Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Diploma Thesis

INNOVATION AND COMPETITIVENESS AS A SOURCE OF ECONOMIC GROWTH

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DIPLOMA THESIS ASSIGNMENT

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The structure of the diploma thesis:

1. Introduction
2. Objectives of thesis and methodology
3. Literature overview
4. Innovation and economic growth - Empirical evidence
5. Conclusions
6. Bibliography
7. Supplements

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Bibliography:

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The Diploma Thesis Supervisor: **Ing. Zuzana Křístková**

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.... Head of the Department

.... Dean

In Prague: 10th June 2010

Declaration

I declare that I have worked on my diploma thesis titled “Innovation and Competitiveness as a Source of Economic Growth” by myself and I have used only the sources mentioned at the end of this thesis.

In Prague on 1.10.2010 ________________________________

Martin Fišer

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INNOVATION AND COMPETITIVENESS AS A SOURCE OF ECONOMIC GROWTH

INOVACE A KONKURENCESCHOPNOST JAKO ZDROJ EKONOMICKÉHO RŮSTU

SUMMARY

This Diploma thesis presents an insight into the sources of economic growth. Despite the fact there have been conducted a massive research since the beginning of the 20th century, there is no single explanation of the sources of growth. This thesis is inspired by theories derived from Robert Solow`s growth model and provides the analysis of the economic growth and its possible sources in the European countries. The analysis and the model, which is based on the factors derived from innovation, education and knowledge-intensive work can be used to evaluate the sustainability of the growth, which is the key factor needed for long-term economic growth. Furthermore, the analysis and model can confirm the spirit of innovation is a key element for long-term growth.

KEYWORDS

Economic Growth, Development, Innovation, Competitiveness, Entrepreneurship, Total Factor Productivity, Patents, European Union

SOUHRN

Tato diplomová práce umožňuje pohled do zdrojů ekonomického růstu. Přesto, že probíhá výzkum ekonomického růstu již od 20. století, stále není dostupná jediná ucelená teorie zdrojů ekonomického růstu. Tato práce je inspirována teoriemi založenými na růstovém modelu Roberta Solowa s jejichž pomocí provádí analýzu ekonomického růstu a jeho zdrojů pro státy Evropy. Prostřednictvím analýzy a ekonometrického modelu, které jsou založeny na faktorech, jako inovace, vzdělání a znalostní ekonomiku, je možné posoudit udržitelnost růstu každého státu a take klíčový faktor růstu. Pak je možné určit, zdali je inovace zdrojem dlouhodobého ekonomického růstu.

KLÍČOVÁ SLOVA

Ekonomický růst, rozvoj, inovace, konkurenceschopnost, podnikání, souhrnná produktivita faktorů, patenty, Evropská Unie.

Table of Content

1. INTRODUCTION

We have come across two major problems in the global economy in the past years: first, we have seen reduced economic growth, increased unemployment and soaring public debt in the developed countries thanks to the global financial crisis. To recover and move towards a more sustainable growth path, new sources of growth are urgently needed. Second, the developing countries are still left behind the developed world and there is no tendency of a quick catch-up. The crisis has struck the whole world, both developed and developing countries. Moreover, it appears it has shown the real economic problems and conditions of the European countries. The unsustainable growth in some European countries has been criticized in the past[1].

We simply need a generalized system of desirable policies, rules and thoughts that could be used as guidance for majority of countries, either developed, or developing. The suggestion is that several general policies can be derived from the variety of policies applied mainly in European countries.

Traditional and broadly used sources of growth are losing their importance. The role of labour as a conventional factor of economic growth is reduced by the stagnation or decline of population of developed countries. Additionally, other factors suffer as well. Investments in physical capital face diminishing returns[2] and have been proven as insufficient to support long-term growth, especially in developed economies. Every government should implement policies for sustaining long-term economic growth, which is sustainable. Despite the fact the word sustainability is broadly used in the connection with environment, sustainability is seen as a crucial aspect of the economic growth policies as well. Nowadays, contemporary theories conclude that several factors increasingly gain importance in designing the representative policies.

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[1] *For example in Ireland, see Gallagher, L. A., Doyle, E., O'Leary, E. 2002*
[2] *See Neoclassical economic growth theory*

The innovation is one of those factors. Innovation will be most likely needed to drive growth, employment and improvement of living standards. It can be applied as well for emerging economies that look to innovation as a way to enhance competitiveness, diversify their economy and move towards more high value added activities. The assumption is leading us to the main questions:

Is the innovation and thus competitiveness an important factor of economic growth? How are the policies for innovation, competitiveness and growth applied in the case of Europe?

This thesis describes the importance of the innovation and competitiveness and its link to the economic growth by using econometric modeling tools. Econometric models will be based on the theoretical base of modern economic growth theories. The thesis describes the possible implications for policy makers and overall importance of perception of innovation and competitiveness as the main source of economic growth.

The first chapter of this diploma thesis is dedicated to the theoretical part that covers the main theories of economic growth that serve as a ground for further research.

Second chapter contains various theories of the innovation and competitiveness factors, main sources models and measurement of innovation. The chapter then defines the relation between innovation and competitiveness. Since the first chapter is fairly macro-economic, second chapter goes rather to micro-level of companies and industries.

Third chapter deals with the models of innovation as the source of economic growth and the impacts of results.

The last chapter recapitulates all the findings in previous parts and contains the discussion about the important conditions and policies for the future growth in EU.

2. OBJECTIVES AND METHODOLOGY

2.1. OBJECTIVES

Main goal of the thesis is to answer to the question: Is innovation an important factor influencing the economic growth? Additionally, the partial objective is to analyze the conditions within the European countries characteristic for knowledge economy that matter.

The main motivation for this thesis is the misguided perception of the innovation in Europe demonstrated by unsuccessful EU plans[3] for sustaining the growth and becoming the world center of innovation. In spite of this fact, there have been some countries with a relatively good growth. The idea is to derive factors that differ among countries and have possible influence on the long-term growth.

The contribution of the thesis is firstly the confirmation of the importance of innovation to the economic growth in Europe and description of the current state of countries by innovation and knowledge economy factors. Furthermore, the thesis offers some insight look in the possible future development

2.2. METHODOLOGY

There is used a descriptive analysis and econometric model in the thesis to assess the impact of innovation on the economic growth.

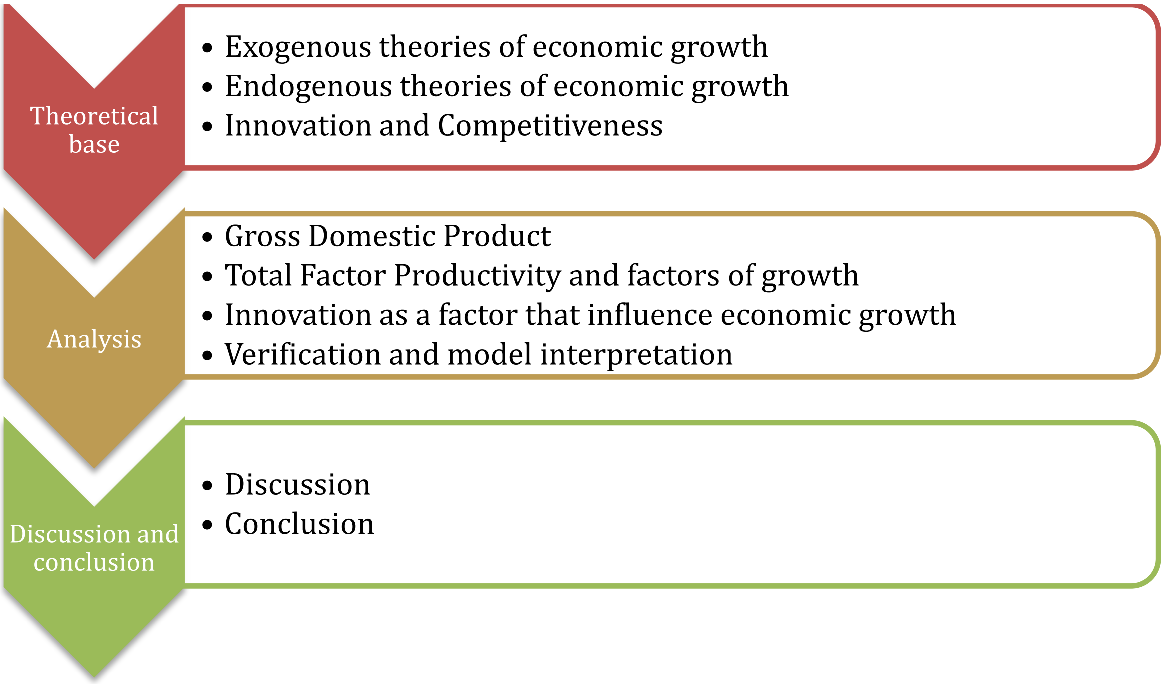
Whereas researchers have been trying to evaluate sources of Total factor Productivity (TFP), it is often considered as a proxy of the technological progress. According to various research[4], TFP is influenced by various factors, namely technological progress and thus innovation activities (R&D, patent activities, education, etc.). The first part contains a descriptive analysis of factors that possibly influence and reflect the accumulation of knowledge and the use of technology. Each factor, derived based on the theoretical part, is used for the evaluation of the countries. At the end, the summary table allows to confirm the

[3] *Mainly Lisbon Agenda*
[4] *Important theories are part of the theoretical background*

importance of innovation as a source of economic growth. Additionally, overview table provides a background for the additional evaluation of growth of European countries and suggests an outlook of the future growth.

Second stage contains an econometric model. Whereas the descriptive analysis aims to confirm the importance of the innovation, the second part contains additional attempt to support this argument. The model uses GDP as an endogenous variable. Factor innovation is among exogenous variables and the model is supposed to evaluate the importance of innovation on TFP.

Figure 1: The scheme of research



2.2.1. Collection of Data

There is used one primary source of data – Eurostat. The dataset is collected for a selection of European countries, relative on their economic characteristics and importance. The data span varies according to the availability of data.

