



LUND
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School of Economics and Management

**Productivity Growth Rates in Europe and
the USA: A Tale of Convergence
in the 21st Century**

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Abstract

In mid 90's, productivity growth rate started to accelerate in the USA. The sources of this resurgence were the IT-producing industry and the IT-using market services. Meanwhile, Europe was still suffering from the low level of productivity growth rates. This fact leads to pessimistic assessments about the economic future of Europe. However, this paper uncovers that productivity growth rate started to accelerate after 2000 in the EU-15ex which consists of Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Spain and United Kingdom. In fact, it is hard to realize the acceleration in the productivity growth rate in early 2000's because of the low level of productivity growth rate in this period. However, the productivity growth rate of the EU-15ex reached to the US productivity growth rate in mid 2000's. The major source of this convergence is the IT-using market services. In addition, acceleration of the productivity growth rate of IT-producing industry has continued in the EU-15ex after 2000. These evidences lead to the conclusion that the resurgence in productivity growth rate of the EU-15ex has the similar recipe as in the case of the USA. This paper also tests empirically the factors behind the productivity improvements that are suggested by the convergence approach of neo-Schumpeterian Growth Model. Accordingly, R&D in business enterprises and high human capital labor compensation are used as the explanatory variables. The stepwise Engle-Granger co-integration test results with the finding of the co-integration relation between TFP level, R&D spending of business enterprises and high human capital labor compensation for the EU-15ex. In this respect, I conclude that these three series are linked to form long-run equilibrium relationship in the period 1981-2007.

Key Words: Convergence, Total Factor Productivity, Institutions, neo-Schumpeterian Growth Model, Engle-Granger Co-integration, unit root

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List of Abbreviations

ELECOM Electrical and Optical Machines

EU European Union

HHCLC High Human Capital Labor Compensation

IATA International Air Transport Association

IT Information Technology

GDP Gross Domestic Product

GPT General Purpose Technologies

M&EQ Merger and Acquisition

OECD Organization for Economic Co-operation and Development

OLS Ordinary Least Squares

PPP Purchasing Power Parity

PPS Purchasing Power Standards

R&D Research and Development

TFP Total Factor Productivity

USA United States of America

WW World War

1. INTRODUCTION

In his famous essay, 'Catching Up, Forging Ahead, and Falling Behind', Abramovitz (1986) underlines that technologically backward countries have a potentiality for rapid growth through successful exploitation of already employed technologies by technological leaders. However, social capability of the technologically backward countries has to be sufficiently developed in order to implement the leading technologies. In this sense, these countries should be technologically backward but socially advanced.

In this regard, productivity improvements in Europe in the quarter century following WW II can be attributed to large backlog in the unexploited technology, especially in mass-production processes. One has to also emphasize that provided social capability, in terms of Abramovitz, in Europe was initially very convenient with the high level of manufacturing knowledge. Beside this knowledge, in the following years of WW II, the tri-partite association between labor unions, employer federations and governments formed institutional framework in Europe. The institutions within this framework created the business environment in which the leading technologies had been adopted in Europe.

In the beginning of 1970's, the technological backlog was almost fully exploited. Additionally, the technological leader, the USA, began to suffer from the low productivity growth rates. The institutional and social capability of Europe was appropriate for imitation of the leading technologies instead of the creation of these leading technologies as it is indicated by Eichengreen (2007). As a result, the in the productivity growth rates of Europe stopped and diminished to low levels through two ways.

1. The room for productivity gains through technology transfer diminished as European countries approached to the frontier.

Table 1 Relative GDP Levels and GDP Growth Rates in the EU-15

	Levels of EU-15 Relative to the US		Growth rates in EU-15	
	1950	1973	1950-1973	1973-1995
GDP per capita	45,5	76,8	4,7	1,7
GDP per hour worked	39,5	75,4	5,3	2,4

Source: Van Ark, O'Mahony and Timmer (2008)

2. The technological leader, the USA, was not able to innovate as before that means that fewer innovations would be available for transfer from the USA to Europe.

Table 2 TFP Growth Rate of the USA and GDP Growth Rate of the EU-15

	Growth rate in USA			Growth rates in EU-15	
	1950-1973	1973-1995		1950-1973	1973-1995
Total Factor Productivity	2	0,5	GDP per capita	4,7	1,7
			GDP per hour worked	5,3	2,4

Source: BLS historical TFP measures and Van Ark, O'Mahony and Timmer (2008)

Thus, two sides of Atlantic headed towards low productivity growth rates. In this sense, the period between mid 70's and mid 90's, although exact years are not agreed upon, is called Great Moderation by the economic literature.

However, the USA broke this path in mid 90's and productivity growth rate resurged. Meanwhile, Europe was not able to follow this resurgence in productivity growth rate. And productivity growth rate continued to stagnate.

This paper aims to research the productivity growth rate improvements in Europe and the USA comparatively in the IT-era and shed some light on the discussion about the productivity growth rate convergence. I will try to accomplish these goals by sectoral level research. In addition, the factors behind TFP will be modeled and tested for the IT-era.

As a natural result, setting these goals bear the following questions about the economic future of Europe and the role of the institutional framework in which European economies function. Why Europe was able to adopt technologies in the third quarter of the 20th century but not in the eve of the 21th century? Is it a permanent divergence or is convergence just a matter of time? And will Europe be able to exploit its technological backlog again in the 21th century as it was able to do in the third quarter of the 20th century? What will be the role of the institutions in Europe, would their old-fashion style inhibit convergence in the 21th century or is this only a transition period of reforms which would transform old continent's institutions into more efficient ones in order to absorb improvements in the 21th century business environment as it is indicated by Blanchard (2004)?

This paper agrees with the optimistic view about the economic future of Europe by uncovering the likely start of convergence of the productivity growth rate of Europe to those of its cross Atlantic counterpart in the mid 2000's and identifies the period after 90's as a transition period to transform into more dynamic institutional framework through reforms at various areas. And this paper uncovers that Europe began to reap the benefits of this transition process slowly after 2000's but this process accelerated and became more apparent in mid 2000's.

The transformation process within Europe has continued very heterogeneously. The social capability to adapt to this transformation process and the needs of new era differs within the EU. It seems that these differences will determine success and failure stories within the EU.

Section 2 will review the literature about recent developments in productivity. Section 3 will present productivity improvements in Europe and the USA comparatively during the IT-age. Section 4 will present the convergence theory of the neo-Schumpeterian model. In section 5, the role of institutional framework in the convergence process will be discussed critically that is based on the convergence theory which is presented in the previous section. Section 6 will test an econometrical model of the total factor productivity level, which is based on the neo-Schumpeterian convergence approach, by employing co-integration techniques. Section 7 will conclude.

2. LITERATURE REVIEW

The resurgence in productivity growth of the USA and the divergence in productivity growth rates between Europe and the USA after mid 90's have been one of the most attractive topics for economists.

Jorgenson, Stiroh and Ho (2008) argue that the source of the resurgence in the US productivity growth rate had been productivity gains in the IT-producing industry for the period between mid 90's and 2000. After 2000, the contribution of IT-producing sectors decelerated but IT-using service sectors had become the main source of the resurgence besides the positive but diminished contribution of the IT-producing industry. Thus, they claim that "computer paradox¹", which is famously underlined by Solow (1987), turned into "productivity resurgence". Bosworth and Triplett (2007) and Fernald and Ramnath (2004) also emphasize the importance of IT-using services at the productivity resurgence. Furthermore, Triplett and Bosworth (2006) announced that 'Baumol disease² has been cured'.

The sustainability of the productivity improvement in the market services was also discussed. Gordon (2003) suggested that this improvement can be attributed to the cyclical recovery after the recession in 2001 and it is unlikely to sustain. However, it also worth to take into account two alternative explanations which are indicated by Jorgenson, Stiroh and Ho (2008):

- 1) The General Purpose Technologies (GPT) approach: The developments in the IT-producing industry triggered innovations in the market services.
- 2) Improvements in unmeasured capital such as research and development, organizational change and other business processes.

The second explanation is related with GPT approach, because the *raison d'être* of research and development, organizational change, and other changes in the business processes in the market services would be generally seeking more efficient use of IT triggered innovations. In this respect, these two alternative explanations should be assessed as complementary arguments rather than singular explanations but the second one comes with certain lags as Basu et al. (2004) argues. It is very likely that the longer firms work with the innovated products the more they learn the efficient usage of these products. This process can be called a kind of the "on the job learning".

¹ It refers to Solow's famous argument: "You can see the computer age everywhere but in the productivity statistics."

² Baumol (1967) argued that productivity growth in services sectors is less likely than in the goods-producing sectors. The reason is the static nature of services.

If we turn into Europe, we would realize that the situation had evolved to the opposite way. The productivity growth rates had been at very low levels between mid 90's and mid 2000's. In this respect, Eichengreen (2004) suggests that the continuous catching-up process of Europe's productivity to the USA ones' stopped in the early 90's and divergence in productivity of two sides of Atlantic started. He addresses the limited capability of Europe to absorb the benefits of New Economy which is considered as the main source of the productivity resurgence since mid 90's in the USA.

