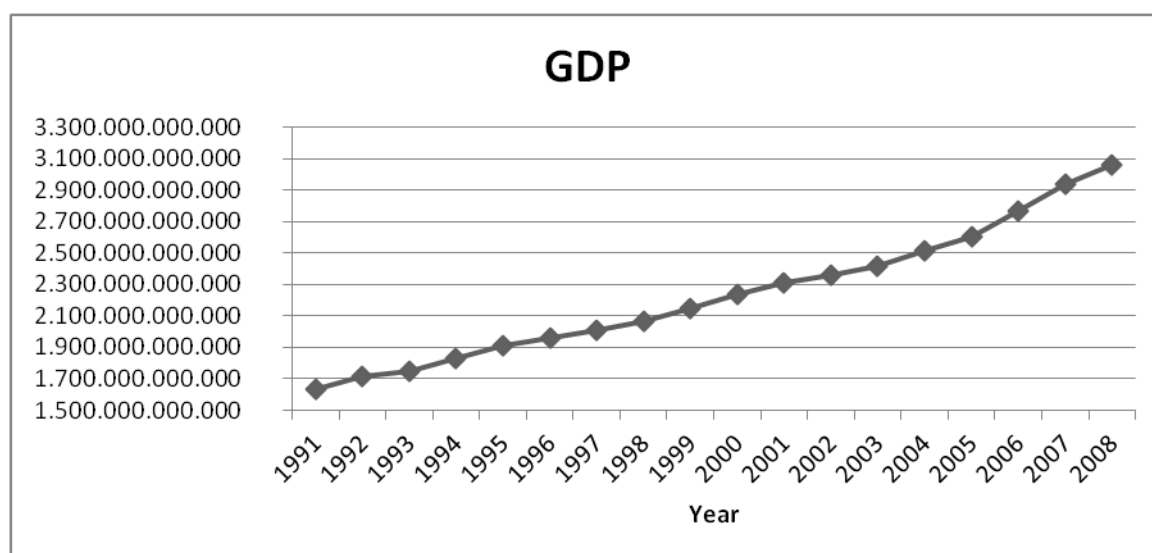


Figure 4.13. Germany GDP between 1991-2008⁹⁹

⁹⁹ Penn World Table

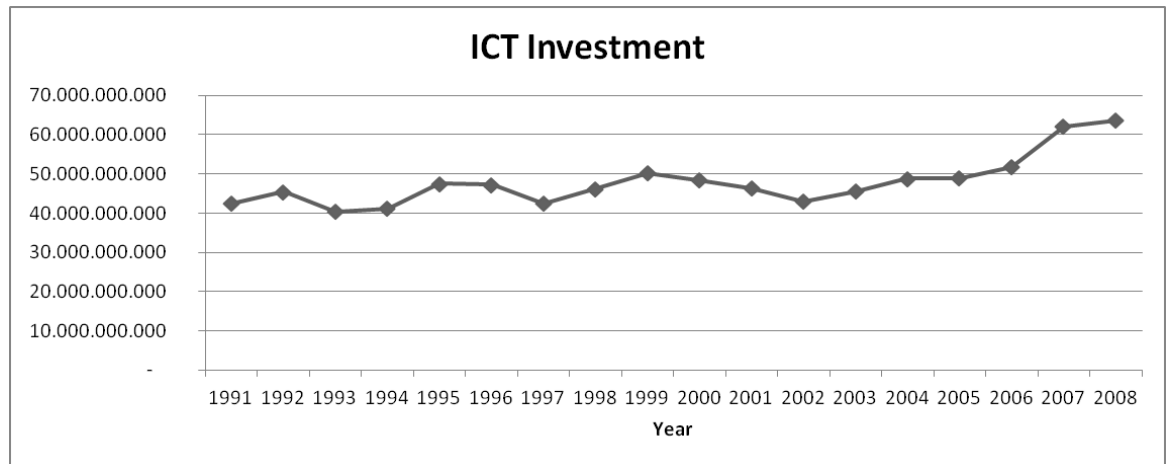


Figure 4.14. Germany ICT Investment between 1991 and 2008¹⁰⁰

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,851	0,725	0,688	0,1007	0,725	19,752	2	15	0,000	0,869

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.13. Germany Model Summary

Coefficients(a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	-25,521	5,854		-4,360	0,001	-37,998	-13,043					
x1	1,588	0,279	1,079	5,691	0,000	0,993	2,182	0,804	0,827	0,771	0,510	1,959
x2	-0,408	0,196	-0,394	-2,077	0,055	-0,826	0,011	0,361	-0,473	-0,281	0,510	1,959

a Dependent Variable: y

Table 4.14. Germany Coefficients

Adjusted R square is 0,688 and coefficients alpha is -0,41 and gamma is 1,59. This shows that model does not fit to Germany, but ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

¹⁰⁰ World Bank(2008), Non-Residential ICT Investment

3.1.8. FRANCE

France data set covers the time span between 1980 and 2008. Figure 4.15. shows GDP is increasing and figure 4.16. shows non-residential ICT investment in the same time period. Both data have increasing trend.



Figure 4.15. France GDP between 1980-2008¹⁰¹

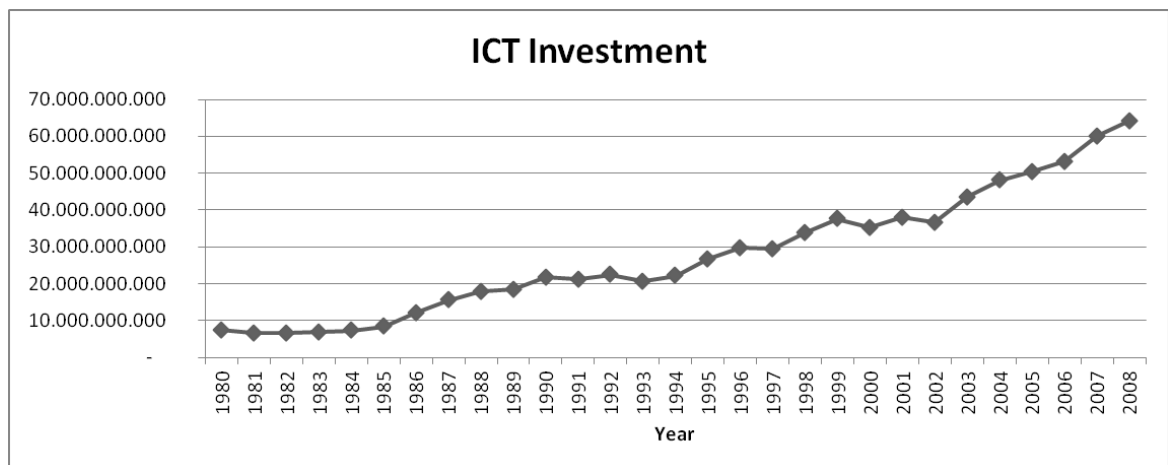


Figure 4.16. France ICT Investment between 1980 and 2008¹⁰²

These data is analyzed by SPSS in OLS and the results are as follows:

¹⁰¹ Penn World Table

¹⁰² World Bank(2008), Non-Residential ICT Investment

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,987	0,973	0,971	0,0606	0,973	474,066	2	26	0,000	0,623

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.15. France Model Summary

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std.	Beta			Lower	Upper	Zero-	Partial	Part	Tolerance	VIF
1	(Constant)	-2,482	0,537		-4,620	0,000	-3,586	-1,378					
	x1	0,556	0,042	1,107	13,24	0,000	0,470	0,643	0,985	0,933	0,424	0,147	6,813
	x2	-0,112	0,071	-0,132	-1,577	0,127	-0,257	0,034	0,891	-0,295	-0,051	0,147	6,813

a Dependent Variable: y

Table 4.16. France Coefficients

Adjusted R square is 0,971 and coefficients alpha is -0,11 and gamma is 0,56. This shows that model does not fit to France, but ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.9. CANADA

Canada data set covers the time span between 1980 and 2008. Figure 4.17. shows GDP is increasing and figure 4.18. shows non-residential ICT investment in the same time period. Both data have increasing trend.

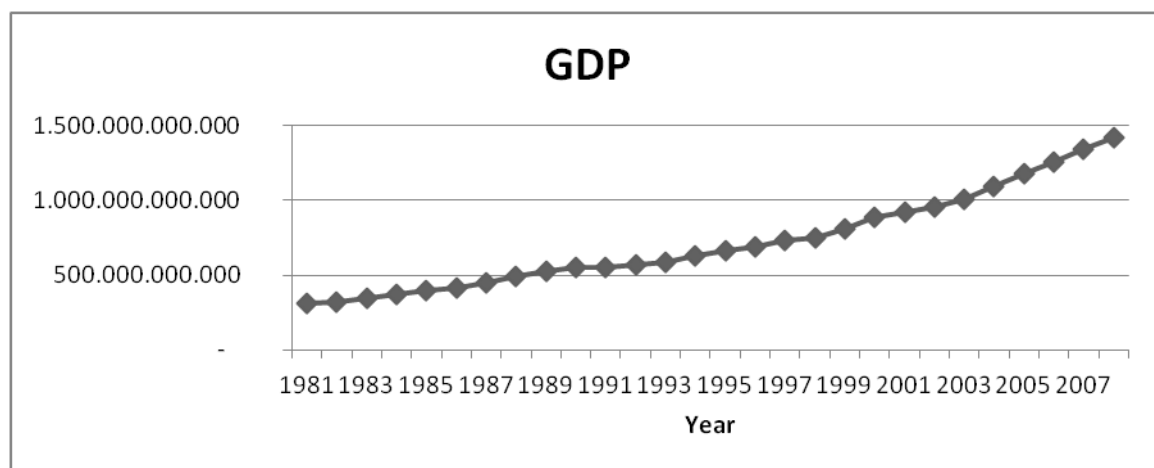


Figure 4.17. Canada GDP between 1981 and 2008¹⁰³

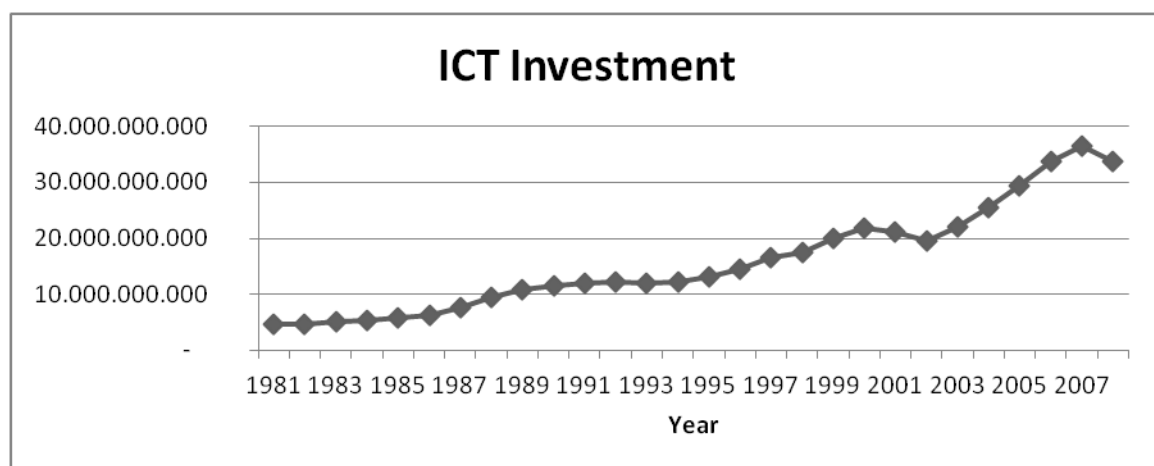


Figure 4.18. Canada ICT Investment between 1981 and 2008¹⁰⁴

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,989	0,978	0,977	0,054	0,978	568,362	2	25	0,000	0,528