For TFP evaluation purposes KLEMS database is used. The database enables to overcome the problem of data inconsistency for derivation of TFP statistics from traditional Solow's equation. As it is mentioned in the theoretical background section, growth accounting is based on deriving the sources of growth by using Solow`s formula (1956). Calculation is following:

Let Y be real GDP, K capital input and L labour input measured in period t. Then the Solow model equation is following:

$$Y = B. La. K1-a$$

Where B is disembodied technical progress, a under certain conditions (ie. perfect competition) is the labour income share and 1-a is the capital income share. Thus,

$$\Delta Y/Y = \Delta B/B + a \Delta L/L + (1-a) \Delta K/K$$

$$\text{or } \Delta B/B = \Delta Y/Y - a \Delta L/L - (1-a) \Delta K/K$$

The equation above can be then rewritten as following (Δ B/B):

$$\Delta TFP = \Delta Y/Y - a \Delta L/L - (1-a) \Delta K/K$$

As it was mentioned Burda and Severgnini (2008), an important weakness of primal TFP growth measure is that it requires clean estimate of the capital stocks time series. Capital stocks are measured the greatest degree of error of all factors of production, simply because they are not observed; rather they reflect the implications of a particular theoretical model for a series of observable measurements on gross increments to the capital stock (gross fixed domestic capital formation, or investment).

Nevertheless, thanks to participation of 15 organizations from across the EU, representing a mix of academic institutions and national economic policy research institutes and with the support from various statistical offices and the OECD, there is an attempt to standardize and perform growth accounting of selected European countries called EU KLEMS project. EU KLEMS stands for EU level analysis of capital (K), labour (L), energy (E), materials (M) and service (S) inputs.

According to the KLEMS website[5], the project aims to create a database on measures of economic growth, productivity, employment creation, capital

[5] *http://www.euklems.net/project_site.html accessed: 14. 3. 2011*

formation and technological change at the industry level for all European Union member states from 1970 onwards. This work will provide an important input to policy evaluation, in particular for the assessment of the goals concerning competitiveness and economic growth potential as established by the Lisbon and Barcelona summit goals. The database should facilitate the sustainable production of high quality statistics using the methodologies of national accounts and input-output analysis. The input measures will include various categories of capital, labour, energy, material and service inputs. Productivity measures will be developed, in particular with growth accounting techniques. Several measures on knowledge creation will also be constructed. Substantial methodological and data research on these measures will be carried out to improve international comparability. The database can be used for analytical and policy-related purposes. In particular, it can be used for studying the relationship between skill formation, technological progress and innovation on the one hand, and productivity, on the other. To facilitate this type of analysis a link will also be sought with existing micro (firm level) databases.

Importantly, KLEMS database is deeply rooted in statistics from the National Accounts and follows the ESA95 framework in many respects. A key objective of the EU KLEMS database is to move beneath the aggregate economy level and examine the productivity performance of individual industries and their contribution to aggregate growth. Full methodology of KLEMS accounts and calculation can be obtained in KLEMS website[6]. Additionally, there is even the attempt to develop the KLEMS database of the whole world[7] that would enable to perform more reliable comparison of the countries in the world.

There are, however, several problems for the use of this thesis. Firstly, KLEMS database is still incomplete; it consists of only selected portion of EU countries.

[6] *http://www.euklems.net/data/EUKLEMS_Growth_and_Productivity_Accounts_Part_I_Methodology.pdf accessed 14. 3. 2011*

[7] *http://www.worldklems.net/ accessed: 14. 3. 2011*

Secondly, KLEMS database only covers small time series. This flaw allows only evaluation of a small portion of countries and data. Yet it is still the most relevant source of data for growth accounting in European countries.

The Gross domestic product (GDP) is a measure of the economic activity, defined as the value of all goods and services produced less the value of any goods or services used in their creation. The calculation of the annual growth rate of GDP volume is intended to allow comparisons of the dynamics of economic development both over time and between economies of different sizes. For measuring the growth rate of GDP in terms of volumes, the GDP at current prices are valued in the prices of the previous year and the thus computed volume changes are imposed on the level of a reference year; this is called a chain-linked series. Accordingly, price movements will not inflate the growth rate[8].

European Innovation Scoreboard[9] is a well-established and recognized tool for assessing innovation performance in EU Member States. The latest 2010 Scoreboard uses 25 research and innovation-related indicators and covers the 27 EU Member States, and also Croatia, Serbia, Turkey, Iceland, Norway and Switzerland. The indicators of European Innovation Scoreboard are grouped into three main categories:

- "**Enablers**", i.e. the basic building blocks which allow innovation to take place (human resources, finance and support, open, excellent and attractive research systems)
- **"Firm activities"** which show how innovative Europe's firms are (firm investments, linkages & entrepreneurship, intellectual assets); and

8 *http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsieb020 accessed 15. 3. 2011*

9 *European Innovation Scoreboard, Available at: http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm Accessed 24. 3. 2011*

- "**Outputs**" which show how this translates into benefits for the economy as a whole (innovators, economic effects).

In general, European Innovation Scoreboard can be found as a best indicator of the innovation performance in the Europe.

2.2.2. Analysis

A set of European countries is used as a sample, because of the homogeneity of several conditions in comparison to the world. Among these conditions belong mainly intellectual property rights (it would be problematic in the developing countries), the free market and the independence of companies on the government (which would be problem for China, Russia, some South American countries, etc.) Moreover, the legal system is also quite similar thanks to EU legal homogenization.

Thanks to the homogeneity in such factors, the inconsistency of crucial conditions and data imperfection is (to some extent) avoided. In the comparison to the developing countries, there is probably smaller difference in the level of black market and house production among European countries, so the use of GDP as a measurement of the economic development seems to be legitimate.

There are Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Norway and Croatia evaluated in the analysis section. However, the FTP is evaluated only in the countries when KLEMS data are available.

Furthermore, the analysis contains the assessment of the factors and for some countries also its comparison with FTP growth derived from KLEMS. The assessment of the factors enables the comparison of the performance of the theoretical predetermines of the growth and the real GDP growth. The comparison then enables to draft the performance of the country in the means of the sustainability of the growth.

The overall profile of the country is then compared with the position of the country in European Innovation Scoreboard in order to find the similarities. Similar performance of the indicators and country profile in European Innovation Scoreboard would mean the analysed factors do represent the innovative activities.

Based on the dataset, the econometric model is formed and the parameters are estimated.

3. Economic growth theories

3.1. The importance of Growth

How is it possible that there are huge differences in the wealth of countries? Why are some countries rich when others are poor? The gap between poor and rich countries sounds unbelievable. There are countries that have GDP per capita twenty-or thirty times less than GDP per capita of the rich countries. Moreover, man can see such disparities among regions and continents. The welfare differences does not affect only the ability to buy goods and services, but it has great influence on the level of health, life expectancy, infant mortality rate, quality of education, etc. Economic growth can have a great impact on the quality of life and has been seen as a most powerful instrument for reducing poverty (Rodrik, 2007). Additionally, some studies suggest the relation between wealth and general trust in the society[10].

Such differences in welfare bring the questions about the factors of economic growth and the role of institutions and policies that have causal effects of growth. Some may argue that natural characteristics of countries have the biggest impacts on economic growth. However, how can be possible that the income of Europe and Asia in the 18th century was approximately at the same level and since then, the Asia and Africa stood still and Europe and America economy was growing? Even at the beginning of the 21st century, only few economies in Asia are catching up the rest of the world.

Thus, there is an importance of the long-term economic growth. Even the decimal difference of growth can have huge impact on the economy when is sustained for a long period of time. The effect of Compound Annual Growth Rate is that if the economy of one state grows 1.4% annually, the whole economy doubles in 51 years. However, if the economy grows 2.0% annually, the whole economy doubles in 35 years. Additionally, when the economy grows 5.7%, the whole economy

[10] *Delhey, Kenneth, Newton, 2005*

doubles in only 12 years. We can see only a slight difference can have significant effects.

Economic growth is generally good for welfare but it often creates "winners" and "losers."[11] Joseph Schumpeter's famous notion of creative destruction emphasizes precisely this aspect of economic growth; productive relationships, firms and sometimes individual livelihoods will often be destroyed by the process of economic growth because growth is brought about by the introduction of new technologies and creation of new firms, which replaces existing firms and technologies (Acemoglu 2009).

In theory, there has been a presumption that there is a natural tendency to converge, mainly supported by theories with traditional models of Robert Solow and others. This is known as "Absolute convergence". The prediction of absolute convergence is unrealistic because countries do not have identical technology, investment rates, depreciation rates and demographical tendencies. However, if differences in these 'other variables' can be controlled for, then we might expect to see convergence. This is known as 'conditional convergence'. Kennedy (2000/01) refers the "potential for catching-up which exists for all developing countries". As an economy approaches nearer to the frontier of best-practice technology, however the scope for catching-up is attenuated." Baumol (1986) sees convergence mechanisms as the 'sharing of productivity growth due to its public good characteristics'. Thus, through technological spill-overs, follower countries may catch-up on leaders. This would be facilitated by the increased integration of world trade and improvements in worldwide communications. This mechanism differs markedly from that envisaged in the Solow model, where technology is exogenous and assumed to be available freely to everybody. Additionally, it is easier for developing countries to grow fast, because they start from the low level. On one hand, a small difference of GDP of developing country can mean a modest

[11] However, Paul Romer denies the whole concept of "winners" and "losers." (Romer interview for Econtalk.com)

growth. On the other hand, rich countries would need a substantially bigger difference of GDP to sustain the same amount of growth.

Despite the fact that the "religion of the growth" is often heavily criticized, growth is still the main goal of every economic operation, either of the industry, businesses, or households. Economic growth helps government to repay the public debt, it allows business to expand and generally helps to improve the quality of life of households and citizens. Growth helps to tackle the disparities between regions and it is important for both urban and rural areas. However, we have to bear in mind the importance of the sustainability as well. Economic development leads us to the creating and maintaining jobs, providing a good standard of living for the citizens. By doing it, increased incomes and wealth increases tax base, therefore the state can provide services expected by its citizens. A balanced, healthy economy is essential for community well-being.