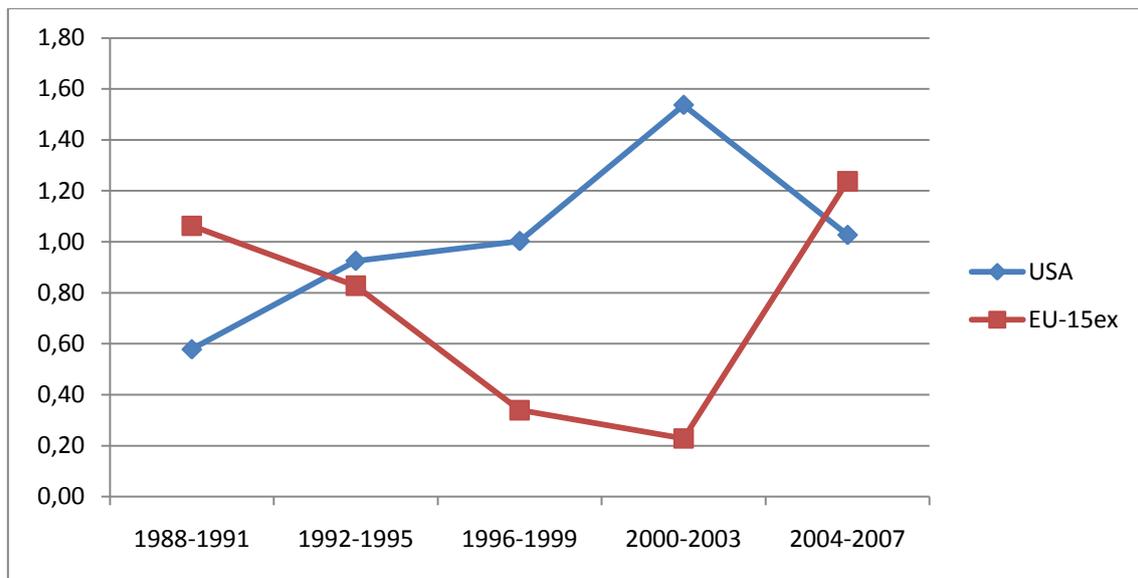
Van Ark, O'Mahony and Timmer (2008) and Van Ark, Inklaar and Timmer (2008) discuss that the productivity slowdown in Europe is led by slower productivity growth in the market services, especially in trade, finance, and business services. Turrini et al. (2009) shows that all of the EU-US TFP growth differential can be explained by electrical and optical equipment industry, wholesale and retail trade, real estate and other business services and to a lesser extent financial services.

The whole body of research which investigates the divergence of the productivity growth rates between Europe and the USA agree upon the idea that Europe has not been able to reap the benefits of the New Economy.

3. PRODUCTIVITY PERFORMANCES in the IT-AGE

The ultimate aim of this section is making comparative analysis of Total Factor Productivity (TFP) growth rates in Europe and the USA for the period 1988-2007. TFP is the best proxy for representing advances in technology and innovation. Government sector is excluded and market economy is taken into consideration.

Figure 1 Average Annual TFP Growth Rate of Market Economy



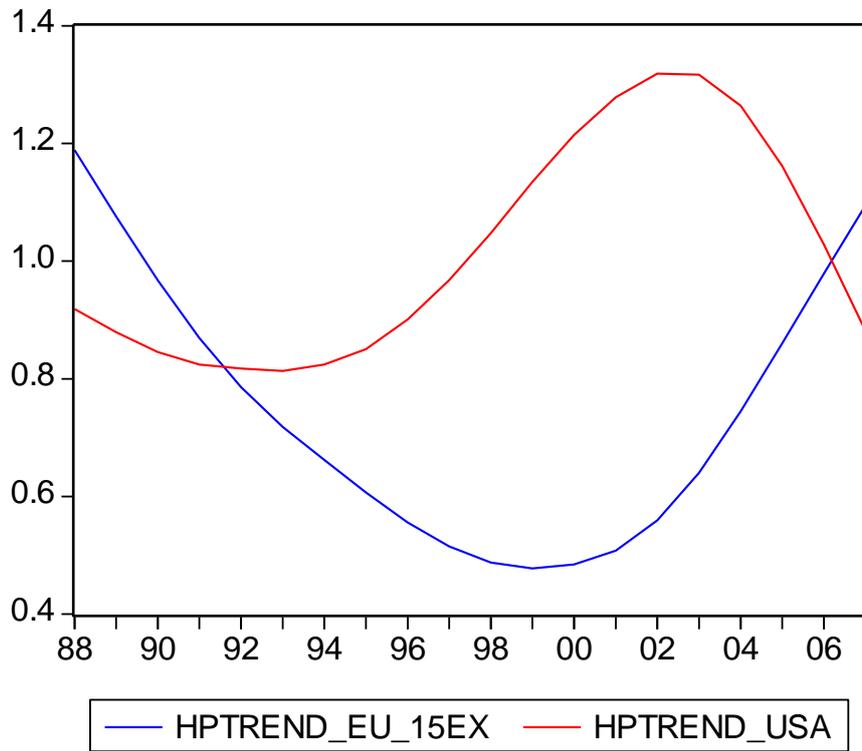
Note1: value added base TFP growth rates

Source: EU KLEMS Page

Figure 1 corresponds with earlier findings of research by indicating the divergence after mid 90's. The gap between TFP growth rates had further widened in early 2000's. However, the trend changed in mid 2000's and it seems TFP growth rate resurged also in the EU-15ex. One has to be careful while concluding some results from relatively short period of time. A cyclical recovery or an outlier may dominate the performance in a certain sub-period or the choice of the start and end years of the sub-periods may have effect on findings. These conditions would distort the interpretation of the findings and may result with wrong evaluations. To my knowledge, there is two alternative ways to check the validity of my argument about the productivity growth rate convergence in mid 2000's.

First, I checked long-run trend growth rates by employing Hodrick-Prescott Filter (Hodrick and Prescott 1997) in order to separate cyclical component. The lambda is chosen as 100 that is generally accepted for the annual data.

Figure 2 Trend TFP Growth Rate of Market Economy



The figure 2 strongly supports my argument that market economy productivity growth rate of the EU-15ex had converged to the US productivity growth rate of market economy in mid 2000's. As we can observe that this trend became significant after 2004 and it is based on two sources; deceleration of the productivity growth rate of the USA and the acceleration of the productivity growth rate of the EU-15ex.

Secondly, I checked the standard deviations of each sub-period in terms of both absolute and relative standard deviation and I figured out that the last sub-period, in which the resurgence in TFP growth rate took place in the EU-15ex, has one of the lowest standard deviation and the lowest relative standard deviation as it is indicated in Table 3.

Table 3 Standard Deviations of TFP Growth Rates in the EU-15ex in Sub-periods

	Standard Deviation of TFP Growth Rate	Relative Standard Deviation of TFP Growth Rate
1988-1991	0,467964658	0,440468
1992-1995	0,908149157	1,097185
1996-1999	0,453731913	1,33719
2000-2003	0,902834032	3,947362
2004-2007	0,455511868	0,368083

These evidences don't guarantee the sustainability of the increase in the productivity growth rate of the EU-15ex, but it supports that this acceleration relies on firm roots rather than cyclical movements.

In the next step, it would be enlightening to disaggregate TFP growth into sectors and investigate contribution of each sector to the TFP growth rate of market economy. Here, the main motive is comparatively analyzing the sectoral performances of both economies in the IT-age. In addition, I aim to uncover that which sectors are the major sources of the last convergence process.

Table 4 Average Annual Sectoral TFP Growth Rate Contributions in Sub-periods

		Market Economy	Elecom	Post & Telecom	Goods Prod.	Market Services	IT-using Serv.
EU-15ex	1988-1995	0,95	0,11	0,09	0,70	0,04	0,12
	1996-2007	0,60	0,13	0,17	0,28	0,03	0,11
	1996-2003	0,28	0,09	0,20	0,21	-0,22	-0,13
	2004-2007	1,24	0,21	0,10	0,40	0,52	0,59
USA	1988-1995	0,75	0,34	0,06	0,17	0,18	0,19
	1996-2007	1,19	0,45	0,09	-0,12	0,78	0,70
	1996-2003	1,27	0,51	0,01	0,04	0,71	0,65
	2004-2007	1,03	0,33	0,24	-0,43	0,90	0,79

Source: Own Calculations based on EU KLEMS page database

The results of Table 4 are very striking and worth to discuss in detail. Although, in pre-mid 90's period, the EU-15ex outperformed the USA slightly in terms of productivity growth rate, the trend changed after mid 90's. The productivity growth rate of the USA had been two times bigger than that of the EU-15ex for the period 1996-2007. However, the increase in the productivity growth rate of the EU-15ex and the deceleration of the productivity growth rate of the USA in mid 2000's decreased the gap between productivity growth rates which was established in two previous sub-periods. And the TFP growth rate of EU-15ex slightly exceeds the TFP growth rate in the USA during this period of time.

The contribution of electrical and optical machines (ELECOM) industry, which includes semiconductors (the main IT producing industry), has been very low in the EU-15ex in comparison to the contribution of this industry to the US productivity growth rate. Between 1988-2007, the contribution to the TFP growth rates had been 0,40% for the USA and 0,125% for the EU-15ex although the weight of this industry had been almost same for both groups in this period of time, 3,65% and 3,46% for the USA and the EU-15ex respectively. The contribution of the ELECOM industry in the USA had been three times bigger than the contribution of the ELECOM sector in the EU-15ex. It clearly proves that ELECOM industry firms in the USA have outperformed their counterparts in the EU-15ex by far in terms of technology creating and innovations. One of the interesting results is the different evolution in the contribution of the ELECOM industries to the market economy TFP growth rate. Even before mid 90's, it was at considerable amounts in the USA. The contribution to the market economy TFP growth peaked in late 90's and in early 2000's, this period of time was heyday of this industry. Then the contribution calmed down and turned back to it's pre mid 90's levels. While heydays of the ELECOM industry were going on in the USA, things were very different in the EU-15ex. Throughout the period 1988-2003, the contribution of the ELECOM industry had been very limited. However, it doubled in mid 2000's although it's share in market economy diminished slightly to 3,21% in this period from 3,51% in previous 1988-2003 period. Thus, Europe was able to close the gap in the ELECOM industry contribution to TFP growth. This fact shows that IT-revolution had happened in the USA but started to firmly penetrate in Europe in mid 2000's.

The source of the relatively better performance of the EU-15ex in pre mid 90's was high productivity growth rates of goods production sectors. However, Europe lost his good performance in goods market production after mid 90's. The productivity growth rate

decelerated from 1,55% for the period 1988-1995 to 0,71% for the period 1996-2007 and there was no development to offset this deceleration. Thus, TFP growth rate decelerated in the EU-15ex after mid 90's. It is hard to summarize the source of this deceleration at goods production sector. In my opinion, main reason behind this deceleration is increasing competition in goods market production in world due to rising globalization. The emerging markets like China and India started to produce and sell good products in large scale in this period of time. This competition meant losing market shares for Europe. It led to less scale gains and under utilization of inputs which harmed productivity gains in the goods production sector.