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.17. Canada Model Summary

¹⁰³ Penn World Table

¹⁰⁴ World Bank(2008), Non-Residential ICT Investment

Coefficients(a)													
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std.	Beta			Lower	Upper	Zero-	Partial	Part	Tolerance	VIF
1	(Constant)	-2,705	0,421		-6,427	0,000	-3,572	-1,838					
	x1	0,510	0,033	0,901	15,40	0,000	0,441	0,578	0,988	0,951	0,452	0,251	3,979
	x2	0,109	0,064	0,100	1,707	0,100	-0,022	0,240	0,880	0,323	0,050	0,251	3,979

a Dependent Variable: y

Table 4.18. Canada Coefficients

Adjusted R square is 0,977 and coefficients alpha is 0,11 and gamma is 0,51. This shows that model fits to Canada and ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

3.1.10. BELGIUM

Belgium data set covers the time span between 1980 and 2004. Figure 4.19. shows GDP is increasing and figure 4.20. shows non-residential ICT investment in the same time period. Both data have increasing trend.

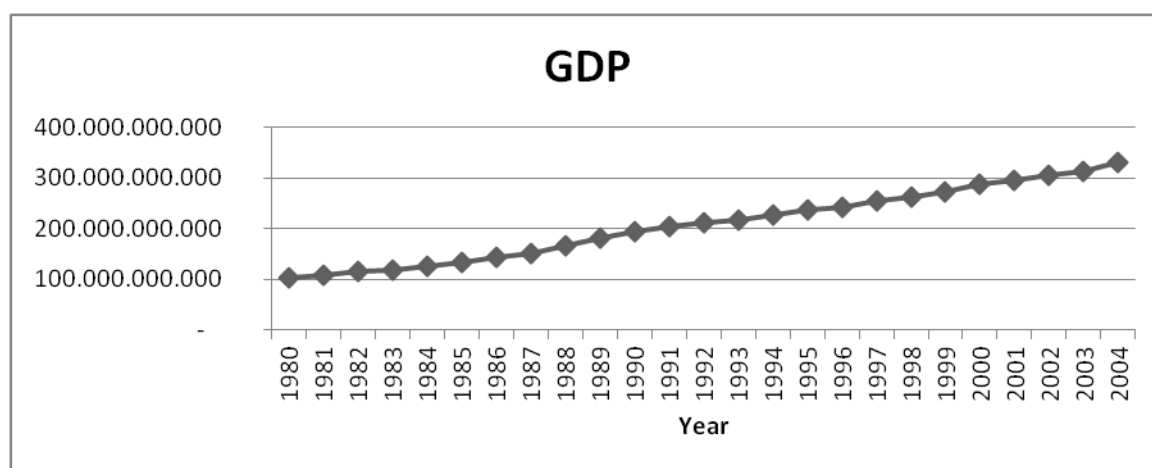


Figure 4.19. Belgium GDP between 1980-2004¹⁰⁵

¹⁰⁵ Penn World Table

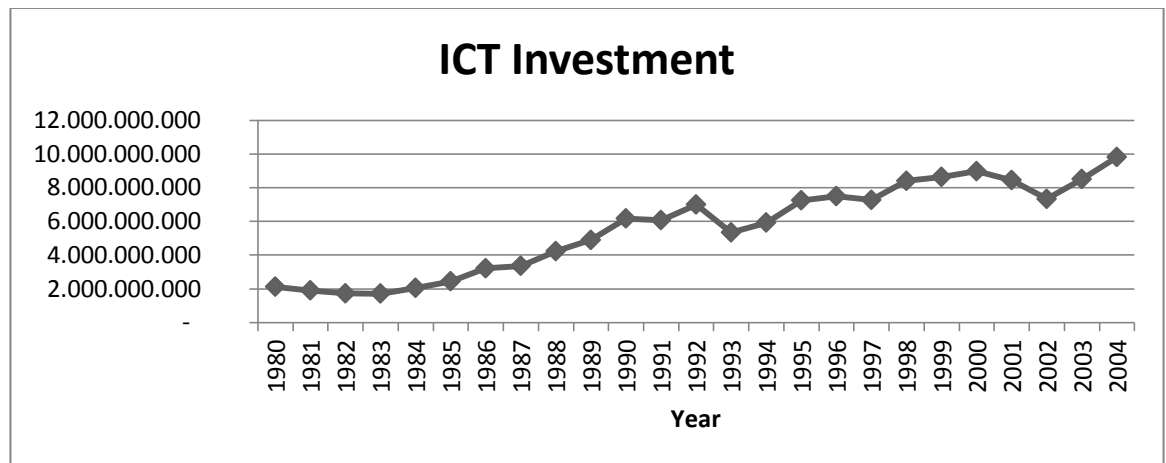


Figure 4.20. Belgium ICT Investment between 1980 and 2004¹⁰⁶

These data is analyzed by SPSS in OLS and the results are as follows:

Model Summary(b)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square	F	df1	df2	Sig. F	
1	0,972	0,946	0,941	0,0853	0,946	190,973	2	22	0,000	0,756

a Predictors: (Constant), x2, x1

b Dependent Variable: y

Table 4.19. Belgium Model Summary

Coefficients(a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	-4,143	0,990		-4,185	0,000	-6,195	-2,090					
x1	0,691	0,077	1,167	8,938	0,000	0,531	0,852	0,969	0,885	0,445	0,145	6,888
x2	-0,182	0,111	-0,214	-1,641	0,115	-0,412	0,048	0,865	-0,330	-0,082	0,145	6,888

a Dependent Variable: y

Table 4.20. Belgium Coefficients

Adjusted R square is 0.941 and coefficients alpha is -0.18 and gamma is 0.69. This shows that model does not fit to Belgium, but ICT industry contributes to economic growth. There is an obvious relation between ICT investment and growth.

¹⁰⁶ World Bank(2008), Non-Residential ICT Investment

3.1.11. COMPARING AND DISCUSSING RESULTS

When we examine table 4.21 below, gamma ratio is always positive for all countries. This implies that ICT has a very important role in growth, but why does it change its effect? It can be associated with the culture or the structure of the economy in this country. These differences are beyond the purpose of this study.

Country	Alpha	Beta	Gamma
US	0,363	0,637	0,442
UK	0,030	0,970	0,449
Sweden	-0,119	1,119	0,535
Spain	0,201	0,799	0,412
Japan	-0,547	1,547	0,523
Italy	-0,051	1,051	0,655
Germany	-0,408	1,408	1,588
France	-0,112	1,112	0,556
Canada	0,106	0,894	0,510
Belgium	-0,182	1,182	0,691

Table 4.21. Alpha, Beta and Gamma Coefficients

Negative alpha ratios mean non-ICT investment is not effective and cause a decline in the Long-run Growth. According to Cobb-Douglas production function alpha ratio has to be between zero and one. Therefore the model fails to explain these economies.

On the other hand, the model explains the Long-run Growth in the United States, the United Kingdom, Spain and Canada. Especially, the model holds with the United States data. However, the model does not hold with Germany and Japan data and it is not significant.

4. CHAPTER FOUR: ICT STRATEGY AND MILESTONES

In the second chapter, the impact of ICT investment on economic growth in some of the OECD countries is explained. Since policy makers are investigating ways to improve their economic growth, some key policies can be addressed to facilitate the ICT investment.

4.1. ENHANCING COMPETITION IN ICT GOODS AND SERVICES

OECD study presents evidence and provides new insights for components in decision making process of ICT investment of a company. There are two key components that firms make decision to invest in ICT: First whether they can use their investment effectively and second expectation for sufficient returns. These returns can be addressed by many components that policy maker may also intervene.¹⁰⁷

The cost of ICT investment is one of the significant components of the decision making process. According to OECD, there is evidence available that the costs of technology investment distinguish across countries and this leads to different investment patterns. Across the OECD area, relative price levels considerably differentiate for ICT investment.¹⁰⁸ This differentiation is evidently smaller than it used to be in 1993 or 1996¹⁰⁹, however still represents that the lowest price levels for ICT (both for hardware and software) is witnessed in the United States. The cost variation can be partly addressed to barriers to trade for example non-tariff barriers of standards, import licensing and government investment. The higher price level in other OECD countries, on the other hand, can be explained with a lack of competition. These price discriminations across countries will approach to much smaller amounts in time by the help of international trade and competition, however

¹⁰⁷ OECD(2003), op. cit., p.15.

¹⁰⁸ OECD(2003), op. cit., p. 88.

¹⁰⁹ OECD(2003), op. cit., p. 88.

policy makers may shorten this time by using more aggressive competition policy and promoting both domestic and international market openness.

The cost of the investment goods is not the only determinant of the investment and diffusion of ICT. It also depends on the related costs of communication and use once the hardware is connected to a network. The considerable regulatory reform has resulted in an increased competition in the telecommunications industry. Competition has been of particular importance in decreasing these costs. Liberalization of ICT industries fostered the competition and OECD countries and users benefited from this competition considerably. In particular market segments, prices have declined and predicted to decline in the future. New service development and technological diffusion have represented rapid growth and estimated to grow. By augmenting efficiency and better levels of service, telecommunication operating firms have adjusted to the new market circumstances. Many firms entered to ICT segment of the market and some entrants failed to operate longer and failed however, the number of firms operating in the market is still large in many OECD countries.

Nevertheless, there are not enough efforts in order to create more competitive circumstances. In 2003, the OECD report pointed out that countries should increase competition. Besides that they should apply a regulatory reform in the ICT sector to improve the diffusion of ICT. The report suggests that this recommendation will be valid through many years with the evidence shown.¹¹⁰

4.2. ICT ADOPTION IN BUSINESS ENVIRONMENT

Instead of protectionist policy, a competitive business environment encourages firms to invest in ICT, because they consider it as a way to enhance performance and survive. In addition to that decision makers are affected by the degree of competition in ICT implementation. E-commerce software implementations are good examples. The e-commerce softwares were ignored by many firms due to

¹¹⁰ OECD(2003), op. cit., p. 89.

their consideration of small market share of it and also some of them did not believe that their product could be sold on e-commerce software. Some other firms, on the other hand, defined e-commerce a rival to their incumbent business models for example online journalism. Because internet users access to news before the published newspaper and this situation resulted in decreasing circulation. The attitudes may seem realistic but also can be considered as a conservative approach.