3.2. EARLY THEORIES

3.2.1. ADAM SMITH

One of the main contributions of Adam Smith's Wealth of Nations published in 1776 is the explanation of economic growth (mainly the income level reached by developed countries) due to increasing returns generated by the division of labour. He viewed the growth process as strictly endogenous (see also Lowe, [1954] 1987, and Eltis, 1984, cited by Kurz H. D. in Kurz and Salvadori N, 2003) In particular, the economic growth is mainly influenced by two factors: labour productivity and the proportion of productive to unproductive workers. Smith' distinction of the productive and unproductive workers has been made based on the materials he utilizes. As such, his labour is fixed in a good that may subsequently be exchanged with other labour. On the contrary, the worker is unproductive when he produces services, which "generally perishes in the very instant of (his) performance, and seldom leave any trace or value behind [it], for which an equal quantity of service could afterwards be procured" (Lavezzi, 2001). Interestingly, examples of unproductive workers are: servants, musicians, lawyers, soldiers, churchmen, etc.

Labour productivity, which is considered the most important factor, essentially depends on the division of labour which (Rostow 1992):

a) improves the dexterity of the worker;

b) allows the worker to save the time necessary to switch among different activities;

c) puts the worker in the condition of inventing machines to facilitate his job.

We can assume, that in contemporary terms, Adam Smith had in mind the concepts of learning by doing, set-up costs, and endogenous technological progress. In this context, technological advances increase the stock of knowledge, and can be considered as consequences of an increased division of labour when workers concentrate on a particular phase of the production process. Capital accumulation in the Smith means should also be considered with respect to division of labour. First, for Smith competition forces, entrepreneurs have to seek the most profitable way of deploying capital, that is the most productive division of labour. In general, capital accumulation and division of labour are intimately connected since not only capital accumulation permits division of labour, but also division of labour stimulates further accumulation of capital.

Adam Smith' works essentially set up the relation between the labour productivity and the division of labour as the sources of economic growth. However, there are sectors of the economy in which the division of labour is hard to achieve. In fact, the agriculture is characterized by a seasonal timing of every operation (such as seeding in spring, harvesting in autumn, etc.). In short, in the Smith' theory of growth we can individuate some basic elements (Lavezzi, 2001):

a) Industrial production is characterized by increasing returns, originating from division of labour;

b) The process of division of labour can reach more advanced stages in the manufacturing sector than in agriculture;

c) Individuals demand a potentially infinite variety of manufactured Goods;

d) Individuals have a natural inclination for social interaction.

As a consequence, economic growth according to Adam Smith appears as an endogenous, cumulative process, where progress builds on previous progress and creates pre-conditions for further growth (Lavezzi, 2001).

3.2.2. THOMAS MALTHUS

Malthus' theory has been made based on his observations (gathered stylized facts) about the cyclical trend of misery and poverty, which had some policy implications. Essentially, Malthus made the observations about the relation between natality rate, mortality rate, and the shape of output per capita as a function of population. If we put all elements of Malthus' theory together, we can obtain all the linkages between the variables and try to find equilibrium. As a result, this economy and its population size is governed by hunger, and it is impossible to escape from this misery. Malthus' principal recommendation was thus to find ways to reduce population growth, such that people can enjoy higher standards of living. The implication on policy seem to sound strange, basically support the policies to increase the mortality rate, for example waging wars at regular intervals, or to reduce the natality rate. In some editions of his work, he even recommends prostitution as the way to alleviate the "passion of the sexes", while driving natality lower.

If we look back at the periods since Malthus, we notice that population and standards of living have both tremendously increased. This was triggered, among others, by the Agricultural and Industrial Revolutions. This highlights that Malthus' model may be a too restrictive abstraction from the reality, as population is the only driving force. History shows us that there should be at least two other driving forces, capital accumulation and technological progress.

3.2.3. *David Ricardo*

The benefits from Ricardo research to the theories of economic growth can be seen from the perspective of capital accumulation and the role of diminishing returns[12]. The beneficial effects of capital accumulation on productivity mediated through the extension of the division of labour play hardly any role in his analysis. Ricardo was keen to show that, given the real wage rate, the rate of profits cannot fall as a consequence of the 'competition of capital', as Smith had argued, but only because of diminishing returns due the scarcity of land(s). (Kurz and Salvadori, 2003). Ricardo saw the rate of accumulation and thus economic growth as endogenous.

3.3. Exogenous growth theories

3.3.1. *Harrod-Domar model*

The Harrod-Domar model, originally developed to help analyze the business cycle, was later used to explain economic growth. They have attempted to integrate Keynesian analysis with the elements of economic growth and paid the attention to make explicit the relationship between the consumption-savings by households and the investment decision by entrepreneurs. It concluded that:

a) Economic growth depends on the amount of labour and capital.
b) It is a lack of physical capital that holds back economic growth and development.
c) More physical capital generates economic growth.
d) Net investment leads to more capital accumulation, which generates higher output and income.
e) Higher income allows higher levels of saving.

The model suggests it is viable for growth to expand the level of investments (both in terms of fixed capital and human capital). The implication of the model is that

[12] *See later the Solow model*

policies are needed that encourage saving and/or generate technological advances which enable firms to produce more output with less capital i.e. lower their capital output ratio.

3.3.2. Neo-classical growth model (Solow Model)

The Solow model, sometimes-called Solow-Swan neoclassical growth model (Solow, 1956), (Swan, 1956) places capital accumulation as the core driver of national income (Y). The Solow model has been used to assess the contributions of labour, capital and technology to output growth. This is known as growth accounting. Basically, an economy can produce more output if it has more labour, more machinery (infrastructure), or better ways of putting together machinery and labour. The Solow model equation is following:

Y = F (L, K, T)

Y……output (national income)

L……number of workers (work hours)

K……the value of capital stock

T…….technology

However, the technology is defined as the way in which L and K are combined to produce Y. In other words, the equation can be written in this form (the modified The Cobb-Douglas Production Function):

Y = T•F (K, L)

For given quantities of the factor inputs, K and L, an increase of T raises output. In other words, a more technologically advanced economy has a higher level of overall productivity. Higher productivity means that output is higher for given quantities of the factor inputs. It was this property that led Solow to recognize that he needed to assume Technology is also growing at an assumed exogenous rate. Under these circumstances, technology lessens the impact of diminishing returns to capital accumulation, so that we can envisage the economy growing indefinitely, as a result of technological improvement.

The model contains several simplifications. For example, the model does not take account for unemployment—labour input equals the labour force, all of which is employed. Additionally, the model ignores a role for government (no taxes, public expenditures, government debt), and the model assumes a closed economy. Despite the fact of the rather theoretical than practical use, it has several implications:

The change in Y from a small increase in K is called the *marginal product of capital* (MPK). It tells us how much Y rises when K increases by one unit. The model contains one important element, which is called the *diminishing returns of capital*. It basically means that when we add more and more K, the Y is not rising proportionally. In fact, the more and more K we add, the less change we get. The labour factor is not the key either. Key statement is that the growth rate of real GDP per worker depends only on the growth rate of capital per worker. The outcome is that growth based on accumulation of the capital is not sustainable and moreover the sustainable growth must be based on technological progress. However, the Solow model of the growth supposed the growth came exogenously from the unmodeled process of labour-augmenting technological progress (Acemoglu D. 2006).

Solow essentially established the basic model of economic growth, which has been modified by other scientists in the future in the task of search for the perfect model of economic growth. The Solow model has been used to assess the contributions of labour, capital and technology to output growth. This is known as growth accounting.

We can use the adjusted function (Jones 1998):

$$Y = B. La. K1\text{-}a$$

Where B is disembodied technical progress, a under certain conditions (ie. perfect competition) is the labour income share and 1-a is the capital income share. Thus,

$$\Delta Y/Y = \Delta B/B + a\,\Delta L/L + (1\text{-}a)\,\Delta K/K$$

$$\text{or } \Delta B/B = \Delta Y/Y - a\,\Delta L/L - (1\text{-}a)\,\Delta K/K$$

$\Delta B/B$ is the growth in technology or what is referred to as growth in total factor productivity (TFP). We can calculate total factor productivity as a residual from the equation. It is a very crude measure of technological progress and has famously been referred to a quote of Abramovitz as 'a measure of our ignorance' (Abramovitz, 1989). Due to the assumption of diminishing returns to capital, Solow-Swan model determine the factor technology as the only factor for sustainable, long-run economic growth.

Furthermore, the model predicts the conditional convergence of the countries. Basically, the country that starts from the lower position (by the factor of economic development – per capita GDP) has the advantage to quickly catch-up and growth faster rate than the more developed country.

Despite the fact the empirical evidence of such process is mixed, the conditional convergence has considerable explanatory power for economic growth across countries and regions (Zarra-Nezhad and Hasainpour, 2011).

3.4. ENDOGENOUS GROWTH THEORIES

The key element of the exogenous growth models is the backing of the limitation of diminishing returns to capital. Further models tried to develop mechanism that prevents the returns to capital from failing below the certain level.

New growth models were based on the so-called `AK model`, which is the simplest version that set aside all non-accumulable factors of production, such as labour and land and therefore assumes all inputs of production are accumulable, mainly the factor capital. Models assumed that there is a direct and linear relationship between output (Y) and a single factor capital (K) of the same commodity:

$$Y = A.K$$

Where 1/A is the amount of that commodity required to produce one unit of itself. Because of the linear form of the aggregate production function, these models are also known as `linear models`. This simple model is important because of further derivates (or sub-classes) of this model: human capital formation and knowledge accumulation. These models incorporate positive external effects that offset any fall in the marginal product of capital (Salvadori 2003).

Further endogenous models mainly differentiate from exogenous models by two important elements: Firstly, endogenous growth theories do recognize the importance of long-term economic growth rather than the principles and mechanics of the business cycles. Secondly, they leave the main idea of exogenous economic growth according to which long-term economic growth is linked exclusively to the technological progress. Consequently endogenous growth models incorporated long-run growth rate within the model.

There is a plethora of endogenous growth theories, including very complex ones that heavily rely on econometric apparatus. Zarra-Nezhad and Hasainpour (2011) divide endogenous theories into two generations. The first phase was the development of the generation of semi-endogenous growth models and the second was the Schumpeterian growth theory (also Aghion and Howitt 1994, 1998). The main distinction between generations is the focus on the empirical implications and the relation between theory and data.

3.4.1. Human Capital

Interpretation of Lucas represents the sub-class model derived from basic AK model that formalizes the effect of the human capital formation to economic growth.

Lucas argued[13] the capital accumulation is not the only solution for the economic growth. It is rather the human capital, skills, knowledge and technology that is important for sustaining long-term growth.