One of the most interesting finding is that the USA had suffered from low productivity growth rate of goods production sector throughout the whole period. The deceleration of productivity growth rate had continued without brake. As a result, the productivity growth rates turned into negative values in mid 2000's. This fact supports my assumption for the deceleration in the TFP growth rate of goods production in the EU-15ex. The globalization and rising competition process had also hit the good producing firms in the USA, as well as their counterparts in Europe. Thus, already low level of productivity growth rate of goods production sector hit the bottom. The most recent evidence was observed in the recent global turm-oil. Almost all of the car manufacturing companies asked for a bail-out in the USA. And government injected money to these companies. Otherwise, they won't be able to survive. This experience was a sad story from these companies' and from their employees' point of view but it was clear cut evidence that the USA has lost its competitiveness in car manufacturing industry.

The most striking results can be observed regarding markets services. The acceleration of the productivity growth rate in this sector had been the main source of the productivity growth rate increase in the US economy after mid 90's. I disaggregated the market services into IT-using industries, which include trade, transport and storage, financial intermediation and renting of m&eq and other business activities, and non IT-using market services which include hotels and restaurants and other community, social and personal services. I figured out that IT-using market services had been almost the sole source of the increase in the market services TFP growth rates after mid 90's.

The reason behind this development has been discussed widely. As it indicated in previous section, Gordon (2003) argues that the acceleration in the TFP growth in the market services

in 2000's was caused by cyclical recovery following the recession in 2001 and this high level of growth rates are not likely to sustain. Another approach, which is summarized well by Jorgenson, Stiroh and Ho (2008), suggest that the improvements in the IT-producing industries triggered innovations in the market services and transformed the organizational and managerial structure of firms in the market services. In fact, the acceleration in the productivity growth rate of the market services could have been observed since mid 90's which challenges the assumption of Gordon (2003). However, part of the productivity acceleration in the post-2001 period can be attributed to cyclical recovery because the productivity growth rate in the market services seems extraordinarily high for the period 2002-2005 as 2,13% increasing from 1,14% for 1996-2001. Therefore, it can be suggested that the productivity growth rates just after following the 2001 recession contain the cyclical recovery component. However, it can't be ignored that the structural changes in the market services after mid 90's have led to more productive market services. Meanwhile, one has to accept that the cyclical recovery following the recession in 2001 stimulated this process.

One of the interesting finding is the coincidence of the introduction of internet to widespread use and the start of the productivity growth rate increase in the market services. In my opinion, it is more than coincidence, there is causality. Before the internet, market services were already exposed to IT-products. However, computers were used only for more efficient work in working places. Computers or other IT-products had no direct effect on "doing business" style of the firms. The exposition to the markets was through traditional ways. However, the introduction of the internet changed "doing business" style of the market services. The definition of the exposition to the market has changed dramatically for the most of the market services. For example, 230 airlines, comprising 93% of air traffic, have sold all of their tickets on the internet since May 2008 according to the legislation of the International Air Transport Association (IATA). IATA argues that an e-ticket costs \$1 but a paper ticket costs \$10. The annual saving from using e-ticket instead of paper ticket is \$3 billion according to IATA data. Internet was the essential complementary invention to the computers in order to have significant productivity gains in the market services. Without internet, the effects of the IT-products on the productivity growth in the market services would be more limited. Probably, we won't be able to observe a dramatic increase in the productivity growth rate from 0,35% for the period 1988-1995 to 1,30% for the period 1996-2007.

When I turned into Europe's market services, I met with a different story. In the period 1988-1995, the productivity growth rate performances were not dramatically different in both economies, 0,09% and 0,35% in the EU-15ex and the USA respectively.

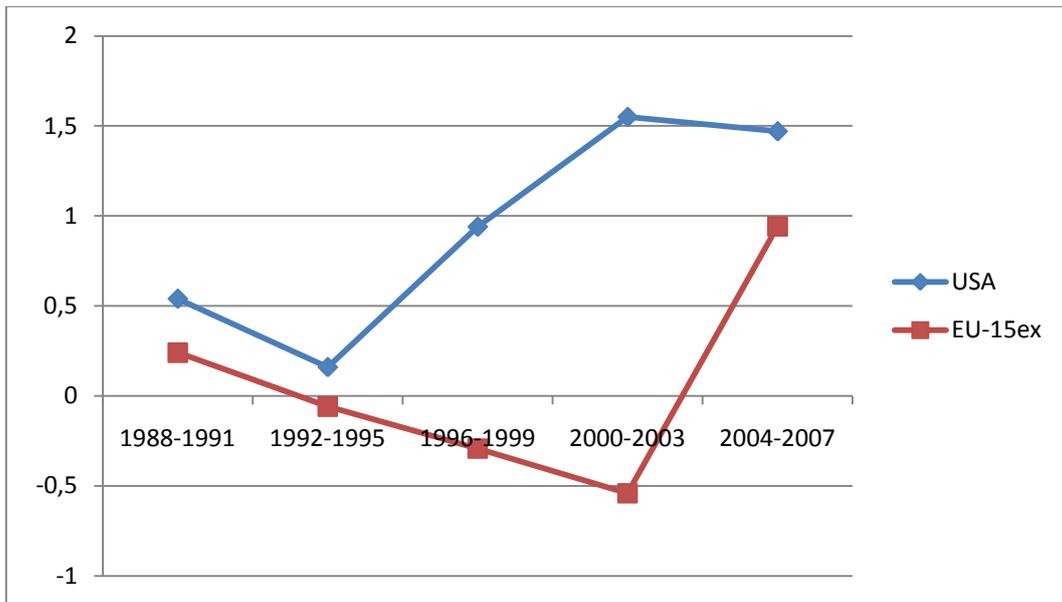
Throughout the period of 1996-2007, the productivity growth rate performance of the market services in the EU-15ex had fallen behind their US counterparts. When I disaggregated the data into two sub-periods, I figured out that market services productivity performance had been extremely disappointing for 1996-2003 period by having -0,42% productivity growth rate while US market services productivity growth rate had been 1,21% for the same period of time.

However, the productivity growth rate of the market services in the EU-15ex shows remarkable change in the period 2004-2007 by increasing to 0,94% from -0,42%. As a result, the contribution of market services became positive and this improvement in the productivity growth rates of the market services was the main source of the productivity growth rate resurgence in this period of time. When I disaggregated market services into IT-using and non IT-using services as I did above, I figured out that all of productivity growth in the market services was caused by IT-using market services. The recipe of the productivity growth resurgence in the EU-15ex was similar to the case of the USA. The productivity growth rate resurgence was largely based on the IT-using market services in both cases but it started to happen in Europe with certain lags. The main reason behind this lag is that the birth place of the innovations in the market services was not Europe. Their usage started in the USA but these innovations began to diffuse firmly in European market services in mid 2000's as it is suggested similarly for the ELECOM industry.

As a result, the productivity growth rate of market economy in the EU-15ex had converged to US productivity growth rates because of the two major sources;

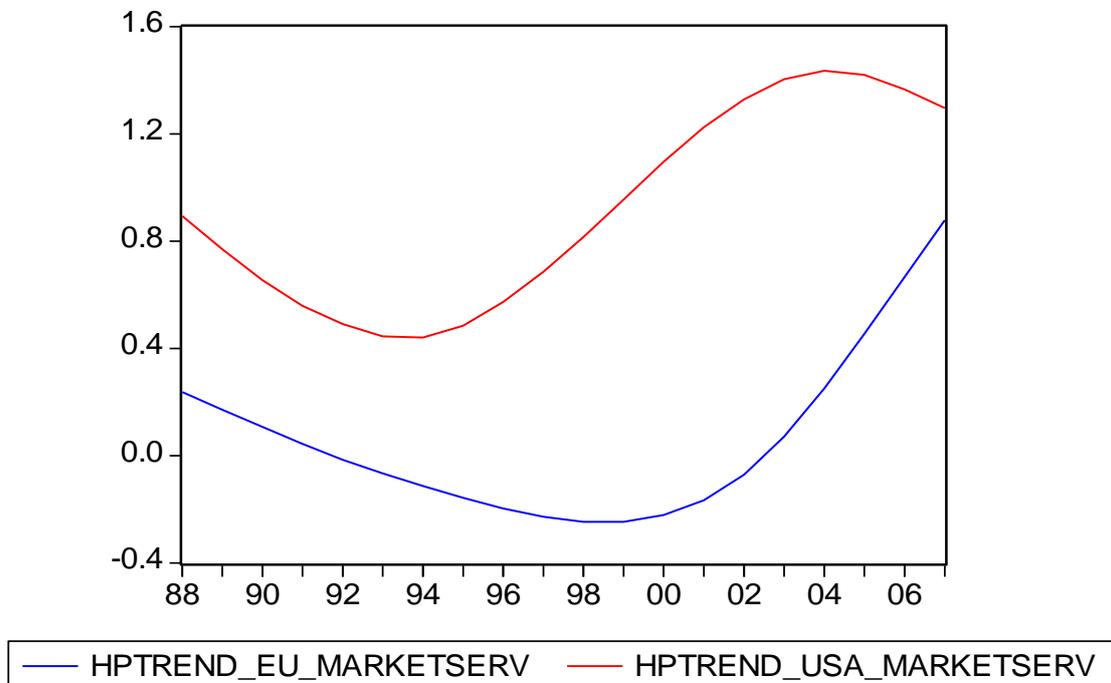
1. Closing the gap between the productivity growth rate of the market services

Figure 3 Average Annual TFP Growth Rates of Market Services



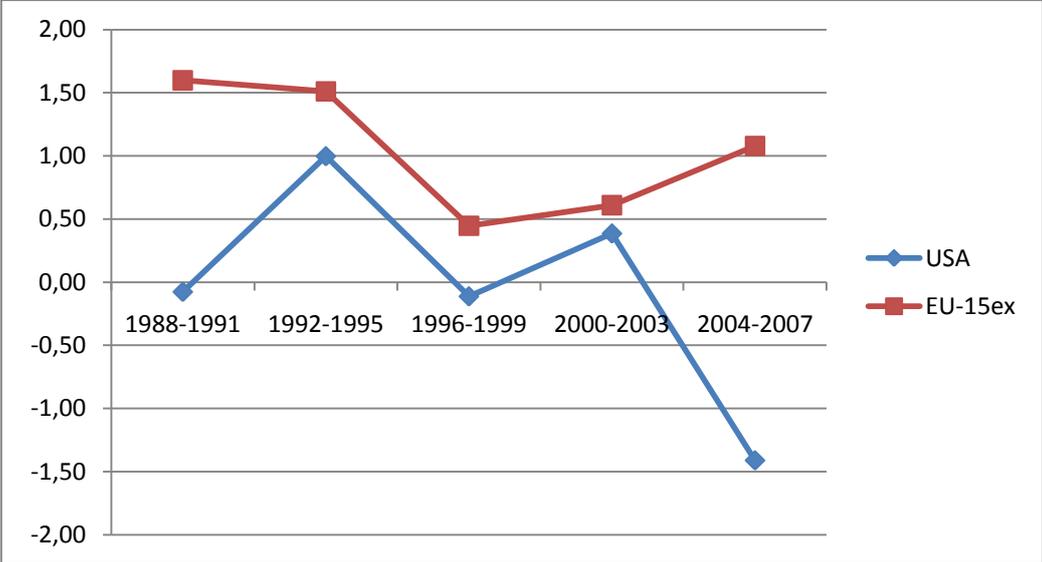
It would be also useful to check trend productivity growth rates in the market services;