New ICT investments and associated new business models may generate risks and this may result in firms to keep their existing business models. New entrant firms can bring dynamism by introducing new business models and lead older firms to change. These industries need key policies to improve entrance of entrepreneurs.

This study aims to understand if ICT is a key industry for the long run growth in a macroeconomic perspective, however ICT has been also studied in microeconomics. ICT has the potential to transform sectors. Firms can utilize it to enhance their operations' performance however; all firms will not accomplish this task and some of them will fail to intake of the needed technology. Therefore, competition and creative destruction just like in evolutionary natural selection, will remove unsuccessful firms from industry while making successful ones grow. Steam engine technology removed old technology transportation and total performance of logistics sector grew. ICT is much more efficient than steam engine. Removal of firms which are unsuccessful to perform ICT transformation will not cause a decline in economy. On the contrary, successful firms will generate enough benefits for the economy to grow.¹¹¹

Experimentation is very important for firms, especially for new entrants, to benefit from ICT investment. Bartelsman's study demonstrates cross-country differences of experimentation.¹¹² Allocating resources for experimentation including space, human resources and financial resources is important because of changing market environment. Experimentation for new business models of new firms in the United States is more than those in other OECD countries. Firms initialize at smaller scales in the United States, however they grow relatively rapid when successful. This

¹¹¹ OECD(2003), op. cit. p.89.

¹¹² Bartelsman et al., op. cit. p. 33.

occasion may be relevant with the lower fear to risk in the United States because of the financial system that supports innovative entrepreneurs with better opportunities, despite of its risk. In addition to this, US regulations make firms carry lower burdens to begin with a small scale, experiment and examine the market with their business model. If the model is successful then they grow. In case, they fail, the costs of failure will be less than other OECD countries.

The entry and exit costs are higher in other OECD countries relative to the United States. In case of rapid technological change, experimentation plays a vital role to generate new ideas and innovation to grow faster, sustaining higher levels of technological diffusion.

Decision makers do not evaluate investment in ICT only for competition and ICT costs; they also have to consider the complementary investment to make ICT investment beneficial. These complementary costs may involve training for employees, organizational change. It is often that these complementary investments cost much higher than the initial expenditures for ICT investment goods. Brynjolfsson and Hitt suggest that USD 1 of ICT investment may correspond to USD 9 of investment in intangible assets, for example employee competences and organizational practices.¹¹³ Organizational change management for ICT is generally costly and difficult for companies. Organization functions and jobs need to be aligned to ICT and employees mostly show resistance to it. Unions and some legal constraints may also limit the adapting projects. If employees are informed about the change and their ideas are taken into account, organizational change may be facilitated including workers competence improvement and organizational hierarchy. Government and social partners may also participate in this process in order to ensure people who hesitate.¹¹⁴

Association of management and workers will result in high trust company climate and higher levels of employee competence and skills. This is crucial for change management. Working time legislation and employment regulation may hamper this change. Management has to be ensured about it. Collective bargaining

¹¹³ Brynjolfsson, Hitt, op. cit. p. 9.

¹¹⁴ OECD(2003), op. cit. p. 90.

institutions should be adapted to the new working environment for ICT. Training workers to adapt the new technology is costly and requires remarkable investment. Since companies invest in ICT and burden high costs, management has to develop and use it efficiently. This task can be accomplished by gaining the right skills and competencies.¹¹⁵

Recruiting and training policies of human resources management have to address sustaining lifelong learning in order to obtain a good supply of qualified personnel. These policies should cover basic ICT literacy, building high level ICT skills such as mastering program developing languages like C++, C# or Java. Since ICT is a very dynamic and innovative technology, lifelong learning is very important for ICT professionals. ICT provides very useful tools to improve managerial and networking skills. For example, business intelligence or analytics (BI) tools and customer relationship management (CRM) softwares contribute to effective management. ICT also provides critical opportunities such as labor mobility; however business law changes are needed to benefit from it in some countries.¹¹⁶

The number of firm-level studies show that there is a positive correlation ICT investment and firm data: profitability, productivity and market shares. These firms enhanced their performance using ICT and innovation. Many cases show that innovation is linked to ICT. These firms also achieved adaptation of their organization and human resources. On the other hand, many companies could not succeed this transformation and they could not gain any by investing in ICT. ICT is not a remedy to cure all problems. Decision makers of the company have to manage this transformation process very carefully. Governments cannot induce firms to succeed it; however they can generate essential circumstances for firms. Creating a framework for corporate management may also play a critical role in this context.¹¹⁷

Fundamental economic and social stability have a key role to benefit from ICT investment policies successfully. All of the policies mentioned so far are strictly

¹¹⁵ OECD(2003), op. cit. p. 90.

¹¹⁶ OECD(2003), op. cit. p. 91.

¹¹⁷ OECD(2003), op. cit. p. 91.

joined to each other. If one of them is missing then the consequence will be failure. If the fundamentals are a good set of variables, country may manage to benefit from ICT investment successfully. Successful countries owe their economic success to competitive and more open economic environment, well-functioning institutions and markets and to sound macroeconomic policies.¹¹⁸ One of the inspiring examples of ICT-driven growth is Australia that shows a structural reform and the uptake of ICT interaction.¹¹⁹ On the other hand, some other countries' growth performance represents a decline. Probably, some of the fundamentals are missing or at least so weak to materialize the new dynamism for example lack of the right institutional structure to generate new business.

4.3. PROVIDING ADEQUATE SECURITY

Information networks that are mostly interconnected globally are utilized by important infrastructures, businesses, governments and consumers, therefore new security issues emerge, because electronic networks have to function stable and ready for safe, secure and reliable use under all circumstances. E-commerce still has barriers because of legal uncertainties such as uncertainty over payments, contracts, terms of delivery and guarantees. In addition to that, the privacy of personal data, security of payments and opportunities for redress stay to be an obstacle for business to customer transactions.

Either for firms or for consumers, the security and reliability of systems and information networks is significant. To address these problems much work has already done. Authentication and certification softwares and hardware are being developed to secure business transactions and keep user identity safe. To prevent damages from computer viruses, hacking and other threats, OECD has prepared new and extensive security guidelines that are being implemented by OECD countries. The purpose of these guidelines is to build up a "security culture" in the

¹¹⁸ OECD(2003), op. cit. p. 91.

¹¹⁹ Parham et al., op. cit. pp. 99-112.

information systems and network operations. Due to the growth of business to consumer e-commerce transactions, consumer complaints oriented from online environment is increasing.

In order to provide an international consensus on essential protection areas, the OECD privacy and consumer protection guidelines appear to be a significant step. Further efforts are needed to implement these guidelines is important and it will require synergic work of governments, business and civil society. As the usage of information technologies increases by easing access to information and improving users' skills to protect themselves for example using anti-virus softwares, consumer trust may be enhanced. Any trust related software or hardware may affect trust positively; however users have knowledge why these protection systems are needed. Therefore education and awareness raising policies are crucial. Furthermore, ensuring users that legislation is effectively applied in cross-border circumstances is a major problem.

Users' attitudes may cause some slowness to do business via the internet, but governments may contribute to change that by providing ICT applications themselves such as supplying digital public services (e.g. healthcare or education), collecting tax, tendering public services, procuring goods and services online may increase efficiency and improve access to public services. These efforts may result in gaining public confidence and strengthening demand as an additional benefit.

4.4. GROWTH OF THE SERVICES SECTOR

ICT has provided many benefits so far and has expected to do more. The service sector is especially significant in gaining benefits from ICT, because sectors like wholesale and retail trade, financial and business services are the most important ICT investors. Not ICT sector itself, these old sectors will have the most important effect of ICT use in the long-run. ICT has contributed to productivity growth in

some of these sectors in the United States and Australia. Policies should answer the needs and characteristics of the services sector to enhance their growth¹²⁰.

Decline of encourage to enhance performance and regulatory burdens limit competition and business dynamism in the number of services sectors. In addition to that, new ICT implementations are hampered by some industry-specific regulations that may also limit to benefit from ICT. In order to improve competition and innovation and to abolish barriers and administrative rules for entrepreneurs and entrants to market, regulatory structures have to be reformed. Reducing trade and foreign investment barriers in services sector may facilitate international competition. There is evidence that foreign-owned companies are adopting new technologies earlier than the domestic companies.

4.5. FACILITATING INNOVATION AND TECHNOLOGY DIFFUSION

Innovation is associated with ICT for many companies, because developing new products and services, initiating new business processes or implementing new applications generally need ICT. Companies have much more productive innovation process after ICT utility because ICT facilitates the innovation process, for instance scientific discovery takes less time. ICT has also enabled and encouraged networking that has facilitate better outsourcing of R&D and fostered informal learning among companies which plays an important role for innovation in services sector.

The OECD Growth Study shows that policies reveal the potential of innovation. Policies are also important to benefit from ICT. These policies may enhance innovative environment and this may lead to new growth opportunities to increase. In order to increase innovation, policy has to give higher priority to essential research and improve the efficiency of public R&D spending and encourage the flow of knowledge between science and industry.

¹²⁰ OECD(2003), op. cit. p. 92.

4.6. ICT IN TURKEY

Turkey has an appropriate ICT investment climate with its growing economy. Since there is a sizeable internal ICT market, the global companies prefer Turkey's strategic positioning to manage their growing markets.¹²¹

Since Turkish Statistic Institute does not have data on ICT, it cannot be measured if there is a correlation between ICT investment and long run growth. However, firms are investing in ICT in an inclining up trend. According to Gartner, ICT investment rose to USD 22 billion in 2012 and expected to be USD 25 billion by 2016.¹²² Among emerging economies Turkey has fourth place with 7.8 % ICT share in GDP where the world average is 4.8%.¹²³ ICT spending is expected to grow faster than the world average.

Telecommunications sector has great share in ICT investment. Current four major GSM and telecommunication operating companies have more than 60 million subscribers. The operating income of these companies is more than TL 30 billion in 2012. Internet subscribers are more than 20 million as of March 2013. The telecommunication industry has 36,865 employees in 2012. According to Turkish Statistics Institute (TUIK) 53.8% of the households' uses internet as of 2014 and the same ratio was 48.9 in 2013.¹²⁴

Nevertheless, greatest ICT spending comes from the banking sector and the government. With securities trading, manufacturing, natural resource management, communications, media and services sectors ICT spending reaches 68% of total ICT spending.