[13] *Lucas on growth, Econtalk session, 2007*

Mankiw (1995) defined ‘knowledge’ as the sum total of technological and scientific discoveries (what is written in textbooks, scholarly journals, websites, etc.), and ‘human capital’ as the stock of knowledge that has been transmitted from those sources into human brains via studying.

Lucas (1988) assumed that agents have a choice between two ways of spending their (non-leisure) time: to contribute to current production or to accumulate human capital. With the accumulation of human capital there is said to be associated an externality: the more human capital society as a whole has accumulated, the more productive each single member will be (Salvadori 2003).

$$Y = AK^{\beta}(uhN)^{1-\beta}h*^{\gamma}$$

N…….number of workers (labour input)

u……..fraction of that time spent working

h……..labour input in efficiency units

h*……externality (optimization)

Lucas`s conceptualization of the process of the accumulation of human capital in the society through the externality is the following:

$$h* = \mu h(1-u)$$

Where μ is a positive constant.

Salvadori (2003) names this function as a `production function of the human capital`. There are several interpretations of the Lucas model[14].

One is at the aggregate level. Here we can think of u as the fraction of the population engaged in useful work to produce goods and services, while

[14] *Carroll Christopher: Lucas Growth*

proportion 1−u is not working but instead is producing 'knowledge' by conducting scientific and technological research.

The other interpretation is at the level of an individual agent. Such an agent can be thought of as operating his or her own production function of the form in (2), where (1−u) is now interpreted as the proportion of the time this individual spends studying and u is the time spent working.

From the point of view of Mankiw's distinction, it is hard to interpret Lucas's model as being either about human capital accumulation or about knowledge. It can't be about human capital because h can be accumulated without bound, and without diminishing returns, neither of which makes sense for an individual. It can't be about generalized knowledge, because the optimization problem reflects the return for an individual, while only a trivial proportion of total knowledge (in Mankiw's sense) is contributed by any single individual.

In the Lucas model, the increasing returns to the production of human capital function are the source long-run growth. Thanks to the increasing availability of stock of human capital and that drives the accumulation of physical capital and consequently the economy grows indefinitely.

3.4.2. TECHNOLOGICAL PROGRESS

Romer (1986) focuses on the role of a single state variable called 'knowledge' or 'information' and assumes that the information contained in inventions and discoveries has the property of being available to anybody to make use of it at the same time. In other words, information is considered essentially a non-rival good. Yet, it need not be totally non-excludable, that is, it can be monopolized at least for some time. It is around the two different aspects of publicity – non-rivalry and non-excludability – that the argument revolves. The idea has been also concluded by Shell (1974, cited by Pomini M. in Salvadori 2003): any economic agent can employ Technical knowledge without altering either its quantity or its quality. Thus, we must think of technical knowledge as a public good – primarily a public good in production'.

Discoveries are made in research and development departments of firms. This requires that resources be withheld from producing current output. The basic idea of Romer's (1986) model is 'that there is a trade-off between consumption today and knowledge that can be used to produce more consumption tomorrow'. He formalizes this idea in terms of a 'research technology' that produces 'knowledge' from forgone consumption. Knowledge is assumed to be cardinally measurable and not to depreciate: it is like perennial capital (D'Agata and Freni in Salvadori 2003).

Companies do research not only for gaining the advantages from their competitors, but mainly thanks to a granted legal protection of their discoveries, i.e. patents. Therefore the policy implication of Romer's ideas is that every country should implement such policies for promoting research and to guard the investments of firms by patent laws and legal protection (Romer 1990). Additionally, Romer (1990) stated that the openness to the international trade speeds up the economic growth.

Later, in Romer's addition to The Concise Encyclopedia of Economics (Henderson, 2007), Romer called for the institutional support of ideas, knowledge-based economy and his concept of "*meta-ideas*". Romer added the distinction between objects and ideas. Objects represent labour and capital, and ideas are thoughts that serve as the instructions to use these objects. Importantly, ideas are non-rivalry and lead to an increasing returns to scale, in contrary to the traditional factors (objects), such as capital and labour. The same unit of capital or labour cannot be use with the producer in the same time. On the other hand, ideas, once discovered, can be simultaneously used by any number of producers without influencing the utility of others. However, in the perfect competition, there would not be the incentives for companies to innovate, due to the ubiquity of the ideas. This is often used as the argument for the existence and enforcement of the patent laws that ensure the invested money in R&D would not be wasted.

If a poor nation invests in education and does not destroy the incentives for its citizens to acquire ideas from the rest of the world, it can rapidly take advantage of the publicly available part of the worldwide stock of knowledge. If, in addition, it offers incentives for privately held ideas to be put to use within its borders—for example, by protecting foreign patents, copyrights, and licenses, by permitting direct investment by foreign firms, by protecting property rights, and by avoiding heavy regulation and high marginal tax rates—its citizens can soon work in state-of-the-art productive activities (Romer 2007).

Romer sees in his concept the `meta-ideas` as the most important of all ideas. These are ideas about how to support the production and transmission of other ideas. In the interview on EconTalk, he stated: "We do not know what the next major idea about how to support ideas will be. Nor do we know where it will emerge. There are, however, two safe predictions. First, the country that takes the lead in the twenty-first century will be the one that implements an innovation that more effectively supports the production of new ideas in the private sector. Second, new meta-ideas of this kind will be found." (Romer 2007)

3.4.3. *CREATIVE DESTRUCTION*

One of the first to argue that innovation is the key to growth was Schumpeter (1942). In his book, Capitalism, socialism and democracy (Schumpeter, Swedberg, R., 1994) Schumpeter clearly pointed at the basic feature of sustaining long-term economic growth - the innovation, or rather the entrepreneurial spirit that drives the innovation. He also argued that the "Capitalist reality is first and last a process of change" (Schumpeter, 1942) and the basic feature of innovation is a disruptive process, the "Creative destruction". The term was originally brought by Marxist theorists and means, that capitalism creates new ways of doing things and in the process destroys the old ways. As an example, we can mention portable mp3 players (iPod, and others) that have replaced the Walkman and Discman to allow people to listen to the music everywhere. This change was due to the development of higher quality products and the more efficient methods of production process. The process of Creative Destruction is the essential fact about capitalism.

According to Schumpeter, every business will fail if it not embodies the entrepreneurial spirit within the operation. According to him, "Capitalist reality is not price-output competition that counts, but competition from a new commodity, new technology and new sources of supply and new geography or the new type of organization." (Schumpeter, 1942). In other words, the innovative entry by entrepreneurs was the force that helps to reach a sustained long-term economic growth. By Schumpeter's words: "This process of creative destruction is the essential fact about capitalism, this what capitalism consist of and what every capitalist concern has got to live in." (Schumpeter, 1942). However, as prof. Schultz pointed out (Schultz, 2010), the dynamic itself was important, not just the end result. For Schumpeter, the order of the word couplet—"creative" followed by "destruction" was significant. Creativity preceded destruction. Destruction occurs only after generative acts yield innovations and technological advances. For this reason, Schumpeter believed that the destruction inherent to the capitalist system was a worthy price to pay economic progress.

Furthermore, Schumpeter discussed the fundamental nature of capitalism and the market economy and questioned whether it can prevail in the era of socialism. He saw capitalism as the foundation of two complementary forces: economic expansion and the role of protecting individual freedom. For Schumpeter, to sacrifice the one would mean to sacrifice the other. That is, the only way the freedom would be secured for every individual, was within the growing economy – so the political freedom relies on economic expansion (Schumpeter, 1942). He predicted that capitalism would eventually be replaced by some form of socialism. Conversely, Schumpeter once said that when socialism came to America, it would not be called socialism.

We can suppose if the society will try to apply some measures that will influence the never-ending economic change, then the capitalism, that is by nature a form or method of economic change, will be replaced as Schumpeter assumed.

3.5. Modern Theories

3.5.1. Stylized Facts

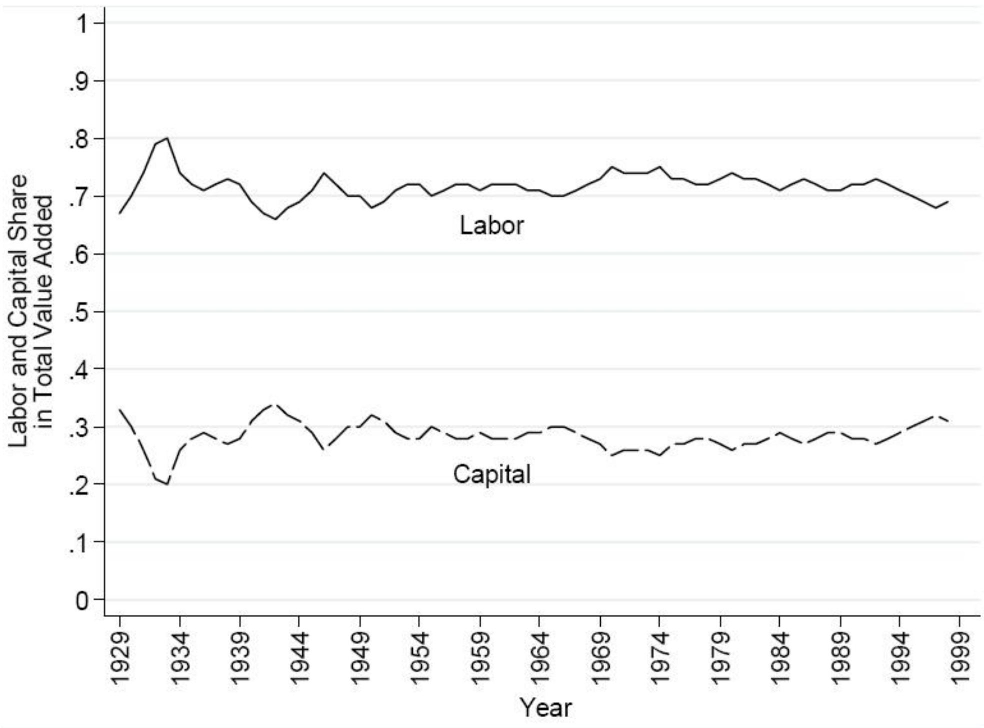
Interesting points have been made by Kaldor (1954a, 1954b, 1961). He holds that it is not saving, investment, technical progress and population growth that are the causes of growth – these being just features of growth – but the attitude of investing by society and in particular of entrepreneurs. In this he follows the Keynesian approach in conceiving the expansion of the economy as driven by psychological and social factors like 'human attitude to risk-taking and money-making' (Kaldor, 1954a, cited by Salvadori 2003). Via this, Kaldor introduces noneconomic motives and objectives: "Economic speculation here trespasses on the fields of sociology and social history.." (Kaldor, 1954a, cited by Rostow 1992).