Figure 4 Trend TFP Growth Rate of Market Services



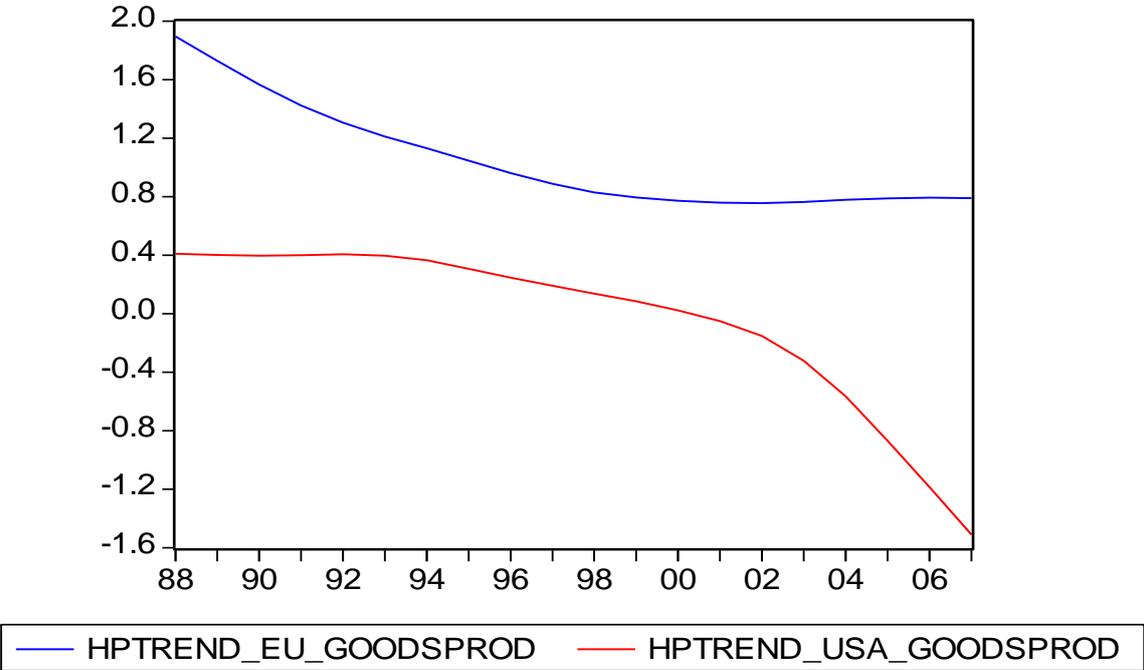
2. Bottoming out of the productivity growth rate of the goods production sector in the USA in the last sub-period

Figure 5 Average Annual TFP Growth Rate of Goods Production Sector



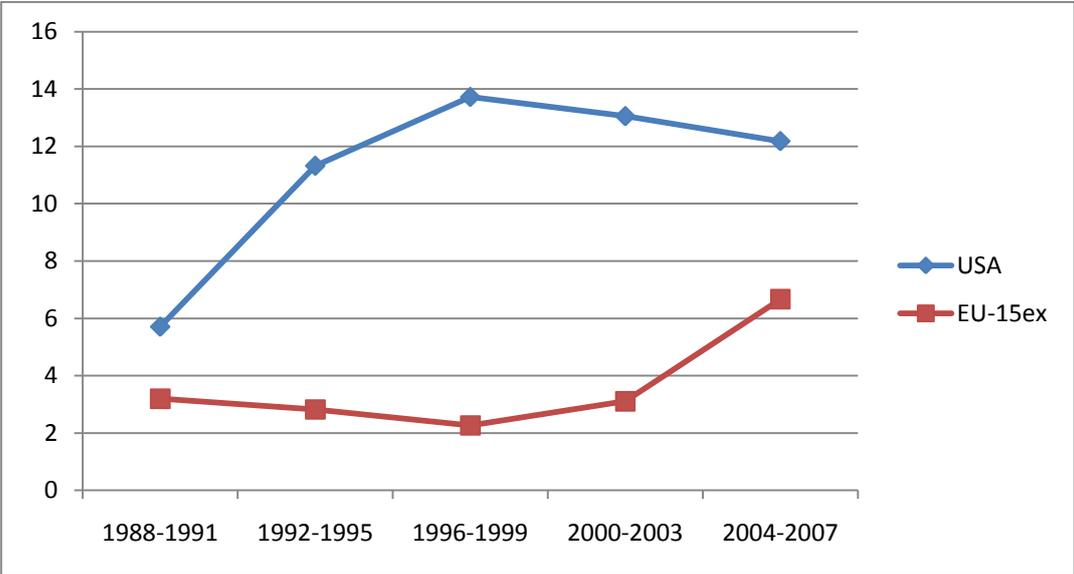
It would be also useful to check trend productivity growth rates of the goods production sector;

Figure 6 Trend TFP Growth Rate of Goods Production Sector



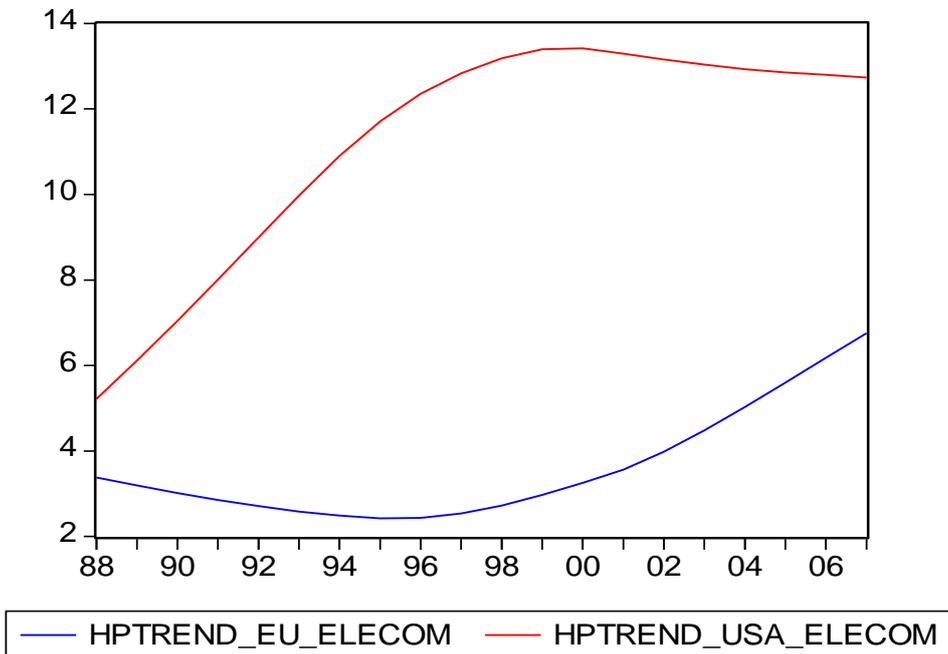
One has to also emphasize the slight closing gap in the ELECOM industry productivity growth rates. However, the contribution of that to the convergence of the market economy TFP growth rate had been very limited due to its magnitude and due to small share of the ELECOM industry in overall economy. However, the indirect effect of this closing gap may be much greater than direct effect by triggering productivity growth rate of the IT-using market services.

Figure 7 Average Annual TFP Growth Rate of ELECOM Industry



It would be also useful to check trend productivity growth rates of the ELECOM industry;

Figure 8 Trend TFP Growth Rate of ELECOM Industry



4. THEORETICAL ASSESSMENT of the CONVERGENCE

In this section, I will discuss the convergence phenomenon and the newest evidence of this phenomenon for the EU-15ex, which is discussed widely in previous section, within the framework of the Schumpeterian model which has been developed by Aghion and Howitt. This theory, with various aspects, is summarized well by Aghion and Howitt (1998) and Aghion and Howitt (2009).

It starts with industry-specific production function;

$$Y_{it} = A_{it}^{1-\alpha} K_{it}^{\alpha}, \quad 0 < \alpha < 1 \quad (1)$$

A_{it} is productivity parameter which refers to the technological level in industry i at time t . K_{it} denotes intermediate good which is used in industry i . The intermediate good is produced by a monopolist by using final goods as input one-for-one.

If innovation takes place, previously innovated products would be rendered obsolete. Only, the innovators would be able to produce and sell the products. Thus, they would have monopolistic power on their products and reap the rents of their innovations until a new innovation would displace their innovations. This process is identified as the source of the

technological advancement. Accordingly, the economic reflection of this technological advancement would be improvements in productivity and economic growth.

The sum of each sector would give us whole production. It is assumed that all sectors are identical. This gives us simple aggregate production function.

$$Y_t = A_t^{1-\alpha} K_t^\alpha \quad (2)$$

Y_t is production per labor. In this regard, both the productivity parameter and the intermediate good are in per labor terms. A_t is unweighted sum of A_{it} of each sector. Thus, A_t refers to economy wide productivity of intermediate goods. The long-run growth rate of an economy is determined by its productivity growth rate which is triggered by increase in innovation and technology.

According to the theory's convergence approach, two main alternative ways lead to productivity improvement;

- 1) Cutting edge innovation: if an industry is the technological leader, an extra innovation would be created on the existing technological knowledge and would advance it.
- 2) Technology transfer: if an industry is not technological leader, implementation of the best practiced technology, which has been developed somewhere else, would increase the technological level in this industry.