Turkish Government studies on legislation and policies for a fertile ICT environment. Some sectors particularly finance sector has obliged for security and all banks' infrastructure have to be compatible with COBIT (Control Objectives for Information and Related Technology). Some other sectors are obliged to be

¹²¹ Deloitte Report, ICT investment in Turkey, 2014, p. 9

¹²² Deloitte Report, p. 10

¹²³ Deloitte Report, p. 15

¹²⁴ TUIK(2014), Household Information Technologies Usage Survey.

compatible with ISO 27001 information security standard. New Turkish Trade Law has important issues on internet, for example firms are obliged to have a web site and publish particular company data.¹²⁵

According to government 2023 (hundredth anniversary of the foundation of Turkish Republic) goal, 80% of all citizens will be computer-literate.¹²⁶ Most of the population is familiar with social media.¹²⁷ An average internet user spends 32.7 hours online per month.¹²⁸ As of 2014, 60.2 of the total houses has access to internet, however the same ratio was 49.1% in 2013.¹²⁹ The ICT diffusion is very rapid due to infrastructure investments.

Since young population between ages 15 and 24 is 16.8% of total population, Turkey has a competitive advantage for ICT investment. Beyond that, exceptional well educated and high skilled workforces facilitate higher return of ICT investment. On the other hand, R&D professionals increased %14 between 2008 and 2009 and 16.4% between 2009 and 2010. Among undergraduate and graduate programs, ICT related engineering majors of universities are preferred by the best students. In 2012, 115,528 students admitted to undergraduate programs and graduate program student increased 29% relative to 2011. Besides, there are number of private education and training centers certifying students in ICT areas such as program coding, system and network management and database management.

Technology Development Zones (TDZ) also have a major role in ICT industry in Turkey. There are 50 TDZs (36 active and 14 under construction) and every year approximately 4 more is expected to open. 55% of the firms in TDZs is in software developing industry.¹³⁰ In addition to TDZs, firms have their own R&D Centers.

¹²⁵ Turkish Trade Law, act 1524.

¹²⁶ Deloitte Report, p. 16

¹²⁷ TUIK(2014), op. cit.

¹²⁸ Deloitte Report, p. 20

¹²⁹ TUIK(2014), op. cit.

¹³⁰ Deloitte Report, p. 34

There are 13 certified R&D centers in ICT business and 1,784 people are employed in these centers.¹³¹

The incentive programs make ICT investment favorable in Turkey. The major incentives are income tax gain exemption, corporate tax gain exemption, income tax exemption for researchers, developers and R&D personnel, social security premium support and value added tax exemption. The total amount of supply and exemption between 2001 and March 2012 reaches TL 1.44 billion.¹³² That is why government certifies the R&D centers. Only granted certification owners can benefit from these incentives.

Public ICT investment in ICT has represented increasing trend between 2002 and 2012. The amount of investment rises from TL 600 million (2002) to TL 2.5 billion (2012). The Fatih Project only itself has TL 803 million budgets in 2012. The project has the purpose to enhance education system by using ICT. The scope of the project covers providing equipment and software to 42,000 schools and 570,000 classes.¹³³ The project also brings many ICT-related business opportunities for investors in software, hardware and in the consulting industries. Besides, the ministry of education will conduct other projects to maintain the Fatih Project: e-book, e-school and kursiyernet.

The e-devlet Project has also very crucial role for information society and better public services. E-devlet portal has nearly 19 million¹³⁴ subscribers and citizens can check insurance, criminal, debt, loan, taxation records and court document investigations. Parents can check their children's grades or men can take military service documents. By January 2014, there are 100 institutions and 740 services available in the portal.¹³⁵

The information society goal is realistic for Turkey, because Turkish people rapidly adapt new technologies. The number of 3G subscribers is increasing and it reaches 43.9% of total subscribers in 2013. In emerging economies Turkey performs better

¹³¹ Deloitte Report, p. 35

¹³² Deloitte Report, p. 39

¹³³ Deloitte Report, p. 46

¹³⁴ <https://www.turkiye.gov.tr/>

¹³⁵ Deloitte Report, p. 45

than Russia and Brazil mobile revenues.¹³⁶ Turkish people also are used to e-commerce. By 2013, the size of e-commerce market reached TL 30.60 billion. E-commerce is one of the fastest growing sectors and expected to grow.¹³⁷ Since Turkey ranks 11th for internet usage with 36 million internet users, e-commerce industry is going to keep growing with strong GDP growth and increase in IT literacy.¹³⁸ E-commerce industry growth rate is 29% where the USA has 16.1%, UK has 17%, France has 22% and Germany has 8% growths in e-commerce industry in 2012.¹³⁹

E-commerce users' ratio in internet users was 24.1 in 2013 and it rose to 30.8% in 2014.¹⁴⁰

¹³⁶ Deloitte Report, p. 56

¹³⁷ Deloitte Report, p. 65

¹³⁸ Deloitte Report, p. 65

¹³⁹ Deloitte Report, p. 66

¹⁴⁰ TUIK(2014), op. cit.

CONCLUSIONS

Growth models have emphasized the importance of technology. Either exogenous models or endogenous models admit that technology has an influence on the long-run growth. Schumpeterian growth model gives an important role to innovation. Innovation process needs knowledge and information to function. Newton's standing on shoulders effect may correspond to this fact.

After 1980's, ICT started play a key role in science and business. Elaborate calculations or monotonous tasks could be accomplished by computers rapidly and successfully. Accessing information and gaining data had become much easier with the internet. Besides, ICT provides more productive and efficient working environment. Due to these remarkable benefits, firms invested in these technologies all over the world.

ICT contributes to growth for three main reasons: Firstly, it is a capital good and ICT investment enhances overall capital deepening, secondly it facilitates rapid technological development in the production of ICT goods and services and thirdly, ICT utility affects firms overall efficiency positively.

There are number of studies that point out the contribution of ICT to economic growth. Since ICT has a crucial role as a mean for economic growth, it is necessary to examine if ICT contribution of economic growth is a fact and to understand the significance of correlation between ICT investment and economic growth in some OECD countries. Therefore it could be possible for Turkey to encourage the utilization of ICT in order to boost economic growth.

The model utilized in this study is an endogenous model inspired by Romer and developed by Yousefi. Non-residential ICT investment and economic growth relation is examined in ten OECD countries (The United States, The United Kingdom, Germany, Japan, France, Spain, Italy, Sweden, Belgium and Canada). Results represent that ICT contribution to economic growth is a fact. The significance of the model changes among countries, however governance of ICT investment is important for the success of ICT investment.

The importance of innovation that is driven by ICT for long-run growth obliges governments and firms to develop a strategy in order to benefit from ICT efficiently. Firstly, these strategies have to involve enhancing competition in ICT industry, because only competitive ICT market generates innovation and efficiency. Secondly, providing a fertile environment for ICT has great importance, otherwise the transformation cannot be achieved. In order to succeed it, education policies can be handled. Thirdly, ICT may generate security problems. Legislative precautions have supreme importance for consumer trust. Fourthly, since services sector has a great share of GDP, encouraging private and public services sector for ICT investment may contribute to higher growth and finally, facilitating innovation and technology diffusion by utilizing incentives reveals the potential of innovation and increases efficiency of R&D activities.

Turkey has an important potential for ICT. Establishing a successful ICT strategy may result in a sustained long-run growth. Since the Turkish culture is fertile for ICT diffusion and adoption, current situation gives hope for the future. If initiated and planned projects reach expected consequences such as IT literate and information society, Turkey may be one of the technological hubs of the world. There are some signs that show the goal is achievable.

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APPENDIX A - THE WORLD BANK DATA

USA

Total
economy

Source: Bureau of Economic Analysis

Non residential GFCF by asset, current prices, billions of US dollars

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year				Total	Hardware	Communication Equipment	Other		Software	Other
1980	442	71	371	181	30	29	122	53	196	12
1981	503	83	420	205	36	33	136	55	228	14
1982	509	89	420	203	38	35	130	52	236	17
1983	504	103	401	211	47	36	128	60	212	20
1984	587	125	462	248	60	41	148	71	242	25
1985	636	136	499	263	62	45	156	77	266	29
1986	638	145	494	272	65	48	159	79	255	32
1987	651	149	502	279	64	49	166	77	258	36
1988	697	163	534	302	67	54	181	82	270	42
1989	750	181	569	334	75	54	205	78	285	52
1990	779	185	593	334	69	57	208	81	304	60
1991	761	193	567	321	69	56	197	82	291	68
1992	779	209	570	342	78	58	206	85	281	73
1993	836	224	612	370	84	60	226	100	288	79
1994	906	241	664	404	89	69	246	119	301	83
1995	998	271	726	451	104	77	270	128	330	90
1996	1075	299	776	483	111	85	287	135	357	103
1997	1183	342	841	518	119	95	303	148	394	128
1998	1286	374	912	558	124	103	331	160	423	147
1999	1403	429	974	588	131	118	339	189	448	181
2000	1534	491	1043	645	136	147	362	186	496	208
2001	1507	457	1051	605	116	132	358	170	523	209
2002	1421	413	1008	569	106	103	360	157	490	204
2003	1438	415	1023	581	107	99	374	149	495	208
2004	1536	431	1105	603	108	102	392	177	527	220
2005	1677	444	1232	653	109	102	442	199	582	233
2006	1862	477	1385	703	117	113	472	217	686	246
2007	2026	526	1500	737	129	121	488	200	815	277
2008	2099	552	1547	749	126	128	495	152	904	299

Japan

Total
economy

Source: Source: Cabinet Office (ESRI)

Non residential GFCF by asset, current prices, billions of yens

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year				Total	Hardware	Communication Equipment	Other		Software	Other
1980										
1981										
1982										
1983										
1984										
1985										
1986										
1987										
1988										
1989										
1990	116665	10336	106329	43700	5061	2317	36323	9833	52476	2958 7698
1991	123957	11745	112212	45116	5147	2460	37509	9478	56946	4138 8278
1992	122472	11756	110716	43004	5254	2191	35560	9339	57274	4312 8542
1993	116755	11258	105497	39359	5233	2303	31823	8826	55815	3722 9034
1994	111495	10752	100743	36745	4886	2463	29397	8611	53323	3403 9412
1995	112218	12107	100111	39868	5560	2986	31323	9538	49755	3562 9494
1996	116126	14632	101494	44340	6817	4012	33511	9709	48164	3803 10111
1997	120101	14569	105533	45628	6810	3695	35123	9750	51277	4063 9383
1998	111972	13405	98567	42319	5848	3119	33351	8206	48573	4438 8437
1999	108348	14104	94245	41030	5969	3025	32036	8746	45883	5110 7580
2000	108363	16271	92092	41507	6417	3172	31917	8987	43590	6681 7598
2001	105919	15944	89975	39711	6013	2348	31350	9536	41968	7584 7121
2002	98190	14537	83653	34422	4979	1924	27519	9581	40298	7634 6255
2003	96021	14229	81792	33967	4805	1961	27201	9950	38644	7463 5997
2004	97223	14207	83016	35192	4819	1853	28520	9723	38824	7534 5950
2005	101090	14436	86653	38188	4972	1803	31413	10355	38753	7661 6133
2006	102597	13741	88856	38729	3879	1858	32993	10193	39522	8004 6149
2007	106205	13979	92226	40262	4041	1804	34417	10159	41565	8134 6086