Kaldor also stressed the importance of construction of the growth models with having a business cycle theory in mind. However, he never formally develops his position on economic growth, and his major contribution consists in solving in an original way the stability problem of the Harrod–Domar model (Salvadori 2003).

Thus, the most important elements of Kaldor's research are statements about economic growth – broad tendencies, also known as Kaldor stylized Facts (Kaldor, 1961). These stylized facts in the process of economic growth rely on the observed patterns:

1. The shares of labor and physical capital in GDP are nearly constant (Figure 2);

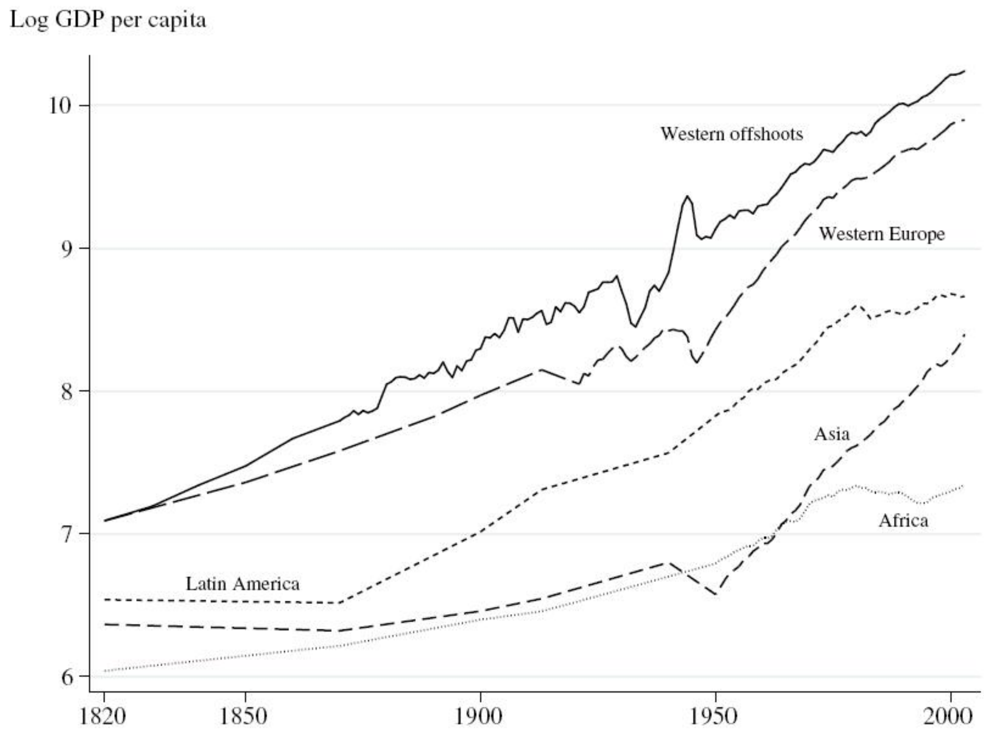
Figure 2: Capital and labour share in the U.S. GDP



<u>Source:</u> *Acemoglu: Introduction to Economic Growth, 2006*

2. The ratio of physical capital to output is nearly constant;
3. The rate of return to capital (or the real interest rate) is nearly constant;
4. Physical capital per worker grows over time;
5. Per capita output grows over time, and its growth rate does not tend to diminish (Figure 3);

Figure 3: The evolution of average GDP per capita in Western offshoots, Western Europe, Latin America, Asia, and Africa, 1820–2000



Source: *Acemoglu: Introduction to Economic Growth, 2006*

6. The growth rate of output per worker differs substantially across countries, but the rates tend to converge.

These observations, typically labeled Kaldor's stylized facts, constitute a first important growth measurement that economists sought to understand and to explain. According to Kaldor's measurements, while economic growth occurs, its benefits divide up in a stable way between rewards to capital and labor--no one factor input, taken as an aggregate, benefited more than another from economic growth. Moreover, since capital's income share can be viewed as the stock of capital multiplied by capital's rate of profit, Kaldor's stylized facts also implied that the profit rate is, in the long run, constant.[15]

These stylized facts have been further enhanced by Thirlwall (2003 and 2002):

1. That as the scope for the increasing returns sector to absorb the labour from the diminishing returns, sector reduces so too will the rate of growth of GDP.
2. That in the early stages of industrialization the demand comes from the agricultural sector, but in the later stages export demand is likely to drive the process. Here the limited size of the internal market is likely to be such as to limit the realization of economies of scale and there is the need for generating foreign exchange to import necessary inputs.
3. A virtuous circle can be generated by export growth and output growth but that this is difficult to establish as it is likely to depend on exceptional enterprise, protection or subsidy.

Additionally, many authors have added their stylized facts based on the cross-country regression analysis. Notably, Rodrik (2007) added four stylized facts:

1. In practice, growth spurts are associated with a narrow range of policy reforms.

The definition of a growth acceleration is the following: an increase in an economy's per capita GDP growth of 2 percentage points or more (relative to the previous five years) that is sustained over at least eight years. In the vast majority of the cases, the "shocks" (policy or otherwise) that produced the growth spurts were apparently quite mild. This reflects the fact that not much reform was actually taking place in these cases. Apparently, small changes in the background environment can yield a significant increase in economic activity. Even in the well-known cases, policy changes at the outset have been typically modest. As a

[15] *Quah, D. Economic Growth: Measurement, available at: http://econ.lse.ac.uk/~dquah/p/01iesbs.pdf*

valuation of the policy changes illustrate, an attitudinal change on the part of the top political leadership toward a more market- oriented, private-sector-friendly policy framework often plays as large a role as the scope of policy reform itself. This is good news because it suggests countries do not need an extensive set of institutional reforms in order to start growing. Instigating growth is a lot easier in practice than the standard recipe, with its long list of action items, would lead us to believe. This should not be surprising from the standpoint of growth theory. When a country is so far below its potential steady-state level of income, even moderate movements in the right direction can produce a big growth payoff.

2. **The policy reforms that are associated with these growth transitions typically combine elements of orthodoxy with unorthodox institutional practices.**

No country has experienced rapid growth without minimal adherence to what I have termed higher-order principles of sound economic governance—property rights, market-oriented incentives, sound money, and fiscal solvency. But as Rodrik has already argued, these principles have often been implemented via policy arrangements that are quite unconventional. Rodrik illustrated this by using examples such as China's two-track reform strategy, Mauritius's export-processing zone, and South Korea's system of "financial restraint."

3. **Institutional innovations do not travel well.**

The more discouraging aspect of the stylized facts is that the policy packages associated with growth accelerations—and particularly the nonstandard elements therein—tend to vary considerably from country to country. Attempts to emulate successful policies elsewhere often fail. When in the Soviet Union Gorbachev tried to institute a system similar to China's household responsibility system and two-track pricing during the middle to late 1980s, it produced few of the beneficial results that China had obtained. Successful reforms are those that package sound economic principles around local capabilities, constraints, and opportunities. Since these local circumstances vary, so do the reforms that work.

4. **Sustaining growth is more difficult than igniting it, and requires more extensive institutional reform.**

The main reason that few of the growth accelerations are etched in the consciousness of development economists is that most of them did not prove durable. In fact, as discussed earlier, over the last four decades few countries except for a few East Asian ones have steadily converged to the income levels of the rich countries. Hence growth in the short to medium term does not guarantee success in the long term. A plausible interpretation is that the initial reforms need to be deepened over time with efforts aimed at strengthening the institutional underpinning of market economies. It would be nice if a small number of policy changes—which, as argued above, is what produces growth accelerations—could produce growth over the longer term as well, but this is obviously unrealistic.

Rodrik (2007) concludes his stylized facts by saying: "Economists can have a useful role to play in this process: they can identify the sources of inefficiency, describe the relevant trade-offs, figure out general-equilibrium implications, predict behavioral responses, and so on. But they can do these well only if their analysis is adequately embedded within the prevailing institutional and political reality. The hard work needs to be done at home."

3.5.2. PAPER TIGERS

Paul Krugman performed several economic analysis of the rapid economic growth of the Asian Tigers (1994). Originally, the rapid growth in output could be fully explained by rapid growth in inputs: expansion of employment, the increases in education levels, and, above all, massive investment in physical capital. However, Krugman conducted analysis, based on two quantitative papers by Alwyn Young (1992 and 1995) on growth in the four Asian Tigers of South Korea, Singapore, Taiwan and Hong Kong revealed shocking facts about the drivers of the economic growth of the Tigers.

Krugman dealt with a theoretical-analytical issue: Whether was the rapid rate of growth of the Asian Tigers based for the most part on a high rate of growth of productivity – productivity of labour, capital, or total factor productivity? Or was it based on quantitative growth of production factors – i. e. accumulation of capital and labour? Krugman (1994) defines the distinction: “Economic expansion represents the sum of two sources of growth. On one side are increases in "inputs": growth in employment, in the education level of workers, and in the stock of physical capital (machines, buildings, roads, and so on). On the other side are increases in the output per unit of input; such increases may result from better management or better economic policy, but in the long run are primarily due to increases in knowledge”.

Additionally, Krugman has found surprising similarities to the “artificial growth” of the Soviet Union and the growth of Asian Tigers. The newly industrializing countries of Asia, like the Soviet Union of the 1950s, have achieved rapid growth in large part through an astonishing mobilization of resources: “If the Soviet economy had a special strength, it was its ability to mobilize resources, not its ability to use them efficiently. It was obvious to everyone that the Soviet Union in i960 was much less efficient than the United States. The surprise was that it showed no signs of closing the gap. But what they actually found was that Soviet growth was based on rapid growth in inputs—end of story. The rate of efficiency growth was not only unspectacular, it was well below the rates achieved in Western economies. Indeed, by some estimates, it was virtually nonexistent.” (Krugman, 1994)

Once Krugman subtracted the growth inducted by the labour input increase (employment, higher skills, etc.) and the rate of additions and improvements to capital, the growth of total factor productivity in the Asian Tiger economies was not remarkable. The point was that the Tiger’s economies have used to be starved of capital and educated workers, which has subsequently driven the growth. Thus, Krugman (1994) call such growth as a “Paper Tigers”.