Thus, productivity growth can be described as;

$$A_{t+1} - A_t = \mu_n(\gamma - 1)A_t + \mu_m(\bar{A}_t - A_t) \quad (3)$$

Hence, growth rate can be described as;

$$g_t = (A_{t+1} - A_t) / A_t = \mu_n(\gamma - 1) + \mu_m(a_t^{-1} - 1)$$

where

$$a_t = A_t / \bar{A}_t$$

γ denotes technological advancement on the previous technological level. And \bar{A}_t is productivity level in the frontier. μ_n stands for the frequency of the innovation in the technological leader industry and μ_m stands for the frequency of the implementation of the best practiced technology.

One of the striking features of this convergence approach is indicated by Aghion and Howitt (2006): “The further the country is behind the global technology frontier (i.e., the smaller is a_t) the faster it will grow, given the frequency of implementation innovations”.

However, Aghion, Acemoglu and Zilibotti (2006) suggest that the institutions that are appropriate for implementation of best practiced technologies may not be appropriate for the advancement in the best practiced technologies. They further argue that as countries approach to the technological leader they are obliged to shift to institutions which favor cutting edge innovation. Otherwise, convergence process would lose its momentum and may be choked off at certain levels.

5. INSTITUTIONAL ASSESSMENT of the CONVERGENCE

In this section, I will discuss some of the key institutions and policies in Europe and their role in the productivity growth rate resurgence which recently took place in the EU-15ex.

5.1 COMPETITION

The competition policies and the degree of competition have been always one of the favorite research topics. In general, high degree of competition would harm the rents on innovation but may trigger the instinct of escaping from competition which means that firms are motivated more for innovation in order to escape from perfect competition and to become renter of their innovations. Low degree of competition increases the rents on innovations but may reduce motivation for innovations by relying on the rents of the innovations for a long time.

Aghion and Howitt (2006) argue that if an industry is close to the frontier technologically, in the case of high of competition, the motive “escape competition” would exceed the discouragement of the decreasing rents. However, if an industry is far from frontier technologically, high degree of competition would harm the efforts of catching up to the frontier by reducing rents because “escape competition” motive is very unlikely when an industry is significantly backward in terms of technology. In this respect, high competition may trigger productivity growth if the industry is close to the frontier but may hinder

productivity growth if the industry is significantly backward. Therefore, low competition may create better environment for productivity growth if the industry is significantly backward.

Aghion and Howitt (2006) further argues that the non-competitive business environment in Europe following WW II was favorable for catching up US industries because Europe was suffering from being technologically backward. As European firms approached to the US firms in terms of technology, the non-competitive business environment in Europe would become an obstacle for further technological advancement through the innovation at the cutting edge.

A research conducted by Aghion et al. (2009) focuses on the effects of entry conditions by investigating firm level data of the UK over the period 1987-1993. They figured out that entry threat triggered innovations among incumbents in the industries which are close to the frontier but didn't motivate technologically laggard firms for innovation. In this regard, entry threat resulted with higher TFP growth rates in the industries which are close to the frontier but resulted with lower TFP growth rates in the industries which are far from the frontier.

Another research conducted by Nicoletti and Scarpetta (2003) presents evidences that privatization and entry liberalizations have positive effects on the TFP growth. Furthermore, they argue that "In manufacturing the gains are greater the further a given country is far from the technology leader, suggesting that regulation limiting entry may hinder the adoption of existing technologies, possibly by reducing competitive pressures, technology spillovers, or the entry of new high-tech firms". This statement confronts with the statement of Aghion and Howitt (2006), at least in manufacturing.

In the next section, I aim to shed some light on the role of competition environment in Europe at recent productivity improvement by employing and challenging previous works. I will do it in sectoral level.

Firstly, I determined which sectors are close to the frontiers and which are laggards. I used relative labor productivity levels as the indicator that is suggested by Aghion et al. (2009). I calculated relative labor productivity values for 2000. The values for 2000 are moving average value of the results for 2000 and two preceding years. I calculated sectoral labor productivity values by employing industry specific PPPs for 1997. The data is obtained from

EU KLEMS page. I measured sectoral PPPs according to the weights of each industry in each sector and adjusted labor productivity values with their PPP values. There are two reasons for choosing the year 2000. First, negative trend in productivity growth rates turned into positive trend in market economy as it is reviewed in Figure 2. In this respect, the year 2000 looks like a brake point. Secondly, the data for competition framework is available for late 90's. Thus, I will be able to assess the impact of these initial conditions on the change of the productivity growth rate trend in the EU-15ex after 2000.

Table 5 Labor Productivity in the EU-15ex Relative to the USA in 2000

Market economy	0,81
Elecom	0,66
Goods production	0,76
Market services	0,88

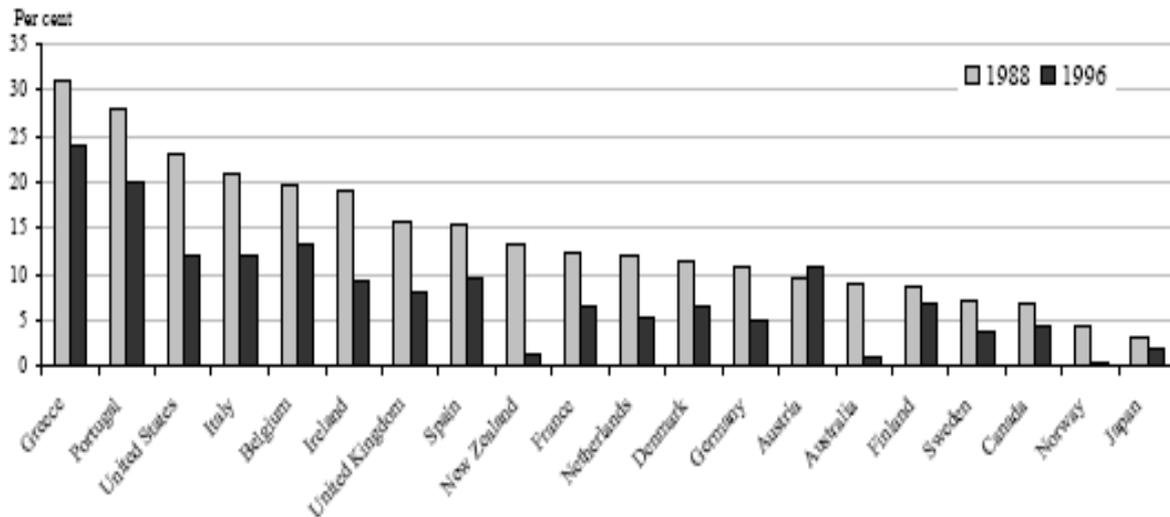
Source: own calculation based on EU KLEMS page data

The first result is that the USA has bigger labor productivity values in each sector. Thus, the USA should be treated as the technological leader in each sector. Table 5 indicates that the distance to the frontier is biggest in the ELECOM industry. It is not a surprise, because US firms have outperformed their counterparts in the EU-15ex throughout the IT-age in terms of innovation and technology as it is indicated at previous sections. The relative labor productivity in goods production sector is bigger than the ELECOM industry but lower than the value for the market economy. The market services are the sector that is the closest to the frontier.

Secondly, it is necessary to present the degree of competition and the changes in the degree of competition. The indicators are taken from the research of Nicoletti and Scarpetta (2003) for the OECD countries.

Figure 9 Manufacturing Trade Liberalization

Import coverage non-tariff barriers

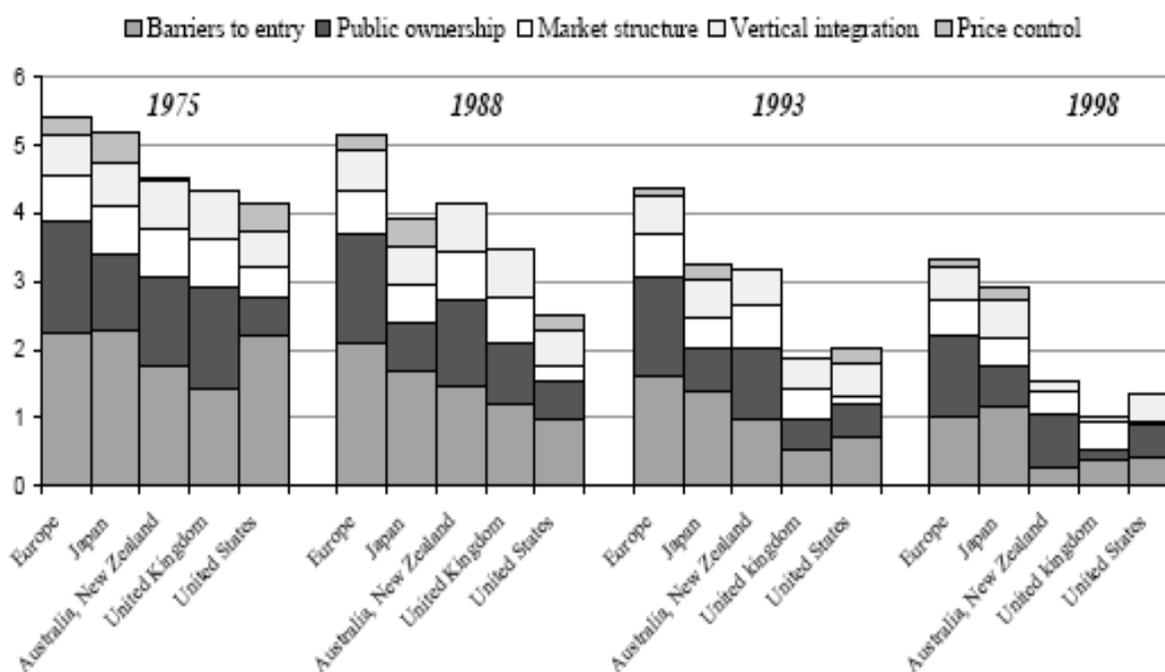


Source: Nicoletti and Scarpetta (2003)

Nicoletti and Scarpetta (2003) argue that “regulatory reform in manufacturing” is related with easing administrative burdens and liberalizing trade which seem as the only tools of the regulatory framework. Thus, trade liberalization in manufacturing by reducing these regulatory costs can be used as a proxy for depicting the competition environment in manufacturing. Figure 9 indicates that trade restrictions diminished after 1988 in almost all of the countries. Furthermore, this figure proves that trade restriction in manufacturing in all of the EU-15ex countries was less than the restrictions in the USA in 1988. In 1996, trade restriction in manufacturing was less in most of the EU-15ex countries in comparison to the USA apart from Belgium in which restrictions slightly exceeds the US restrictions. This finding is not very surprising. The US manufacturing firms are famous with their lobbying groups. They may hardly press the governmental authorities while demanding protection. Therefore, I assume that Europe had had more competitive environment in manufacturing relative to the USA in late 90’s.