United Kingdom

Total
economy

Source: EUKLEMS

Non residential GFCF by asset, current prices, millions of pounds sterling

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year	Total			Hardware	Communication Equipment	Other			Software	Other
1980	31793	2511	29282	13784	1041	625	12117	4906	12259	845
1981	32249	3021	29228	14147	1312	716	12120	4163	12945	994
1982	35431	3655	31776	15632	1634	812	13185	4651	13940	1209
1983	37438	4428	33010	17195	2067	933	14196	4892	13922	1429
1984	42775	5367	37408	19615	2575	1061	15979	6109	15321	1731
1985	47909	6682	41227	22798	3184	1226	18388	6970	15869	2272
1986	49584	7735	41849	23003	3630	1410	17964	6735	17150	2695
1987	56643	8951	47692	25215	4258	1632	19325	8081	20286	3061
1988	67539	10759	56779	28966	4952	1887	22126	9345	25309	3919
1989	81818	13239	68579	33690	6105	2172	25413	10853	32313	4962
1990	87956	14016	73941	34238	6011	2196	26031	10818	37092	5808
1991	84415	15370	69045	32771	5737	1820	25214	9312	34519	7812
1992	79652	14744	64908	32603	5873	1946	24784	8511	31614	6924
1993	78772	15016	63757	32690	5991	1905	24794	9447	29516	7120
1994	85010	17702	67308	35288	7244	2532	25512	11641	30155	7926
1995	94872	21806	73066	42664	8726	4396	29542	11425	32099	8684
1996	101341	25456	75885	46191	10227	5261	30702	12258	32925	9967
1997	106482	25391	81091	46674	9335	4618	32722	12610	35759	11439
1998	122593	31363	91229	52693	11742	6128	34822	16133	40274	13493
1999	126041	34262	91779	53206	12105	6942	34159	14686	42934	15215
2000	130510	39188	91321	56963	13136	9257	34569	13577	43175	16795
2001	131417	36848	94569	54717	11772	7965	34981	14656	44932	17111
2002	133192	35247	97945	51547	11278	6199	34069	16314	47562	17769
2003	135594	33222	102372	49351	10344	4572	34435	15642	52295	18306
2004	138663	34670	103994	55410	10867	5418	39125	14339	50530	18385
2005	145342	35754	109588	54974	11545	5313	38116	14763	56709	18896
2006	152473	37731	114742	56583	12086	5195	39301	14884	60557	20450
2007	168950	40152	128798	63226	12476	5836	44915	15392	68491	21840

France

Total
economy

Source: Institut National de la Statistique et des Etudes Economiques

Non residential GFCF by asset, current prices, millions of euros

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year				Total	Hardware	Communi- cation Equipment	Other		Software	Other
1980	63000	4800	58200	23500	1100	1800	20600	6300	31300	1900
1981	69300	5500	63800	25900	1300	1900	22700	6800	34300	2300
1982	78900	6700	72200	29200	1600	2100	25500	8000	38700	3000
1983	82000	8100	73900	30600	1900	2500	26200	8300	39400	3700
1984	86700	9800	76900	32900	2300	2800	27800	7900	41200	4700
1985	94100	11500	82600	36700	3000	3100	30600	8600	43400	5400
1986	103300	12800	90500	40100	3400	3600	33100	9500	47900	5800
1987	113000	14300	98700	43500	4000	3900	35600	10800	52300	6400
1988	128300	16200	112100	48100	4300	4300	39500	12800	59800	7600
1989	141700	17900	123800	53000	4600	4800	43600	15100	65100	8500
1990	152000	18100	133900	56800	5500	4600	46700	16100	71100	8000
1991	159000	18300	140700	57300	5300	4600	47400	16400	76900	8400
1992	153800	18100	135700	53400	4300	4700	44400	15200	76100	9100
1993	142600	17800	124800	50600	4700	4600	41300	14000	69500	8500
1994	144000	18800	125200	53700	5000	4900	43800	14600	66800	8900
1995	146900	20400	126500	54900	5400	4800	44700	15900	65900	10200
1996	150000	23200	126800	56100	5600	5200	45300	16400	65100	12400
1997	150000	26300	123700	56700	5700	5700	45300	15800	62600	14900
1998	163100	30500	132600	62000	6100	6700	49200	18300	65100	17700
1999	177700	35300	142400	66200	8500	5900	51800	21500	69100	20900
2000	199100	38300	160800	73500	8900	6800	57800	22600	80400	22600
2001	206700	42400	164300	74100	9400	7800	56900	23500	83900	25200
2002	202400	38900	163500	69000	7500	6800	54700	23500	85300	24600
2003	207500	38500	169000	68300	8600	5400	54300	24600	90100	24500
2004	219400	38700	180700	70500	8100	5400	57000	25500	98200	25200
2005	233700	40600	193100	73700	7500	6200	60000	27300	105800	26900
2006	249000	42400	206600	76000	7200	6200	62600	28500	115500	29000
2007	273000	43900	229100	83400	6100	6500	70800	32100	126200	31300
2008	285400	45700	239700	86800	5900	6300	74600	33100	132000	33500

Canada

Total
economy

Source: Statistics Canada

Non residential GFCF by asset, current prices, millions of Canadian dollars

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year				Total	Hardware	Communication Equipment	Other		Software	Other
1980										
1981	66954	5715	61239	22295	2559	2083	17653	7118	36468	1073
1982	65011	5697	59314	21663	2346	2010	17307	5229	36778	1341
1983	61851	6376	55475	19901	2974	1825	15102	6375	33998	1577
1984	65282	7044	58238	20276	3116	1999	15161	8057	35020	1929
1985	72395	8007	64388	22466	3621	2142	16703	8931	38754	2244
1986	74437	8590	65847	25342	3373	2474	19495	9225	37127	2743
1987	81691	10228	71463	27578	4020	3017	20541	11167	39755	3191
1988	93806	11641	82165	31229	4274	3440	23515	13601	45049	3927
1989	101812	12793	89019	34585	4659	3677	26249	13698	49072	4457
1990	102608	13572	89036	33878	4646	3858	25374	11926	51736	5068
1991	97056	13820	83236	32511	4436	4068	24007	9601	49628	5316
1992	90844	14639	76205	31088	4804	4347	21937	10770	43498	5488
1993	91104	15433	75671	31064	4585	4228	22251	9763	43657	6620
1994	102289	16754	85535	33573	5224	3953	24396	11920	49219	7577
1995	106686	17895	88791	36584	6042	4249	26293	12761	49737	7604
1996	110181	19866	90315	38586	6952	4428	27206	12382	50727	8486
1997	131076	22959	108117	45735	7602	5791	32342	18188	57587	9566
1998	139104	26103	113001	50006	9881	5438	34687	19720	58594	10784
1999	149113	29680	119433	52578	11022	6806	34750	22724	61959	11852
2000	157430	32448	124982	56567	11974	8246	36347	23289	65346	12228
2001	161905	32694	129211	55400	10944	8255	36201	22191	70819	13495
2002	159248	30628	128620	52824	10284	7463	35077	23604	69939	12881
2003	165162	30974	134188	53013	10373	6679	35961	23961	74266	13922
2004	178926	33170	145756	56015	11499	6459	38057	23700	83999	15212
2005	202582	35650	166932	60533	11873	6252	42408	26559	97965	17525
2006	225189	38191	186998	65891	13517	6345	46029	27532	113437	18329
2007	238046	39261	198785	67005	12269	6785	47951	26975	123859	20207
2008	253618	41037	212581	69341	11645	7772	49924	25645	137012	21620

Germany

Total
economy

Source: Statistisches Bundesamt Deutschland

Non residential GFCF by asset, current prices, millions of euros

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products		
Year				Total	Hardware	Communication Equipment	Other		Software	Other	
1980											
1981											
1982											
1983											
1984											
1985											
1986											
1987											
1988											
1989											
1990											
1991	262780	36063	226718	116830	13980	12310	90540	36880	96040	9773	3258
1992	277140	36280	240860	116520	13010	12890	90620	34200	112580	10380	3460
1993	260110	34235	225875	103210	11360	12120	79730	27070	115490	10755	3585
1994	263420	34245	229175	100740	11610	11250	77880	27530	119970	11385	3795
1995	262710	34840	227870	101170	12000	10840	78330	28650	116890	12000	4000
1996	258070	36390	221680	101660	12510	11040	78110	30210	109080	12840	4280
1997	260350	37643	222708	103160	13530	10320	79310	34060	104740	13793	4598
1998	272280	41608	230673	112960	15480	10790	86690	37100	101770	15338	5113
1999	284300	47083	237218	121330	18070	12070	91190	38260	102120	16943	5648
2000	301640	52638	249003	132490	20960	13640	97890	44170	100930	18038	6013
2001	290680	51750	238930	129310	19280	13780	96250	38050	98400	18690	6230
2002	268710	45635	223075	116440	17100	10040	89300	35410	92200	18495	6165
2003	263620	40453	223168	107950	13430	8700	85820	41300	89940	18323	6108
2004	266100	39303	226798	108830	11440	9210	88180	45680	86720	18653	6218
2005	272100	39303	232798	112370	11440	9210	91720	48930	85930	18653	6218
2006	295050	41325	253725	121770	13320	8910	99540	56580	91240	19095	6365
2007	321900	45375	276525	134890	15380	10030	109480	61640	98750	19965	6655
2008	337170	45320	291850	141330	15040	9520	116770	60460	107700	20760	6920