However, such miraculous growth can be then achieved by any country that has starved as well, for instance, China. Although China is still a very poor country, its population is so huge that it will become a major economic power if it achieves even a fraction of Western productivity levels. Even a modest slowing in China's growth will change the geopolitical outlook substantially.

Krugman asked whether this growth will occur in China as well: "The World Bank estimates that the Chinese economy is currently about 40 percent as large as that of the United States. Suppose that the U.S. economy continues to grow at 2.5 percent each year. If China can continue to grow at 10 percent annually, by the year 2010 its economy will be a third larger than ours. But if Chinese growth is only a more realistic 7 percent, its GDP will be only 82 percent of that of the United States" From the perspective of the year 2010, current projections of Asian supremacy extrapolated from recent trends may well look almost as silly as i96os-vintage forecasts of Soviet industrial supremacy did from the perspective of the Brezhnev years. " (Krugman, 1994).

There are several observations made by Krugman (1994). In general, Krugman forecasted a substantial shift of the world's economic center of gravity, but it will be far less drastic than many people now imagine:

- First, there is a major diffusion of world technology in progress, and Western nations are losing their traditional advantage.
- Second, the world's economic center of gravity will inevitably shift to the Asian nations of the western Pacific.
- Third, in what is perhaps a minority view, Asian successes demonstrate the superiority of economies with fewer civil liberties and more planning than we in the West have been willing to accept.
- If there is a secret to Asian growth, it is simply deferred gratification, the willingness to sacrifice current satisfaction for future gain.

Despite the fact of various criticisms of the implications of Krugman's research on Asian Tigers (Ross, 2009), the great importance of the article can be found. First, there are two important elements of the growth – the sustainability of the growth and the source of the growth that are crucial. Thanks to various techniques, academics can derive the sources of growth. However, there are still some parts of the whole picture missing.

Such analysis of the growth has been conducted in other countries, e.g. in Ireland. (O'Grada, 2002 and furthermore Barry, 2002). The analysis focused more on the effect of (mainly US) multinationals and the downward revision and the questions about the sustainability of growth rates. Additionally, O`Grada analyzed the effect of convergence on the growth of so-called Celtic Tiger. Study suggests that the Celtic Tiger's main achievement was catching up with the rest thanks to massive reserves of unemployed labour. However, O`Grada`s and Barry`s research stressed several policy factors, that helped to sustain massive growth: generous corporation tax regime; the prospects of wage moderation, industrial peace, a single European market; and the beginnings of a sustained US economic boom, the conditions for an economic recovery in Ireland were right. The Tiger's achievement was to capitalize on this situation. Though, O'Grada (2002) warned about the risks in the future: `Small open economies, no matter how successful, get buffeted by exogenous shocks. Ireland now faces the double threat of slower US economic growth in the short run and of competition from Eastern Europe diverting FDI in the longer run". From today`s perspective, we can now see how cruel, but accurate forecast it was.

3.5.3. THE ROAD TO THE KNOWLEDGE ECONOMY

There is a plethora of theories mixing various factors that can, or may affect the spread of technology and knowledge, which is seen as crucial for ensuring the sustainable, long-term growth. Many theories have been introduced above. However, some common characteristics can be found. Basically, the main idea is that only intangible factors such as knowledge are the only "renewable sources" of long-term growth. Base on the theory three main factors can be found:

Education

- Assumption: technology depends on the stock of human capital (measured as the number of hours spent in formal education).
- Long run growth depends on the rate of increase in the stock of human capital.
- Clear and appealing implications for government policy.
- However, it does not explain how education increases output.
- Implication: If rich countries invest more in education than poor countries, then they will grow faster. There are increasing returns from education.

Learning by Doing

- The knowledge of production that is acquired by workers on the job through use of capital equipment.
- Long run growth partly depends on the rate of increase in the efficiency with workers use of capital.
- Growth also depends on the amount of capital per worker. Policies to increase saving now have a long run effect on growth. (vs. criticisms of the Solow model was that capital accumulation has a level but not a growth effect).
- Implication: If rich countries save a greater proportion of their income than poor countries, then they will grow faster. There are increasing returns from saving.

Research and Development (R&D)

- Growing the stock of technological knowledge.
- Increasing the stock of knowledge depends on the fraction of the labour force engaged in R&D.
- There are no limits to technological improvement
- Implication: If rich countries devote a greater number of workers to R&D than poor countries, then they will grow faster. Thus, there are increasing returns from R&D.

4. INNOVATION AND COMPETITIVENESS

4.1. INNOVATION

Innovation has been widely recognized as the driving factor for sustainable economic growth. Romer (2007) stated that economic growth occurs where "people take resources and rearrange them in ways that are more valuable". From the business perspective, innovation is the process of creating new ideas and turning them into new business value. It is imperative that businesses continue to innovate if they are to thrive in the future.

An important distinction has to be made between invention and innovation. Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice. Sometimes, innovation and invention are closely linked (Fagerberg, Mowery, Nelson, 2006).

According to Schumpeter (1934), innovation involves the production of a:

- New product or service
- Existing product or service for a new market
- New method of production
- New source of supply and/or
- New organization of production

Schumpeter`s concept of innovation basically acknowledges two basic types of innovation. First type is the innovation of the product or service. It is basically the common concept of innovation – new finalized product (or service). Second, type of the innovation is the innovation of the process. It could be the introduction of a new product or service for a new market, new method of production;, new source of supply, or a new organization of production. Whereas product innovation is more common concept and can be more easily observed, it is often wrongly assumed to be more important as it may have a clear and economy-wide impact (while process innovation may only be limited to individual businesses). Furthermore, product innovation may involve or may result in process innovation.

Innovation can be also divided according to the impact. It can be either 'Continuous' or 'Incremental' innovation (e.g.: new model of a car) or 'radical' innovation (e.g.: first car). Sometimes, the radical innovation are called "general purpose technologies" (GPTs) (Bresnahan and Trajtenberg, 1995, cited by Helpman, 2004) to describe technologies that triggered the development of many complementary inputs, which starts with a prolonged slowdown followed by a fast and radical acceleration.

Additionally, the Oslo Manual[16] defines four types of innovation: product innovation, process innovation, marketing innovation and organizational innovation:

- **Product innovation**

A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.

- **Process innovation**

A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.

- **Marketing innovation**

A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.

- **Organizational innovation**

A new organizational method in business practices, workplace organization or external relations.

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[16] *OECD: The Oslo Manual, 3rd edition, 2005*

As the example of such distinction can be mentioned an iconic MP3 player iPod – The product included relatively low R&D, but included heavily the marketing and design innovations.

According to the manual, innovation activities include all scientific, technological, organizational, financial and commercial steps, which actually lead, or are intended to lead, to the implementation of innovations. Some of these activities may be innovative in their own right, while others are not novel but are necessary to implementation.

Innovation comprises a number of activities that are not included in R&D, such as later phases of development for preproduction, production and distribution, development activities with a lesser degree of novelty, support activities such as training and market preparation, and development and implementation activities for innovations such as new marketing methods or new organizational methods which are not product and process innovations. Innovation activities may also include acquisition of external knowledge or capital goods that is not part of R&D.

During a given period, a firm's innovation activities may be of three kinds:

- Successful in having resulted in the **implementation of a new innovation** (though not necessarily commercially successful)
- On-going, **work in progress,** which has not yet resulted in the implementation of an innovation.
- Abandoned before the implementation of an innovation.

(Oslo Manual, 2005)

Base on the heterogeneity of the definition of innovation, it is important to note the definition greatly varies. This fact can lead to difficulties in the data collection, statistics and evaluation of innovation activities.

4.2. SOURCES OF INNOVATION

"Innovation comes from differences – differences among people"[17].

There has been a strong discussion who carries the innovation, especially in the Czech Republic during the draft process of the reform of state support of research institutes. Basically, there was a strong debate whether universities, or the Academy of Sciences of The Czech republic (Science Academy) are the main source of research. Moreover, question conducted research has greater importance, whether the cooperation between private companies and universities or commercial research conducted by the science academy. According to general theory, there are various sources of innovation:

- Research and Development (R&D)
- Interaction with other businesses/agents, such as suppliers, customers and competitors
- Interaction with academic based researchers
- Interaction with innovation supporting agencies, which are publicly-funded institutions that support R&D in firms, through research grants and facilitating interaction

Though, neither universities nor Science Academy are the key drivers. It is the firm, who carries the innovation based on the research and/or educated and skilled people. Each source of innovation mentioned earlier is based on the activities of the companies. Either is the research conducted within companies, or it is outsourced to the universities and other institutions. Oslo Manual defines the relationship between key players according to various factors influencing the innovative activities of the companies, such as the variety and structure of its links to sources of information, knowledge, technologies, practices and human and financial resources. Each linkage connects the innovating firm to other actors in the innovation system: government laboratories, universities, policy departments,

[17] *Nicholas Negroponte at #ideaseconomy*

regulators, competitors, suppliers and customers: “Three types of external linkages are identified. Open information sources provide openly available information that does not require the purchase of technology or intellectual property rights, or interaction with the source. Acquisition of knowledge and technology results from purchases of external knowledge and capital goods (machinery, equipment, software) and services embodied with new knowledge or technology that do not involve interaction with the source. Innovation co-operation requires active co-operation with other firms or public research institutions on innovation activities (and may include purchases of knowledge and technology)”[18].

Still this perception of the innovation is very limited. It basically uses the innovation as a proxy for research (or vice versa). Based on the definition of the innovation mentioned earlier, the real discussion of policy instruments should be about the support of firms to ease the process of innovation.

However, according to the research of Baumol (2004), only a small number of companies actually conduct the innovation activities. In fact, it has been suggested that only 5 percent of companies creating entrepreneurs engage in significant innovation activities. Therefore the most significant portion of R&D activities are conducted by very large companies. These corporations are employers of a great portion of scientists and highly educated people. But, despite this concentration of knowledge, talent, and expenditure in these major enterprises, an examination of the list of revolutionary technological breakthroughs since the onset of the Industrial Revolution suggests that they were contributed in overwhelming proportion by independent inventors and small, newly founded enterprises, not by major firms (Baumol, 2004).