Figure 10 Regulatory Reform in Non-manufacturing Industries

0-6 indicator from least to most restrictive



Source: Nicoletti and Scarpetta (2003)

However, things were very different for market services as it is observed in Figure 10. Regularity framework consists of various tools like barriers to entry, public ownership, price control. The regulations in the market services had been always tighter in Europe but significant increase in competition in 90's should be noted. The reforms in the market services like privatization, entry liberalization notably increased the degree of competition in 90's. However, the degree of competition was much lower in Europe in comparison to the USA in late 90's. Thus, I assume that the degree of competition in the market services had been low in Europe but the biggest increase in the degree of competition had happened in the market services in 90's.

5.1.1 Sectoral Assessment

Market Services

Labor productivity in the market services was above the market economy average and the degree of competition was low in 2000. However, the deceleration trend in the productivity

growth rate stopped and turned into acceleration trend. This fact confronts with the assumption of Aghion and Howitt (2006) but one has to note that the biggest increase in the degree of competition in Europe happened in the market services in 90's. Therefore, if we think in terms of change in the degree of competition rather than the absolute degree of increase in the degree of competition at market services in 90's may lead to the acceleration trend in the market services productivity growth rate after 2000. The increase in competition might lead to more efficient use of the inputs in the sector and more implementation of the best practiced technologies. It is obvious that the gains from these facts have exceeded the discouragement of decreasing rents. Thus, innovation and technology started to trigger productivity growth rates after 2000 but this process was not so apparent in early 2000's because of the low growth rates of productivity. It became more apparent after 2004 by exceeding pre-mid 90's levels and the productivity growth rate of the EU-15ex converged to the US productivity growth rate.

Manufacturing

Labor productivity in the ELECOM industry was well below the market economy average by having lowest relative value and the degree of competition was high in 1996. The degree of competition had increased since 1988 but the increase was not as significant as in the case of the market services due to already low level of the restrictions.

I observe the continuation of the already started acceleration trend of the productivity growth rate of the ELECOM industry after 2000. This confronts with assumption of Aghion and Howitt (2006) but fits with the assumption of Nicoletti and Scarpetta (2003).

Labor productivity in goods production sector was below the market economy but above the ELECOM industry and the degree of competition was high in 1996. The degree of competition had increased since 1988 but the increase was not as significant as in the case of the market services due to already low level of the restrictions. The trend of the productivity growth rate deceleration stopped in 2000 but it didn't turn into positive trend as in the case of the market services rather the productivity growth rate has stagnated after 2000. This fact fits with the assumption of Aghion and Howitt (2005).

In this point, it is important to present structural differences of these two manufacturing sectors in order to understand why one fits with one assumption one doesn't.

The ELECOM industry is highly IT-intense industry but goods production relies more on traditional types of capital. In 2000, 22 % of capital compensation was made for IT-capital in the ELECOM industry of the EU-15ex but only 8 % capital compensation was made for IT-capital in goods production. It means that the ELECOM industry is much more technologically advance industry in comparison to the traditional goods production sectors. Jorgenson (2001) points out: “Rapid decline in semiconductor prices can be traced to a shift in the product cycle (the time between new model introductions) for semiconductors from three years to two years around 1995 as competition intensified” However, it may take many years in the traditional goods production industries to develop new products. Therefore, the product life cycle is much longer in traditional goods production than the product life cycle in the ELECOM industry. Longer product life cycle means relying longer on innovation rents. As a result, decrease in the rents on innovation, due to higher competition, would discourage innovation in traditional goods producing sectors more than it would discourage innovation in the ELECOM industry. Although the relative labor productivity is the lowest in the ELECOM industry, high degree of competition may trigger innovation. The reason is the rapid changing nature of this industry which doesn’t allow relying on the rents of innovation for a long period of time. In fact, it seems that although distance to the frontier is the highest in the ELECOM industry, the “escape competition” effect dominates the discouragement of the reducing rents. One additional explanation may come from a factor outside the model which differently affects these two sectors. It may be the effect of the international trade. Globalization and increase in competition with foreign producers may have different effects on both sectors. The value added capacity is lower in traditional goods producing sectors than the value added capacity of the ELECOM industry. Accordingly, human capital need is much lower in most of the traditional good producing sectors like textiles, textile products, leather and footwear, rubber and plastics industries. The globalization and liberalizing trade has led to massive shifts of production of the traditional goods to the developing countries like China, India and Brazil thanks to the low costs in these countries. This means the loss of market shares of the European goods producing firms which may cause decrease in the scale gains and less efficient use of the productive inputs. On the contrary, the ELECOM industry needs high level of human capital which limits competition from the developing countries. Globalization and liberalizing trade has led to exposition of the European ELECOM firms to big developing country markets which may result with the increase in the scale gains and more efficient use of the productive inputs. These asymmetric impacts of foreign competition on both sectors may have detrimental effect on different productivity growth rate trends after 2000.

These two adverse effects caused by structural differences between two sectors and international competition combine and lead to different results on the ELECOM industry and traditional goods production sector.

5.2 Human Capital

Within the framework of neo-Schumpeterian-model, Aghion and Howitt (2006) argue that the different educational attainments do not have the same impact on TFP. Primary and secondary education favor imitation but tertiary education leads to innovation. Eichengreen (2007) emphasizes that the focus of education policy in Europe has been on vocational education rather than tertiary education and he suggests that the focus on vocational education was appropriate for imitating best practiced technologies when Europe had technological backlog after WW II. He further argues that this focus on vocational education have been an obstacle for innovation which requires tertiary education. Vandenbussche, Aghion and Meghir (2006) present empirical evidence for this assumption by investigating OECD countries. However, a specific research conducted by Ark, Inklaar and Timmer (2008) argues that the analysis of aggregate levels may result with positive correlation between TFP and human capital because of a common factor which affects both and indicates that a larger high-skilled labor share has no effect on TFP growth according to their research on market services industries.

The sectors (IT and market services), in which productivity growth rates had accelerated, had the share of high-skilled labor above the average. However, the convergence trend in the productivity growth rate of these sectors to their US counterparts is also observed. I read this fact as a catching-up process in these sectors instead of innovations in these sectors. The common factor of these two sectors is both of them are IT-related sectors, one is IT-producing and the other one is IT-using.

Table 6 IT Capital Share in Capital Compensation and High Skilled Labor in Labor Compensation in the EU-15ex in 2000

	IT capital share in Capital compensation	High skilled Labor share in Labor compensation
Market Economy	17,1%	16,5%
Elecom	22,2%	18,3%
Goods Production	8,1%	10,7%
Market Services	21,0%	20,6%

These facts lead to conclude that the implementation of the best practiced technologies in the IT-related industries requires a larger share of high-skilled labor. It means that not only innovation is caused by the tertiary education but also imitation is caused by the tertiary education, especially in the IT-related industries. In this regard, high human capital level in the EU-15ex and high human capital share in the IT-related industries of the EU-15ex can be associated with the acceleration of the TFP growth rates of the IT-using markets services and the ELECOM industry. Efficient use of technology transfers in the IT-related sectors would be more likely if human capital is high enough to absorb the developments in the cutting edge.

5.3 Labor Market

The empirical evidence for the effects of the labor market institutions on the TFP growth is scarce to my knowledge. Turrini et al. (2009) find that the effect of labor market regulation on the TFP growth is insignificant but the interaction variable between TFP growth rate at the frontier and labor regulation is positive and significant for the EU. They identify this fact as “TFP growth benefits from developments at the frontier” is correlated positively with the decline in labor market regulations.

There are two channels how a decrease in labor market regulations may affect TFP growth. First one is summarized well by Eichengreen (2007) that higher hiring and firing costs discourage entrepreneurs to take risky actions on unproven technologies which may have potentiality of a great commercial success. In addition, high hiring and firing costs make harder to reorganize firms by making costly to place high human capital that is the input

which has become superior in the new kind of knowledge-base economy. In this respect, highly regulated labor markets negatively affect innovation and TFP growth.

The second one is well summarized by Acemoglu and Shimer (2000). They argue that a higher job protection may increase “job tenure” and “investment in job-specific skills” which are necessary for the advancement in leading technologies.

It seems that these two counterfactual effects offset each other and lead to insignificant effect for the labor market regulation variable in the empirical research.

However, the significant interaction variable between TFP growth rate at the frontier and labor regulation indicates that labor market regulations have a considerable impact on the magnitude of the spillovers from best practiced technologies.

These facts lead to conclude that the effect of employment protection is inconclusive on the cutting edge technology creation but employment protection negatively affects the implementation of the best practiced technologies.

The labor protection has decreased in the EU-15ex countries at various degrees and the source of the convergence of the EU-15 ex productivity growth rate to the US productivity growth rate had been the IT-related sectors. This observation supports the assumption that lowering labor protection in the EU-15ex countries reduced the burden of reorganization of the labor structure according to the needs of the IT-related industries. And this improvement has played positive role in the productivity growth rate resurgence in the EU-15ex.