Spain

Total
economy

Source: Instituto Valenciano de Investigaciones Economicas

Non residential GFCF by asset, current prices, millions of euros

	Total	Total ICT	Total Non-ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products		
Year				Total	Hardware	Communication Equipment	Other		Software	Other	
1980	14602	1253	13349	5430	441	601	4388	1757	6967	212	237
1981	16257	1573	14685	5969	526	779	4664	2106	7662	267	252
1982	18769	2004	16766	6562	612	1049	4901	2889	8734	343	242
1983	21489	2588	18900	7706	895	1247	5564	2886	10175	447	275
1984	22314	3113	19201	8542	1121	1416	6006	2163	10733	577	299
1985	26251	3671	22580	10097	1432	1480	7186	2680	12385	760	329
1986	31005	4518	26487	11802	1671	1867	8264	3195	14645	981	382
1987	37165	5635	31530	14376	1955	2481	9940	4262	16900	1199	428
1988	44635	6748	37887	17091	2279	2995	11817	5276	20359	1475	436
1989	54181	7884	46297	19420	2552	3495	13373	6209	26224	1837	491
1990	60577	8293	52284	19890	2631	3556	13703	6452	31624	2106	505
1991	65275	8137	57138	19784	2730	3115	13939	6617	36064	2292	518
1992	64507	7496	57011	19171	2539	2616	14016	6486	35928	2341	581
1993	60119	7554	52565	16472	2293	2890	11289	5675	34894	2371	707
1994	64007	8235	55772	17472	2506	3104	11862	6367	36972	2624	571
1995	71986	9004	62983	20296	2911	3209	14176	7320	40919	2884	569
1996	73270	10669	62601	23654	3418	3987	16250	7783	38019	3265	549
1997	80264	11620	68643	26476	3745	4330	18400	9663	39925	3545	655
1998	90476	13320	77157	31230	3924	5297	22009	11606	42799	4099	743
1999	102232	15244	86989	34499	4215	6008	24276	13921	48063	5021	729
2000	114126	16738	97389	38146	4490	6827	26829	16096	53239	5420	1225
2001	121037	16542	104495	38325	4519	5869	27937	16091	59372	6154	1095
2002	127018	15676	111342	37889	4082	5309	28499	15705	65454	6286	1683
2003	136149	15081	121069	39075	4030	4679	30367	17511	70564	6372	2627
2004	147667	16528	131138	40871	4029	5688	31155	19360	77489	6812	3133
2005	165054	17956	147098	45202	4264	6331	34607	21612	87061	7361	3818
2006	183996	19246	164750	50417	4545	7003	38869	24115	97400	7698	4366

Belgium

Total
economy

Source: EUKLEMS

Non residential GFCF by asset, current prices, millions of euros

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year	Total			Total	Hardware	Communi- cation Equipment	Other		Software	Other
1980	14966	1537	13430	4669	1043	285	3341	1972	8117	209
1981	15016	1750	13266	4685	1134	367	3185	2004	8078	249
1982	16013	1950	14063	5134	1341	281	3512	2129	8422	328
1983	15881	2173	13708	5289	1610	154	3525	2210	7972	409
1984	16902	2936	13966	6133	2071	314	3749	2438	7780	552
1985	17928	3594	14334	6756	2470	425	3861	2459	8014	699
1986	18734	3557	15177	7081	2506	236	4339	2719	8119	815
1987	19479	3109	16369	7361	2108	283	4971	3175	8223	719
1988	22470	3854	18616	8886	2405	629	5852	3463	9301	820
1989	26067	4778	21289	11155	2880	876	7399	4211	9679	1023
1990	28967	5113	23853	12708	3043	995	8670	4714	10470	1075
1991	28857	5140	23717	12158	2950	1088	8120	4314	11283	1102
1992	29590	5578	24012	12339	3078	1196	8065	4444	11503	1303
1993	28731	4581	24150	11975	2181	1347	8447	4196	11507	1053
1994	29113	4917	24196	11638	2431	1290	7917	4214	12065	1196
1995	29439	5297	24142	13226	2696	1293	9237	4206	10699	1308
1996	31236	5753	25483	14250	2940	1426	9884	4300	11299	1387
1997	33294	6449	26845	15973	3237	1665	11071	4141	11632	1547
1998	35203	7560	27643	16784	3746	1766	11273	4290	12080	2049
1999	37322	8108	29214	17718	3855	2031	11832	5340	12041	2222
2000	40186	9743	30443	19877	5450	2037	12390	6020	12034	2255
2001	40587	9442	31145	20033	5051	1980	13001	6064	12080	2411
2002	38297	7791	30507	18957	4007	1715	13235	5774	11498	2069
2003	37849	7543	30306	18649	3941	1468	13240	5716	11350	2134
2004	39308	7907	31401	19393	4099	1640	13654	5944	11803	2168

Italy

Total
economy

Source: Istituto nazionale di statistica

Non residential GFCF by asset, current prices, millions of euros

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery		Transport equipment	Non residential construction	Other products		
Year				Total	Hardware	Communication Equipment		Software	Other	
1980	37504	3180	34324	20005	1178	1723	17104	4177	13043	279
1981	44798	3826	40972	21942	1507	1859	18575	5386	17010	460
1982	49834	4536	45297	24043	1785	2109	20149	5876	19273	642
1983	53111	5179	47932	25308	1955	2411	20942	6038	20952	813
1984	61117	6610	54508	30471	2640	2840	24992	6878	22638	1131
1985	68515	7328	61187	33948	2718	3175	28056	7693	25438	1435
1986	74389	8613	65776	35905	2806	3481	29619	8066	28091	2327
1987	83335	10168	73167	41263	3156	4113	33994	9206	29967	2899
1988	95284	11954	83330	48126	3672	4779	39675	10496	33159	3504
1989	105412	12960	92452	52080	3760	5354	42967	12208	37278	3846
1990	116205	14098	102107	55956	4029	5943	45985	13087	43035	4126
1991	122607	14905	107702	58808	4055	6428	48325	13094	46283	4421
1992	124686	15610	109075	59280	3949	6653	48678	13795	46602	5009
1993	110453	14249	96204	51908	2716	6558	42633	11474	42097	4975
1994	115326	15570	99755	57886	3330	6945	47610	12642	39503	5295
1995	131841	17085	114756	65808	3706	7469	54632	16709	43415	5910
1996	140590	19169	121421	68766	4126	8092	56548	18239	46634	6951
1997	148258	21914	126344	74485	4676	9981	59829	18863	47652	7257
1998	159720	22569	137151	80176	5126	9397	65653	22561	48937	8046
1999	169002	23382	145620	82833	5456	9045	68332	25826	51462	8881
2000	185533	27031	158501	91306	7032	10421	73854	27514	57133	9579
2001	195318	26645	168673	92132	6633	9510	75989	30121	62563	10502
2002	208009	25636	182374	95186	6372	8390	80424	31976	69974	10874
2003	204889	23726	181163	92265	5503	7828	78934	29171	73058	10395
2004	214257	24447	189810	97035	6177	8490	82369	30031	77410	9781
2005	218487	25453	193034	100269	6503	8830	84935	29903	78196	10120
2006	229771	25029	204742	108181	6572	7878	93731	31498	79514	10579

Sweden

Total
economy

Source : Statistics Sweden

Non residential GFCF by asset, current prices, millions of Swedish krona

	Total	ICT	Non ICT	Products of agriculture, metal products and machinery			Transport equipment	Non residential construction	Other products	
Year	Total			Hardware	Communi- cation Equipment	Other			Software	Other
1980	95276	8901	86374	49130	4093	2963	42075	5306	38994	1845
1981	96304	9987	86317	48738	4266	3605	40867	5373	40077	2116
1982	107184	11385	95799	55577	4861	3848	46867	6105	42826	2676
1983	122151	15036	107114	64635	6582	4687	53366	7254	46494	3767
1984	134223	18951	115272	71285	7975	6183	57128	8236	49908	4793
1985	158813	23334	135479	88486	10607	5957	71922	10113	53445	6770
1986	167760	25235	142525	91961	11093	6012	74856	10479	57189	8130
1987	189126	29096	160030	106065	12847	6369	86849	12000	61181	9880
1988	211553	33874	177680	119656	15599	6288	97770	13525	66385	11988
1989	257420	38708	218712	145973	17476	7242	121256	16265	81191	13990
1990	265188	39193	225995	148445	17545	7673	123226	16581	86187	13975
1991	236335	38572	197763	122176	16703	7798	97675	14102	85985	14071
1992	199755	38462	161293	97072	15633	7907	73532	11690	76072	14922
1993	182148	46829	135319	80043	17726	9803	52514	10740	72065	19300
1994	213177	52657	160520	96305	21548	10309	64448	14351	81721	20800
1995	249680	60206	189474	117344	23897	12179	81268	16069	92137	24130
1996	257309	59924	197385	121099	23185	10439	87475	19587	90323	26300
1997	262009	65065	196944	123933	24493	10563	88877	21810	86257	30009
1998	287599	77879	209720	133061	29428	10591	93042	25406	91272	37860
1999	316979	91057	225922	142644	31179	12989	98476	36870	90576	46889
2000	340992	106875	234117	147507	33871	17030	96606	41592	95919	55974
2001	340972	97691	243281	143845	28002	14667	101176	35375	106730	55022
2002	331330	87211	244119	137134	25508	11967	99659	34482	109978	49736
2003	327970	81145	246825	133333	23289	8112	101932	36890	108003	49744
2004	341812	83162	258650	137632	23450	6430	107752	36942	113956	53282
2005	372280	95404	276876	159821	28291	10379	121151	38253	117472	56734
2006	404626	101169	303457	166958	29555	10842	126561	43293	133603	60772

APPENDIX B - PENN WORLD TABLE

Country	Year	Population	Exchange Rate	Currency	GDP (in \$)
Belgium	1980	9.846.800	0,72	Euro	103.072.810.000
Belgium	1981	9.852.400	0,92	Euro	108.680.140.000
Belgium	1982	9.856.300	1,13	Euro	114.589.420.000
Belgium	1983	9.855.520	1,27	Euro	118.740.890.000
Belgium	1984	9.855.300	1,43	Euro	126.490.230.000
Belgium	1985	9.858.200	1,47	Euro	132.977.660.000
Belgium	1986	9.861.800	1,11	Euro	141.986.010.000
Belgium	1987	9.870.200	0,93	Euro	150.995.320.000
Belgium	1988	9.884.000	0,91	Euro	165.848.340.000
Belgium	1989	9.937.700	0,98	Euro	180.081.250.000
Belgium	1990	9.969.310	0,83	Euro	193.473.420.000
Belgium	1991	10.004.490	0,85	Euro	203.177.430.000
Belgium	1992	10.045.620	0,80	Euro	212.466.880.000
Belgium	1993	10.085.430	0,86	Euro	215.920.350.000
Belgium	1994	10.122.910	0,83	Euro	227.584.530.000
Belgium	1995	10.155.460	0,73	Euro	237.154.370.000
Belgium	1996	10.178.930	0,77	Euro	242.018.890.000
Belgium	1997	10.199.790	0,89	Euro	254.725.750.000
Belgium	1998	10.217.030	0,90	Euro	261.418.130.000
Belgium	1999	10.235.660	0,94	Euro	272.892.590.000
Belgium	2000	10.263.620	1,09	Euro	286.668.500.000
Belgium	2001	10.291.680	1,12	Euro	294.536.270.000
Belgium	2002	10.311.970	1,06	Euro	305.676.950.000
Belgium	2003	10.330.820	0,89	Euro	313.639.610.000
Belgium	2004	10.348.280	0,81	Euro	331.570.910.000
Belgium	2005	10.364.390	0,80	Euro	349.485.780.000
Belgium	2006	10.379.070	0,80	Euro	370.449.240.000
Belgium	2007	10.392.230	0,73	Euro	394.263.430.000
Belgium	2008	10.404.000	0,71	Euro	404.671.790.000
Belgium	2009	10.414.000	0,72	Euro	401.767.720.000
Canada	1980	24.593.300	1,17	Canadian Dollar	283.204.440.000
Canada	1981	24.900.000	1,20	Canadian Dollar	313.672.220.000
Canada	1982	25.201.900	1,23	Canadian Dollar	322.736.590.000
Canada	1983	25.456.300	1,23	Canadian Dollar	344.091.810.000
Canada	1984	25.701.800	1,30	Canadian Dollar	375.124.390.000
Canada	1985	25.941.600	1,37	Canadian Dollar	401.770.780.000
Canada	1986	26.203.800	1,39	Canadian Dollar	418.523.180.000
Canada	1987	26.549.700	1,33	Canadian Dollar	453.794.370.000
Canada	1988	26.894.800	1,23	Canadian Dollar	492.681.580.000