The preceding observations support following outcomes:

- The concentration of R&D in corporate hands is a gross misallocation of social resources

[18] *Oslo Manual, 3rd edition*

- Even that education contributes little and may even be a hindrance to technical progress.

Moreover, there is evidence that suggests that there is a difference between the ways of thinking of the personnel of large industrial laboratories who focus on successive, incremental technical advances in product and process design, and the innovative entrepreneur. (Entrepreneur is seen as the inventive individuals who are responsible for true technological breakthroughs).

This evidence is also supported by Vivek Wadhwa[19], who is lobbying for policy that would ease the conditions for entrepreneurship, rather than support companies directly to conduct the so-called "paper innovation". Furthermore, Wadhwa`s research identifies small companies as the main drivers of innovation and significant providers of employment.

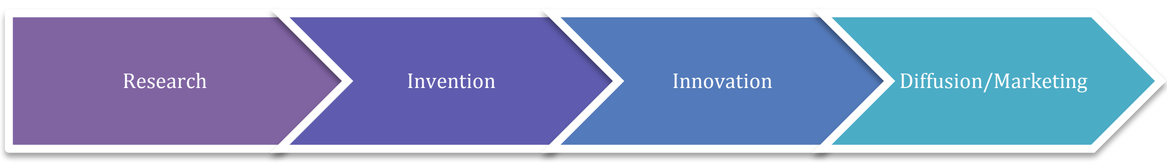
4.3. MODELS OF INNOVATION

There are two general models of innovation.

4.3.1. LINEAR MODEL

One of the first (theoretical) frameworks developed for understanding science and technology and its relation to the economy was the linear model of innovation. Obviously, this model indicates that innovation takes place in a linear process:

Figure 4: The conventional "linear model"



__Source:__ Godin, B.: The Linear Model of Innovation: The Historical Construction of an Analytical Framework

[19] *Wadhwa Vivek: To Spur Economic Growth, Bet on 60 Startups*

In the model, research represents basic research, which is followed by applied research that leads to the invention.

As it was mentioned earlier, it is important to distinguish innovation from invention and diffusion – invention is the first occurrence of an idea, innovation is its first commercial application and diffusion is the spread of the innovation throughout markets and economies

The model postulates that innovation process starts with basic research, followed by invention or development, and ends with innovation and marketing (diffusion). However, this model is generally obsolete. It does not reflect modern interpretation of the innovation as a concept.

Main problems with the linear model:

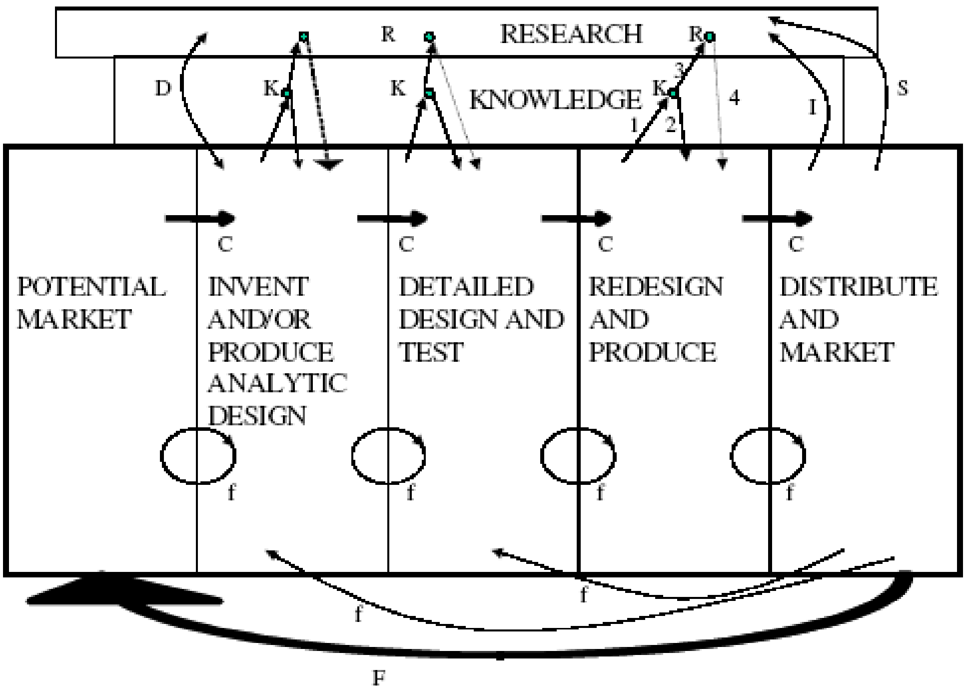
- No feedback paths
- Central process of innovation is not science but design
- Does not recognize the importance of process innovations

4.3.2. CHAIN LINK MODEL

Kline and Rosenberg (1986) put forward the chain link model and, in doing so, Rosenberg claimed “the linear model in dead”.

This model assumes that the accumulation of knowledge necessary for innovation comes from complex interactions. The chain-link model begins with a linear process moving from potential market to invention, design, adaptation and adoption but adds feedback loops and the potential for the inventor to seek out existing knowledge or undertake or commission research to solve problems in the process. It is a broader model of innovation.

Figure 5: The Chain link model of innovation



Source: Kline and Rosenberg (1986)

Where the main parts are:

C…The central chain of innovation

f…Feedback loops

F…particularly important feedback

K-R…Links through knowledge to research and return paths

I…support of scientific research by instruments, tools and procedures of technology

The chain-link model is broad. However, it also does have limitations:

- It fails to address the question of the ideal mix of public and private involvement at each stage of the model.

- It is also unclear as to whether the unit of analysis is industries or individual businesses.

4.3.3. *Value Chain*

Hansen and Birkinshaw (2007) recommend, in their Harvard Business Review article, to view innovation as a value chain, which could be used as a framework for evaluating innovation performance of the companies. The value chain encompasses three key phases: Idea generation, conversion and diffusion, as well as the critical activities performed during those phases.

Figure 6: The Hansen and Birkinshaw Innovation Value Chain

The Innovation Value Chain: An Integrated Flow

Viewing innovation as an end-to-end process rather than focusing on a part allows you to spot both the weakest and the strongest links.

	IDEA GENERATION			CONVERSION		DIFFUSION
	IN-HOUSE Creation within a unit	CROSS-POLLINATION Collaboration across units	EXTERNAL Collaboration with parties outside the firm	SELECTION Screening and initial funding	DEVELOPMENT Movement from idea to first result	SPREAD Dissemination across the organization
KEY QUESTIONS	Do people in our unit create good ideas on their own?	Do we create good ideas by working across the company?	Do we source enough good ideas from outside the firm?	Are we good at screening and funding new ideas?	Are we good at turning ideas into viable products, busi-nesses, and best practices?	Are we good at diffusing developed ideas across the company?

<u>Source:</u> *The Hansen and Birkinshaw (2007) Innovation Value Chain*

The innovation value chain is based on the findings of conducted research projects. Research contained interviews with more than 130 executives from over 30 multinationals in North America and Europe, survey of 4,000 nonexecutive employees in 15 multinationals and analysis of innovation effectiveness in 120 new projects and 100 corporate venturing units.

According to Hansen and Birkinshaw (2007), managers must perform six critical tasks across all the phases of the innovation value chain: Internal sourcing, cross-unit sourcing, external sourcing, selection, development, and companywide spread of the idea.

Hansen and Birkinshaw, research shows important flaw of all measurements of innovation – not every action that is counted as innovation (or leading to an innovation) is effective and can be counted as innovation activity. Very often such activity leads to the dead-end., despite the fact that modern statistics counted it as the innovation activity. Such measurements could create another "paper tigers".

4.4. CLUSTERS AS THE SOURCES OF INNOVATION

According to Michael Porter (1998), most of the attention on innovation has been on two levels: National and Firm level. On the national level, government policy is seen as crucial; it influences the policy towards science and technology, intellectual property protection and therefore the competitiveness of the whole economy. In other words, national policy really matters and it is then reflected on the firm level. On the firm level, we speak mainly about the ability to conduct R&D and innovation in the operations of the company and its products or services. On the firm level, we can observe the shift in the firm's challenges – from the needs of destructuralization, cutting the costs and raising quality to the state when these operations, continuous improvements of standards and methods will not sustain the competitive advantage of companies. Companies do have to innovate in the global scale – Porter (1998) sees it as a never-ending process of new commercialization of the new ideas, processes and new technologies. On the firm level, Porter defines innovation as a two-factor force: internal and external. Internal represent capabilities and processes within companies for commercialization of new ideas and technology. However, Porter and Stern (2001) sees external environment more, or at least at the same level of importance for innovation to happen.