6. EMPIRICAL MODELING³

The previous sections investigated TFP growth rate performance of the EU-15ex within the framework of the convergence. In addition, the role of the institutional framework in the convergence process was also discussed in detail. The next step is modeling the TFP level in the IT-era which aims to test the factors behind productivity improvements in this period of time. Employing endogenous growth model provides theoretical background for the factors behind TFP improvement. This modeling will reveal how chosen explanatory variables work within the framework of the already mentioned institutions and whether they are the sources which are able to explain the improvements in productivity as it is suggested by the theory. In this respect, this section of paper aims to model TFP level of the EU-15ex. My modeling is based on the convergence approach of Aghion, Acemoglu and Zilibotti (2006):

³ All calculations in this section were made on E-views program

$$A_t = \eta \bar{A}_{t-1} + \gamma A_{t-1} \quad (4)$$

Where the first component represents imitation of the best practiced technologies and the second component represents innovation. The neo-Schumpeterian Growth Theory, which is developed by Aghion and Howitt and summarized well by Aghion and Howitt (1998) and Aghion and Howitt (2009), suggest that Research and Development (R&D) is the main factor behind innovations and productivity improvements. In this respect I use R&D spending of the business sector as a proxy for the innovation component by excluding R&D spending outside business sector because I have taken into consideration the market economy TFP level. However, they don't suggest any clear cut proxy for the imitation of the best practiced technologies. The research of the productivity improvements in the EU-15ex reveals that productivity increase in the EU-15ex had been the real source of convergence of the TFP growth rates of the IT-related sectors to the US rates. This convergence process can be read as the technology transfer from the frontier, the USA. And implementing these technologies in the IT-related sectors requires high human capital. In this respect, I use high human capital labor compensation (HHCLC) in market economy as a proxy for imitation of the best practiced technologies. Thus, I aim to model TFP level of market economy in the EU-15ex. In this regard, the estimated model will be:

$$TFP_t = \beta_1 R\&D_{bus_{t-1}} + \beta_2 HHCLC_{t-1} + \varepsilon_t \quad (5)$$

6.1 Data Collection

The investigated time interval is 1981-2007. I obtained TFP level data, the ratio of high human capital labor compensation to aggregate labor compensation and aggregate labor compensation data from EU-KLEMS page which is conducted by Groningen Growth and Development Centre. TFP level data is constructed on value added base and it is index data. Both the aggregate labor compensation data and TFP level data are constructed according to multilateral Purchasing Power Parities (PPPs). The R&D data for business enterprises is obtained from EU-Stat database. The data is constructed according to Purchasing Power Standards (PPS). The data is available for the EU-15 instead of the EU-15ex. Despite this fact, I still use this data as the indicator of the EU-15ex, because the EU-15ex includes all of the big countries in the EU-15. R&D spending of the EU-15ex countries' business enterprises consists of 93% R&D spending of the EU-15 countries' business enterprises in 2007. In this

respect, the R&D spending of the EU-15ex countries' business enterprises constitutes almost all of the R&D spending of the EU-15 countries' business enterprises. Thus, it is convenient to use this data set. However, the data for the ratio of high human capital labor compensation to aggregate labor compensation data is available for 1981-2005. The last two year data is obtained through extrapolation.

6.2 The Choice of the Modeling Technique

Each series contain continuously increasing trend as it is observed in Figure 11. It looks like that they are not mean-reverting series. A simple test reveals that each series contain unit root the results of which will be discussed in detail in the following section. In this respect, I decided to employ co-integration method. If each series are I(d), which means that the series become stationary at dth difference, then the linear combination of each series will be I(d) that means the residuals obtained from the model will be also I(d). If, however, linear combination of series would be a lower order of integration as I(d-b), where b>0, the residuals will be also a lower order of integration as I(d-b), where b>0. Engle and Granger (1987) interpret this occasion as the series are co-integrated of order (d,b).

6.3 Implementation of the Co-integration Test

I employ the 4 Steps Engle-Granger approach in order to investigate the long-run relationship between human capital, R&D and TFP level.

1. Step

First step aims to investigate whether each series are non-stationary. In other words, the series are tested whether they are I(1) or not. These tests are called '*unit roots tests*' by the econometrics literature. And the most well-known unit-root test is the Dickey-Fuller Test (Dickey and Fuller 1979). Dickey-Fuller Test is implemented through following OLS estimates of any regressions.

$$\Delta \ln y_t = (a - 1) \ln y_{t-1} + u_t \quad (6)$$

$$\Delta \ln y_t = \beta_0 + (a - 1) \ln y_{t-1} + u_t \quad (7)$$

$$\Delta \ln y_t = \beta_0 + \beta_1 t + (a - 1) \ln y_{t-1} + u_t \quad (8)$$

where;

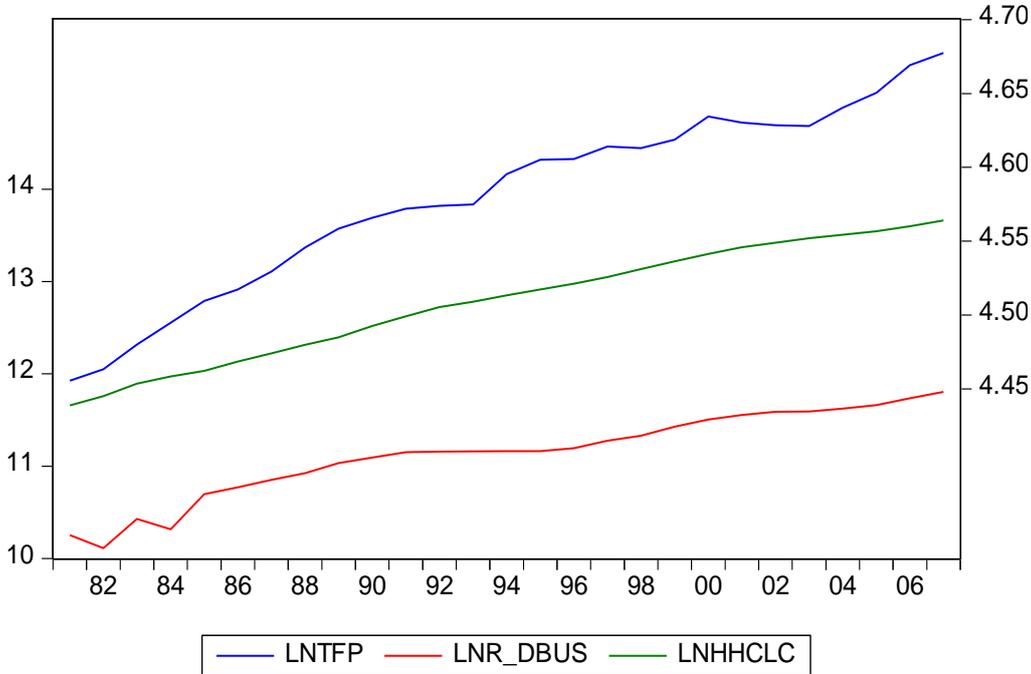
$$H_0: a-1=0$$

$$H_1: a-1<0$$

In the equations, t denotes for linear time trend, u_t is an error term and a is parameter which provides equality.

However, it can be useful to plot the series for visual check before conducting tests.

Figure 11 Time-Series Data of Variables



Right axis values stand for TFP level values. Left axis values stand for R&D spending of business enterprises and high human capital labor compensation. The Figure 11 shows that none of the series are mean-reverting. It means that it is very likely that series contain unit roots and they are non-stationary series. However, one has to also implement unit root tests. The results of the unit root tests are summarized in the following table.

Table 7 Unit Root Test Results

Series	Test	Value	Probability	Hypothesis Testing	Result
LN(Total Factor Productivity)	t,0	6,26	1,00	fail to reject Ho	non-stationary
	tc,0	-1,83	0,36	fail to reject Ho	non-stationary
	tct,0	-2,09	0,53	fail to reject Ho	non-stationary
LN(R&D in business enterprises)	t,0	2,9	1,00	fail to reject Ho	non-stationary
	tc,0	-1,29	0,62	fail to reject Ho	non-stationary
	tct,0	-2,25	0,44	fail to reject Ho	non-stationary
LN(High Human Capital Compensation)	t,0	14,30	1,00	fail to reject Ho	non-stationary
	tc,1	-2,59	0,11	fail to reject Ho	non-stationary
	tct,0	-0,27	0,99	fail to reject Ho	non-stationary

The test results prove my assumption. So, I failed to reject H_0 . Therefore, I consider that each series contain unit root and they are non-stationary series. Thus, I am able to step up to the second step.

2. Step

In this step, it is aimed to test whether the series are stationary at their first differences. In other words, it is tested whether the first differences of the series are $I(0)$. The tests are implemented through following OLS estimates of any regressions similar to the first step.

$$\Delta\Delta\ln y_t = (a - 1)\Delta\ln y_{t-1} + u_t \quad (9)$$

$$\Delta\Delta\ln y_t = \beta_0 + (a - 1)\Delta\ln y_{t-1} + u_t \quad (10)$$

$$\Delta\Delta\ln y_t = \beta_0 + \beta_1 t + (a - 1)\Delta\ln y_{t-1} + u_t \quad (11)$$

where;

$$H_0: a-1= 0$$

$$H_1: a-1 < 0$$

The results of the unit root tests are summarized in the following table.

Table 8 Unit Root Test results for the First Differences

Series	Test	Value	Probability	Hypothesis Testing	Result
ΔLN(Total Factor Productivity)	t,0	-2,1	0,036	reject Ho	stationary**
	tc,0	-3,91	0,007	reject Ho	stationary***
	tct,0	-4,14	0,016	reject Ho	stationary**
ΔLN(R&D Business enterprises)	t,0	-5,44	0,000	reject Ho	stationary***
	tc,0	-9,27	0,000	reject Ho	stationary***
	tct,0	-10,64	0,000	reject Ho	stationary***
ΔLN(High Human Capital Compensation)	t,6	-1,71	0,082	reject Ho	stationary*
	tc,1	-2,71	0,086	reject Ho	stationary*
	tct,5	-6,4	0,000	reject Ho	stationary***

***at 1% level

**at 5%level

*at 10% level

The test results indicate that I reject H_0 . Therefore, I suggest that each series contain no unit root and they are stationary series. In this respect, I am able to step up to the third step.

3. Step

In this step, I estimate long-run relation with OLS. The model is:

$$LNTFP_t = \beta_0 + \beta_1 LNR\&DBUS_{t-1} + \beta_2 LNHCLC_{t-1} + dummy + \varepsilon_t \quad (12)$$

Figure 12 Estimation Output of the Model

Dependent Variable: LNTFP

Method: Least Squares

Sample (adjusted): 1982 2007

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNR_DBUS(-1)	0.038072	0.013506	2.818872	0.0100
LNHHCLC(-1)	0.071632	0.010281	6.967553	0.0000
DUMMY	-0.020915	0.004919	-4.251843	0.0003
C	3.251043	0.040770	79.74137	0.0000
R-squared	0.986293	Mean dependent var		4.584466

Adjusted R-squared	0.984424	S.D. dependent var	0.058395
S.E. of regression	0.007288	Akaike info criterion	-6.864548
Sum squared resid	0.001169	Schwarz criterion	-6.670995
Log likelihood	93.23912	F-statistic	527.6747
Durbin-Watson stat	1.768782	Prob(F-statistic)	0.000000

I put dummy variable for 2002-2004, because actual values deviate significantly from the fitted values. It means that short-run values differ significantly from long-run values for this period of time. In this respect, I put fixed time effect for this period of time.