Canada	1989	27.379.300	1,18	Canadian Dollar	528.345.090.000
Canada	1990	27.790.600	1,17	Canadian Dollar	548.596.760.000
Canada	1991	28.117.900	1,15	Canadian Dollar	552.451.320.000
Canada	1992	28.544.890	1,21	Canadian Dollar	568.366.200.000
Canada	1993	28.953.340	1,29	Canadian Dollar	591.036.370.000
Canada	1994	29.330.810	1,37	Canadian Dollar	630.110.140.000
Canada	1995	29.690.530	1,37	Canadian Dollar	667.986.900.000
Canada	1996	30.026.320	1,36	Canadian Dollar	694.181.620.000
Canada	1997	30.305.600	1,38	Canadian Dollar	730.650.700.000
Canada	1998	30.551.660	1,48	Canadian Dollar	753.157.720.000
Canada	1999	30.820.260	1,49	Canadian Dollar	810.558.000.000
Canada	2000	31.099.560	1,49	Canadian Dollar	888.844.010.000
Canada	2001	31.376.740	1,55	Canadian Dollar	919.740.040.000
Canada	2002	31.640.960	1,57	Canadian Dollar	952.505.500.000
Canada	2003	31.889.310	1,40	Canadian Dollar	1.011.523.120.000
Canada	2004	32.134.760	1,30	Canadian Dollar	1.091.705.710.000
Canada	2005	32.386.380	1,21	Canadian Dollar	1.180.454.090.000
Canada	2006	32.656.680	1,13	Canadian Dollar	1.259.900.120.000
Canada	2007	32.935.960	1,07	Canadian Dollar	1.342.941.050.000
Canada	2008	33.213.000	1,22	Canadian Dollar	1.417.466.750.000
Canada	2009	33.487.000	1,05	Canadian Dollar	1.340.246.220.000
France	1980	55.110.240	0,64	Euro	559.413.480.000
France	1981	55.398.580	0,83	Euro	608.903.700.000
France	1982	55.696.960	1,00	Euro	656.665.290.000
France	1983	55.929.110	1,16	Euro	691.962.900.000
France	1984	56.245.830	1,33	Euro	727.313.180.000
France	1985	56.489.820	1,37	Euro	762.497.070.000
France	1986	56.725.300	1,06	Euro	815.236.870.000
France	1987	56.988.960	0,92	Euro	863.002.840.000
France	1988	57.254.620	0,91	Euro	935.949.650.000
France	1989	57.821.320	0,97	Euro	1.006.104.620.000
France	1990	58.168.160	0,83	Euro	1.075.226.020.000
France	1991	58.514.110	0,86	Euro	1.119.553.770.000
France	1992	58.858.690	0,81	Euro	1.164.432.100.000
France	1993	59.169.210	0,86	Euro	1.177.835.210.000
France	1994	59.444.740	0,85	Euro	1.227.930.130.000
France	1995	59.712.210	0,76	Euro	1.278.454.680.000
France	1996	59.980.820	0,78	Euro	1.315.143.500.000
France	1997	60.253.880	0,89	Euro	1.366.212.820.000
France	1998	60.534.770	0,90	Euro	1.425.244.820.000

France	1999	60.823.980	0,94	Euro	1.494.063.200.000
France	2000	61.136.520	1,09	Euro	1.576.913.550.000
France	2001	61.479.300	1,12	Euro	1.644.585.660.000
France	2002	61.828.990	1,06	Euro	1.700.661.910.000
France	2003	62.171.390	0,89	Euro	1.756.497.930.000
France	2004	62.534.160	0,81	Euro	1.850.379.330.000
France	2005	62.911.520	0,80	Euro	1.948.595.830.000
France	2006	63.292.510	0,80	Euro	2.050.049.970.000
France	2007	63.681.740	0,73	Euro	2.175.614.720.000
France	2008	64.058.000	0,71	Euro	2.260.066.000.000
France	2009	64.420.000	0,72	Euro	2.215.112.510.000
Germany	1980	78.297.900	0,93	Euro	793.964.580.000
Germany	1981	78.401.830	1,16	Euro	854.968.350.000
Germany	1982	78.335.270	1,24	Euro	896.810.540.000
Germany	1983	78.121.650	1,31	Euro	947.522.770.000
Germany	1984	77.855.420	1,46	Euro	1.002.198.740.000
Germany	1985	77.684.910	1,51	Euro	1.052.739.710.000
Germany	1986	77.713.490	1,11	Euro	1.136.842.150.000
Germany	1987	77.718.300	0,92	Euro	1.203.103.120.000
Germany	1988	78.030.570	0,90	Euro	1.288.657.700.000
Germany	1989	78.644.910	0,96	Euro	1.377.877.040.000
Germany	1990	79.380.390	0,83	Euro	1.510.698.090.000
Germany	1991	79.984.240	0,85	Euro	1.631.289.370.000
Germany	1992	80.597.760	0,80	Euro	1.715.917.510.000
Germany	1993	81.132.270	0,85	Euro	1.745.683.250.000
Germany	1994	81.414.160	0,83	Euro	1.830.618.300.000
Germany	1995	81.653.700	0,73	Euro	1.910.616.110.000
Germany	1996	81.890.670	0,77	Euro	1.957.092.710.000
Germany	1997	82.011.070	0,89	Euro	2.008.580.140.000
Germany	1998	82.023.670	0,90	Euro	2.067.951.540.000
Germany	1999	82.074.780	0,94	Euro	2.146.628.740.000
Germany	2000	82.184.000	1,09	Euro	2.234.538.350.000
Germany	2001	82.321.000	1,12	Euro	2.311.361.660.000
Germany	2002	82.458.000	1,06	Euro	2.363.562.020.000
Germany	2003	82.505.000	0,89	Euro	2.416.938.870.000
Germany	2004	82.487.000	0,81	Euro	2.511.697.830.000
Germany	2005	82.439.000	0,80	Euro	2.605.948.640.000
Germany	2006	82.346.000	0,80	Euro	2.769.481.040.000
Germany	2007	82.237.000	0,73	Euro	2.942.480.250.000
Germany	2008	82.065.000	0,71	Euro	3.058.539.560.000

Germany	2009	81.838.000	0,72	Euro	2.964.652.120.000
Italy	1980	56.451.250	0,44	Euro	525.770.540.000
Italy	1981	56.502.490	0,59	Euro	574.691.310.000
Italy	1982	56.535.640	0,70	Euro	613.743.750.000
Italy	1983	56.630.130	0,78	Euro	644.629.180.000
Italy	1984	56.696.960	0,91	Euro	690.371.190.000
Italy	1985	56.731.210	0,99	Euro	731.425.220.000
Italy	1986	56.733.830	0,77	Euro	789.130.170.000
Italy	1987	56.729.700	0,67	Euro	844.712.490.000
Italy	1988	56.734.030	0,67	Euro	907.888.270.000
Italy	1989	56.737.530	0,71	Euro	973.866.750.000
Italy	1990	56.742.890	0,62	Euro	1.042.108.600.000
Italy	1991	56.715.000	0,64	Euro	1.101.398.870.000
Italy	1992	56.909.000	0,64	Euro	1.131.198.070.000
Italy	1993	57.087.000	0,81	Euro	1.135.835.500.000
Italy	1994	57.198.000	0,83	Euro	1.180.562.670.000
Italy	1995	57.295.000	0,84	Euro	1.235.720.900.000
Italy	1996	57.406.000	0,80	Euro	1.271.708.600.000
Italy	1997	57.493.000	0,88	Euro	1.314.831.890.000
Italy	1998	57.567.000	0,90	Euro	1.352.374.250.000
Italy	1999	57.656.000	0,94	Euro	1.400.110.950.000
Italy	2000	57.784.000	1,09	Euro	1.461.629.200.000
Italy	2001	57.931.000	1,12	Euro	1.525.763.610.000
Italy	2002	58.077.000	1,06	Euro	1.568.936.140.000
Italy	2003	58.336.000	0,89	Euro	1.609.372.480.000
Italy	2004	58.716.000	0,81	Euro	1.677.255.120.000
Italy	2005	59.038.000	0,80	Euro	1.734.283.100.000
Italy	2006	59.273.000	0,80	Euro	1.818.916.190.000
Italy	2007	59.627.000	0,73	Euro	1.913.752.400.000
Italy	2008	60.091.000	0,71	Euro	1.939.097.350.000
Italy	2009	60.462.000	0,72	Euro	1.867.948.740.000
Japan	1980	116.807.310	226,74	Yen	1.153.396.840.000
Japan	1981	117.648.090	220,54	Yen	1.305.665.990.000
Japan	1982	118.454.970	249,08	Yen	1.412.101.520.000
Japan	1983	119.269.950	237,51	Yen	1.491.763.360.000
Japan	1984	120.034.700	237,52	Yen	1.602.429.160.000
Japan	1985	120.754.340	238,54	Yen	1.742.798.850.000
Japan	1986	121.491.910	168,52	Yen	1.863.821.920.000
Japan	1987	122.091.320	144,64	Yen	1.997.804.830.000
Japan	1988	122.613.000	128,15	Yen	2.206.647.400.000

Japan	1989	123.107.500	137,96	Yen	2.405.586.360.000
Japan	1990	123.537.400	144,79	Yen	2.627.107.310.000
Japan	1991	123.946.270	134,71	Yen	2.802.012.920.000
Japan	1992	124.329.270	126,65	Yen	2.888.117.280.000
Japan	1993	124.668.020	111,20	Yen	2.951.248.130.000
Japan	1994	125.014.050	102,21	Yen	3.029.334.200.000
Japan	1995	125.341.350	94,06	Yen	3.158.187.560.000
Japan	1996	125.645.310	108,78	Yen	3.277.816.520.000
Japan	1997	125.956.490	120,99	Yen	3.351.942.940.000
Japan	1998	126.246.090	130,91	Yen	3.300.091.840.000
Japan	1999	126.494.400	113,91	Yen	3.338.756.370.000
Japan	2000	126.729.220	107,77	Yen	3.512.216.190.000
Japan	2001	126.971.910	121,53	Yen	3.598.691.110.000
Japan	2002	127.187.240	125,39	Yen	3.667.938.790.000
Japan	2003	127.357.740	115,93	Yen	3.783.224.300.000
Japan	2004	127.480.500	108,19	Yen	3.984.782.260.000
Japan	2005	127.537.190	110,22	Yen	4.178.261.890.000
Japan	2006	127.515.170	116,30	Yen	4.369.745.520.000
Japan	2007	127.433.490	117,75	Yen	4.589.536.690.000
Japan	2008	127.288.000	90,75	Yen	4.598.797.520.000
Japan	2009	127.079.000	92,06	Yen	4.449.224.420.000
Spain	1980	37.488.360	0,43	Euro	272.211.570.000
Spain	1981	37.750.800	0,55	Euro	292.107.420.000
Spain	1982	37.983.310	0,66	Euro	311.515.170.000
Spain	1983	38.184.170	0,86	Euro	326.668.620.000
Spain	1984	38.362.860	0,97	Euro	347.849.830.000
Spain	1985	38.534.850	1,02	Euro	368.233.950.000
Spain	1986	38.707.560	0,84	Euro	397.217.020.000
Spain	1987	38.880.700	0,74	Euro	434.126.240.000
Spain	1988	39.053.880	0,70	Euro	474.487.600.000
Spain	1989	39.214.520	0,71	Euro	518.346.890.000
Spain	1990	39.350.770	0,61	Euro	564.437.380.000
Spain	1991	39.461.420	0,62	Euro	601.573.440.000
Spain	1992	39.549.440	0,62	Euro	622.354.240.000
Spain	1993	39.627.590	0,76	Euro	625.702.290.000
Spain	1994	39.690.970	0,81	Euro	651.264.310.000
Spain	1995	39.749.710	0,75	Euro	685.872.300.000
Spain	1996	39.803.830	0,76	Euro	715.111.700.000
Spain	1997	39.855.440	0,88	Euro	751.454.590.000
Spain	1998	39.906.240	0,90	Euro	793.761.560.000

Spain	1999	39.953.260	0,94	Euro	844.554.730.000
Spain	2000	40.589.000	1,09	Euro	900.670.740.000
Spain	2001	41.047.000	1,12	Euro	960.782.090.000
Spain	2002	41.640.000	1,06	Euro	1.013.498.960.000
Spain	2003	42.321.000	0,89	Euro	1.072.608.180.000
Spain	2004	43.000.000	0,81	Euro	1.139.283.200.000
Spain	2005	43.704.000	0,80	Euro	1.223.005.380.000
Spain	2006	44.432.000	0,80	Euro	1.316.636.880.000
Spain	2007	45.212.000	0,73	Euro	1.411.124.160.000
Spain	2008	45.910.000	0,68	Euro	1.464.533.400.000
Spain	2009	46.295.000	0,72	Euro	1.430.865.130.000
Sweden	1980	8.310.470	4,23	Swedish Krona	92.261.140.000
Sweden	1981	8.320.490	5,06	Swedish Krona	100.640.790.000
Sweden	1982	8.325.260	6,28	Swedish Krona	106.272.500.000
Sweden	1983	8.329.030	7,67	Swedish Krona	111.910.190.000
Sweden	1984	8.342.620	8,27	Swedish Krona	121.974.100.000
Sweden	1985	8.356.340	8,60	Swedish Krona	127.873.440.000
Sweden	1986	8.384.070	7,12	Swedish Krona	136.671.240.000
Sweden	1987	8.421.400	6,34	Swedish Krona	145.062.910.000
Sweden	1988	8.469.340	6,13	Swedish Krona	154.191.180.000
Sweden	1989	8.526.280	6,45	Swedish Krona	164.645.280.000
Sweden	1990	8.600.820	5,92	Swedish Krona	172.264.440.000
Sweden	1991	8.668.110	6,05	Swedish Krona	177.308.000.000
Sweden	1992	8.718.870	5,82	Swedish Krona	179.068.260.000
Sweden	1993	8.769.280	7,78	Swedish Krona	177.952.070.000
Sweden	1994	8.831.490	7,72	Swedish Krona	188.937.750.000
Sweden	1995	8.877.890	7,13	Swedish Krona	201.840.870.000
Sweden	1996	8.892.230	6,71	Swedish Krona	206.891.410.000
Sweden	1997	8.897.620	7,63	Swedish Krona	214.313.230.000
Sweden	1998	8.902.680	7,95	Swedish Krona	222.821.320.000
Sweden	1999	8.909.790	8,26	Swedish Krona	233.787.140.000
Sweden	2000	8.924.000	9,16	Swedish Krona	247.978.390.000
Sweden	2001	8.940.000	10,33	Swedish Krona	254.886.140.000
Sweden	2002	8.954.000	9,74	Swedish Krona	263.030.820.000
Sweden	2003	8.970.000	8,09	Swedish Krona	273.509.680.000
Sweden	2004	8.986.000	7,35	Swedish Krona	291.344.740.000
Sweden	2005	9.002.000	7,47	Swedish Krona	313.767.600.000
Sweden	2006	9.017.000	7,38	Swedish Krona	338.193.830.000
Sweden	2007	9.031.000	6,76	Swedish Krona	362.974.450.000
Sweden	2008	9.045.000	6,59	Swedish Krona	373.621.940.000

Sweden	2009	9.060.000	7,65	Swedish Krona	356.012.740.000
United Kingdom	1980	56.314.000	0,43	Pound Sterling	522.670.450.000
United Kingdom	1981	56.382.600	0,50	Pound Sterling	568.695.550.000
United Kingdom	1982	56.339.700	0,57	Pound Sterling	604.576.310.000
United Kingdom	1983	56.382.620	0,66	Pound Sterling	646.904.240.000
United Kingdom	1984	56.462.230	0,75	Pound Sterling	682.400.530.000
United Kingdom	1985	56.620.240	0,78	Pound Sterling	730.024.620.000
United Kingdom	1986	56.796.260	0,68	Pound Sterling	766.579.640.000
United Kingdom	1987	56.981.620	0,61	Pound Sterling	825.067.350.000
United Kingdom	1988	57.159.600	0,56	Pound Sterling	896.543.590.000
United Kingdom	1989	57.324.470	0,61	Pound Sterling	953.768.960.000
United Kingdom	1990	57.493.310	0,56	Pound Sterling	1.006.404.940.000
United Kingdom	1991	57.665.650	0,57	Pound Sterling	1.034.446.710.000
United Kingdom	1992	57.866.350	0,57	Pound Sterling	1.064.690.020.000
United Kingdom	1993	58.026.920	0,67	Pound Sterling	1.110.736.030.000
United Kingdom	1994	58.212.520	0,65	Pound Sterling	1.174.720.520.000
United Kingdom	1995	58.187.000	0,63	Pound Sterling	1.223.583.120.000
United Kingdom	1996	58.345.000	0,64	Pound Sterling	1.284.742.580.000
United Kingdom	1997	58.494.000	0,61	Pound Sterling	1.352.956.730.000
United Kingdom	1998	58.680.000	0,60	Pound Sterling	1.414.035.030.000
United Kingdom	1999	58.910.000	0,62	Pound Sterling	1.481.523.230.000
United Kingdom	2000	59.140.000	0,66	Pound Sterling	1.569.240.830.000
United Kingdom	2001	59.375.000	0,69	Pound Sterling	1.642.229.970.000
United Kingdom	2002	59.602.000	0,67	Pound Sterling	1.717.907.530.000
United Kingdom	2003	59.824.000	0,61	Pound Sterling	1.823.904.950.000
United Kingdom	2004	60.127.000	0,55	Pound Sterling	1.942.622.730.000
United Kingdom	2005	60.487.000	0,55	Pound Sterling	2.067.628.330.000
United Kingdom	2006	60.847.000	0,54	Pound Sterling	2.198.568.350.000
United Kingdom	2007	61.249.000	0,50	Pound Sterling	2.336.880.310.000
United Kingdom	2008	61.643.000	0,69	Pound Sterling	2.410.847.420.000
United Kingdom	2009	61.997.000	0,62	Pound Sterling	2.293.945.100.000
United States	1980	227.726.460	1,00	US Dollar	2.768.900.000.000
United States	1981	229.966.240	1,00	US Dollar	3.105.300.000.000
United States	1982	232.187.830	1,00	US Dollar	3.229.400.000.000
United States	1983	234.307.210	1,00	US Dollar	3.508.900.000.000
United States	1984	236.348.290	1,00	US Dollar	3.902.700.000.000
United States	1985	238.466.280	1,00	US Dollar	4.187.600.000.000
United States	1986	240.650.760	1,00	US Dollar	4.427.600.000.000
United States	1987	242.803.530	1,00	US Dollar	4.702.100.000.000
United States	1988	245.021.410	1,00	US Dollar	5.063.900.000.000

United States	1989	247.341.700	1,00	US Dollar	5.441.700.000.000
United States	1990	250.131.890	1,00	US Dollar	5.757.300.000.000
United States	1991	253.492.500	1,00	US Dollar	5.946.800.000.000
United States	1992	256.894.190	1,00	US Dollar	6.286.800.000.000
United States	1993	260.255.350	1,00	US Dollar	6.604.200.000.000
United States	1994	263.435.670	1,00	US Dollar	7.017.600.000.000
United States	1995	266.278.000	1,00	US Dollar	7.342.300.000.000
United States	1996	269.394.000	1,00	US Dollar	7.762.300.000.000
United States	1997	272.647.000	1,00	US Dollar	8.250.900.000.000
United States	1998	275.854.000	1,00	US Dollar	8.694.600.000.000
United States	1999	279.040.000	1,00	US Dollar	9.216.200.000.000
United States	2000	282.172.000	1,00	US Dollar	9.764.800.000.000
United States	2001	285.082.000	1,00	US Dollar	10.076.000.000.000
United States	2002	287.804.000	1,00	US Dollar	10.417.600.000.000
United States	2003	290.326.000	1,00	US Dollar	10.907.900.000.000
United States	2004	293.046.000	1,00	US Dollar	11.630.900.000.000
United States	2005	295.753.000	1,00	US Dollar	12.579.800.000.000
United States	2006	298.593.000	1,00	US Dollar	13.336.200.000.000
United States	2007	301.580.000	1,00	US Dollar	14.010.700.000.000
United States	2008	304.375.000	1,00	US Dollar	14.369.400.000.000
United States	2009	307.007.000	1,00	US Dollar	14.003.780.000.000