The estimation output shows that all of the variables are significant at 1% level.

4. Step

In the final step, it is aimed to test whether residuals are stationary or non-stationary. If residual series would contain no unit root and hence they are stationary, the co-integration relation can be found among series. If, however, residual series would contain unit root and hence they are non-stationary, the co-integration relation can not be found among series. The tests are implemented through following OLS estimates of any regressions similar to the previous steps:

$$\Delta \varepsilon_t = \beta_0 + (a - 1)\varepsilon_{t-1} + u_t \quad (13)$$

$$\Delta \varepsilon_t = \beta_0 + \beta_1 t + (a - 1)\varepsilon_{t-1} + u_t \quad (14)$$

where;

$$H_0: a-1= 0$$

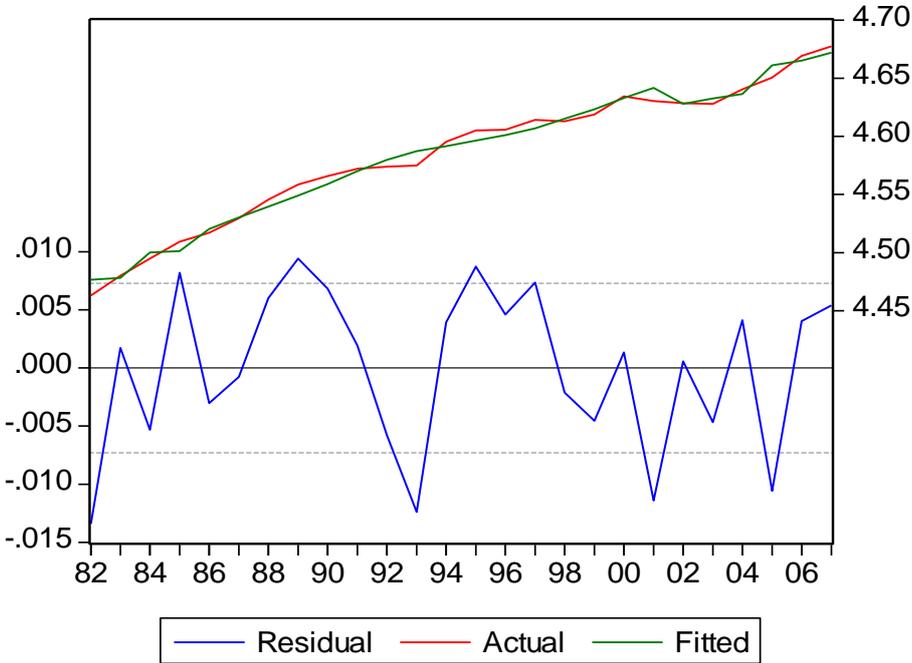
$$H_1: a-1 < 0$$

However, there is an important thing to remind that Dickey-Fuller unit-root critical values are not valid in this step. The reason is that OLS method minimizes the square of the residuals in order to have a small set of variances as possible. This nature of OLS estimation leads to make the residuals as stationary as possible. In addition, if more variables are added to single

independent variable, the residuals shift further to the left. The solution is using response surface parameters. The critical values calculated by this technique are presented at Table 9. Unfortunately, critical values are not available for the case of no deterministic component. Therefore, I dropped the equation which includes no deterministic component.

It can be useful to plot actual, fitted values and residuals for visual check before conducting tests.

Figure 13 Actual, Fitted Values and Residuals of the Model



The residual series looks like as a mean-reverting series by fluctuating around mean. It seems that residual series is stationary and $I(0)$ according to the figure above. However, I have to also check the test results. The test results are summarized in the table below.

Table 9 Co-integration Test Results

Series	Test	Values	Critical Values			Hypothesis Testing	Cointegratin Relation
			1%	5%	10%		
TFP: R&Dbus(-1), HHCLC(-1)	$t_{c,0}$	-5,01	-4,92	-4,1	-3,72	reject H_0	Cointegration***
TFP: R&Dbus(-1), HHCLC(-1)	$t_{ct,0}$	-4,99	-5,49	-4,69	-4,21	reject H_0	Cointegration**

***at 1% level

**at 5% level

The results prove that the residual series is stationary and $I(0)$. Therefore, the stepwise Engle-Granger co-integration test results with the finding of co-integration relation between TFP level, R&D spending of business enterprises and high human capital labor compensation for the EU-15ex. In this respect, these three series are linked to form long-run equilibrium relationship in the period 1981-2007.

The coefficient value of human capital variable is almost twice as much as the coefficient value of R&D variable. This finding supports the assumption that technology transfers play a larger role in the TFP improvements than the innovations through R&D.

The results of this co-integration test bear some policy issues. These results prove that a higher human capital and a higher level R&D result in the innovations and implementations of the best practiced technologies which lead to improvements in productivity. In this respect, R&D policies, which favor R&D spending of business enterprises, should be devised and implemented properly. Thus, the costs of the R&D can be eased and more resources can be directed to R&D spending which would result with more innovations and increase in productivity. In addition, the policies, which favor increase in human capital level in the EU-15ex, should be properly organized and implemented in order to capitalize the spillovers from the developments in the cutting edge technology. That would also lead to productivity improvements.

7. CONCLUSION

In the quarter century following WW II, Europe had experienced significant increase in the productivity growth rate which had led to high economic growth rates. This advancement is attributed to the exploitation of the initial backlog in technology in comparison to the USA, especially in mass-production processes. However, it should be kept in mind that the economic framework was appropriate for the exploitation of this technological backlog. The high human capital and the outcomes of tri-partite association like non-competitive business environment and high level of labor protection formed appropriate framework for the adoption of the best practiced technologies. Thus, the convergence process had taken place within this framework. However, as Europe approached to the USA in terms of technology, the potentiality of the exploitation of technological backlog was exhausted. In this point, Europe had to be able to innovate and create leading technologies rather than transferring them. However, the already mentioned institutional economic structure was appropriate for imitation of the best practiced technologies but not appropriate for creating new technologies. Therefore, Europe headed towards low productivity growth rates after the second half of the seventies like the USA.

However, the USA was able to change this trend in mid 90's by having productivity growth rate resurgence. This resurgence can be attributed to both productivity improvements in the IT-producing industry and the IT-using market services. On the contrary, Europe had been suffering from low productivity growth rates during this time. The question is whether Europe will be able to exploit its technological backlog, which is caused by IT-related sectors this time, again. This paper suggests that the exploitation of the technological backlog already started. This fact dismisses the views that argue that the institutions in Europe are not appropriate to reap the benefits of the New Economy. On the contrary, Europe has revised and transformed its institutional economic framework since the beginning of the 90's. This transformation of the institutional economic framework accompanies with traditional high level of human capital. And this combination led to form appropriate framework for adoption of the developments in New Economy. The exploitation of the technological backlog in the IT-related sectors started slowly in the beginning of 2000's. However, low productivity growth rates in the beginning of 2000's disguised this process. However, the pace of the exploitation of the technological backlog in the IT-related sectors accelerated in mid 2000's. Thus, this closing gap in technology became more apparent in this period of time. In this sense, the 90's can be assessed as the transition period of reforms.

However, the good news should not be exaggerated. First, the transformation of the institutional economic framework won't create the environment which is appropriate for radical innovations. It would create a framework which is appropriate for adoption of the improvements in IT-related industries rather than advancement in the technology of this industry. Thus, as Europe will approach to US again, the potentiality for the exploitation of technological backlog will diminish again. Secondly, the technological backlog is not as large as in the aftermath of the WW II. This fact means that the potential gains from the exploitation of the technological backlog in new economic era are much more limited in comparison to the potentiality following WW II.

This paper also presents an empirical modeling of TFP level for the EU-15ex in order to uncover the factors behind the improvements in productivity. This modeling is based on the structure of neo-Schumpeterian Growth Model's paradigms. The time span of the model covers the period 1981-2007. The results of test procedure find the co-integration relation between TFP level, R&D spending of business enterprises and high human capital labor compensation in the EU-15ex. In this regard, these three series are linked to form long-run equilibrium relationship in the period 1981-2007. The economic interpretation of these results is that a higher human capital and a higher level R&D result in the innovations and adoption of the leading technologies which lead to improvements in productivity.

Although the EU-15ex productivity growth rate converged to the US productivity growth rate, the TFP growth rates differ significantly within the EU-15ex. The Mediterranean countries like Spain and Italy, which were success stories in the period following WW II, suffer from negative TFP growth rates for the period 2000-2007 by having -0,6% and -0,4% growth rates respectively. On the contrary, countries like Germany and Netherland had positive TFP growth rates for the period 2000-2007 by both having 0,7% growth rate. This fact bears a significant research agenda which should investigate the variations of the TFP improvements among the EU members.

Time will show whether Europe will be "the comeback continent" as it is suggested by Krugman (2008). However, there are good signs that Europe is able to adapt to new economic era and started to reap the benefits of developments in the IT-age. The real challenge is that the level of adaptation to the new economic era varies greatly within the EU. The economic reflection of this variety is high degree variation in reaping the benefits of the IT-age that

result in different productivity improvements within the EU. This fact is the core reason of current struggle in the EU.

This challenge brings the necessity of harmonized policies within the EU. The Lisbon Strategy appeared with this goal in 2000. The aim of the agenda was set as making the EU “the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion,” by 2010. However, the goals of the agenda were not achieved. And Fredrik Reinfeldt, the prime minister of Sweden, admitted that “Lisbon Strategy has been a failure” just before Sweden took the presidency of the EU in 2009.

If Europe would learn the lessons from this failure and would be able to dedicate itself wholly to the new EU 2020 strategy, then the gains from the developments of the IT-age will spread to whole EU. And “the comeback continent” argument becomes more likely.

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