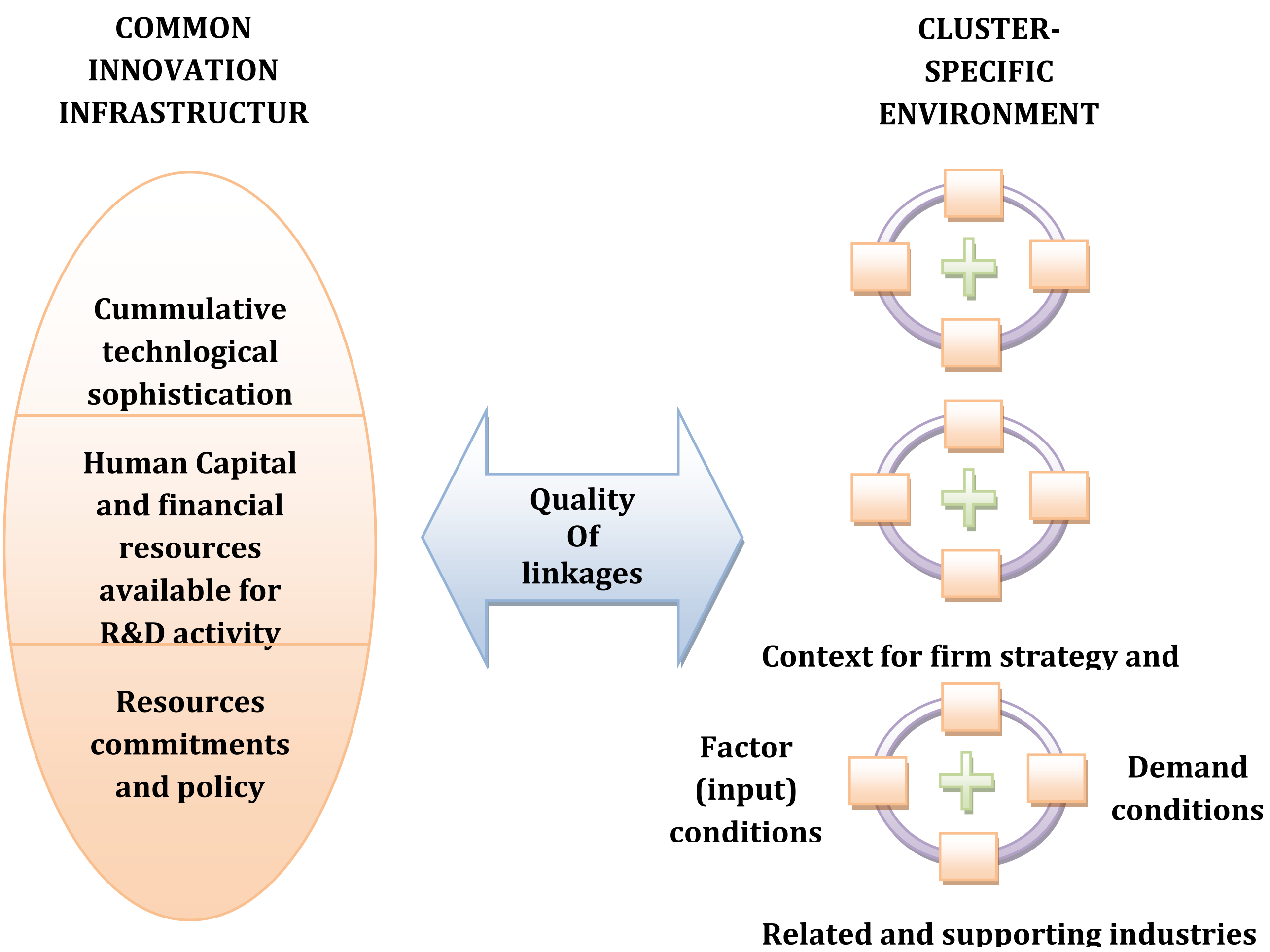
In general, Porter has seen one more level, that lies in between National and Firms. It is the regional level, in which Porter speaks about clusters. Overall, Porter (1998) has seen the innovation conducted on this level as crucial not only for the competitiveness of the region, but for the competitiveness of the whole economy.

In their research conducted for Organization for Economic Cooperation and Development (OECD), Porter and Stern (2001) evaluated how the national circumstances explain the differences of innovative output. They have found only limited characteristics on the nation circumstances explain the large differences to innovative output across countries. According to their research, there is an influence of local conditions that vastly influence the innovative activity to happen.

Basically, the outcome of the research was that location matters for innovation (Porter and Stern, 2001).

The tool of their research used was the National innovative capacity index, which is the country's potential for innovation as both the political and economical. They have developed the framework to identify the sources of innovation capacity. The concept of National innovative capacity framework is drawn in the Figure 7.

Figure 7: Elements of the National Innovative Capacity Framework



<u>Source:</u> *Porter and Stern, 2001*

However, there are some flaws to be seen in the research. There is a debate about the relevance of patents as an universal measurement of the innovation activity. These measures cannot capture the full potential of national innovative capacity. However, Porter and Stern (2001) acknowledge that no single measurement of innovation is ideal.

Despite the fact of using patents as a proxy measurement for innovation, there are some implications of the research. Porter and Stern stress these implications:

- **Locate R&D investments and commercialize new technologies to environments with strong innovative capacity.**

  Find opportunities for effectively developing new products and services and strong linkages between various actors. Do not look only for low labour costs and resources.

- **Proactively access the local strengths**

  This involves active participation in industry associations, deep relationships with universities, conducting assisting programmes for skilled workforce, etc.

- **Enhance local innovative capacity**

  Shape the local environment to make it more conductive for innovation. Encourage public policies and resources to enhance the innovation infrastructure.

According to the cluster theory, a government can create a viable hub of economic activity in a specific industrial sector by supporting and bringing in businesses, suppliers, researchers, and additional related people or entities. In other words, a focused governmental effort can create something from nothing. According to various critics[20], governments all over the world have invested millions (or rather billions) of dollars to attract industries they consider strategic, but their efforts will likely fail. All such global efforts, including in Japan, have failed miserably. Cluster theories are deeply flawed. As Vivek Wadhwa quoted: "Only entrepreneurs can do magic".

Common problem is that clusters engineered from the top down don't usually work. Such top-down approach can be judged as a central planning applied in free economies. Clusters are seen as inorganic structures. However, real growth comes from organic demand, organic supply, real collaboration & imperfect scenarios.

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[20] *Lately Vivek Wadhwa in his businessweek and Techcrunch articles. Wadhwa Vivek: Lessons from a New Industry Cluster in India*

4.5. Competitiveness

Innovation has become the defining challenge for global competitiveness. Schumpeter (1934) was one of the first to argue that innovation is the key to growth. His vision was blatant – all businesses will fail, victims of innovation by competitors. He used the metaphor "gales of creative destruction" (Schumpeter, 1942) when he spoke of innovation because he thought of it as hitting the economy hard. According to him, in the process of creating something new you must destroy something that is already there. However, the never-ending process of creation and destruction leads to the constant innovation conducted by entrepreneurs and therefore innovation is the force that helps to reach a sustained long-term economic growth. Additionally, Porter (1990) recognized the importance of innovation for national competitiveness.

The problem of innovation leads us to the general question: Why do businesses have to innovate? There are several factors that can be seen as crucial driving force for firms to perform innovation activities:

1. Advancing technology
2. Changing environment
3. Changing industrial structures and strategies
4. Evolving society
5. Evolving customer demands
6. Competition

If we extrapolate the reasoning of the necessity of innovation to the national level, we can see that the innovation conducted within country greatly improves its competitiveness. Hence the policies for innovation are crucial for the competitiveness of the country. This definition of the relation between innovation and competitiveness is based on the previously stated theories of Schumpeter (1942), Porter (1990) and others.

5. INNOVATION AND ECONOMIC GROWTH - EMPIRICAL EVIDENCE

5.1. THE GROWTH OF GROSS DOMESTIC PRODUCT OF EUROPEAN COUNTRIES

One of the most used indicators of economic growth is the Gross Domestic Product (GDP). Eurostat collects the data of GDP growth regularly.

According to Eurostat[21], Gross domestic product (GDP) is a measure for the economic activity that is defined as the value of all goods and services produced less the value of any goods or services used in their creation. Basic figures are expressed in PPS, i.e. a common currency that eliminates the differences in price levels between countries allowing meaningful volume comparisons of GDP between countries. Overall trend of GDP is pictured in the following table. The table is coloured based on the values to show differences among countries.

From the selected data in Table 1, man can firstly notice the impact of the global financial crises on the European countries can be firstly noticed. The only country that has sustained growth even in the year 2009 was Poland, that even reached greater growth in 2010 by 3.8%. Among the most impacted countries are Baltic countries as Estonia, Latvia, and Lithuania.

Additionally, man can derivate countries with overall trend of higher GDP growth and countries with lower growth rate trend in the selected sample of 15 years can be detected. With regards to Barro and Lee (1993), countries can be titled as losers and winners based on their performance. Overall winners are new emerging economies in Europe – new members of EU ("New Europe") and also countries that lagged behind countries of so-called "Old Europe". However, a global economic crisis has impacted some of these countries very hard, resulting in a radical shrink

[21] *http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsieb020 accesed: 12. 2. 2011*

of the economy. Namely biggest impacted countries were mentioned Baltic countries and also so-called new tigers of Europe: Ireland and Iceland.

The preliminary data of 2010 shows which countries most likely overcome the crisis quickly and reached growth again in the aftermath of the crisis. Interestingly, Germany, which has grown in average of 1.6% per year, has reached the growth of 3.6%. It is a good sign for its border economies of Poland, Czech Republic and Austria, which are strongly linked with the economy of Germany.

From the data we can observe the pattern of growth of new emerging European economies. Besides great growth of Baltic countries mentioned earlier, countries such as Bulgaria, Hungary, Slovakia, Czech Republic, Slovenia, Croatia and Romania tend to growth by much higher rate than the Old Europe. This fact supports the convergence theories and also supports the overall convergence and cohesion policy of European Union.

However, as it has been shown on the impacts of the crisis on the Baltic countries and the new European Tigers (Ireland, Iceland), it is important to observe the source of the growth and its sustainability.

Therefore deeper look inside the sources of growth has to be done.

Table 1: Growth rate of GDP volume - percentage change on previous year

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	1,4	3,7	1,9	3,5	3,7	0,8	1,4	0,8	3,2	1,7	2,7	2,9	1	-2,8	2,1
Bulgaria	-9,4	-5,6	4	4,4	5,7	4,2	4,7	5,5	6,7	6,4	6,5	6,4	6,2	-5,5	0,2
Czech Republic	4	-0,7	-0,8	1,3	3,6	2,5	1,9	3,6	4,5	6,3	6,8	6,1	2,5	-4,1	2,4
Denmark	2,8	3,2	2,2	2,6	3,5	0,7	0,5	0,4	2,3	2,4	3,4	1,6	-1,1	-5,2	2,1
Germany	1	1,8	2	2	3,2	1,2	0	-0,2	1,2	0,8	3,4	2,7	1	-4,7	3,6
Estonia	5,7	11,7	6,7	-0,3	10	7,5	7,9	7,6	7,2	9,4	10,6	6,9	-5,1	-13,9	3,1
Ireland	7,8	11,5	8,4	10,9	9,7	5,7	6,5	4,4	4,6	6	5,3	5,6	-3,5	-7,6	-0,2
Greece	2,4	3,6	3,4	3,4	4,5	4,2	3,4	5,9	4,4	2,3	5,2	4,3	1	-2	-4,5
Spain	2,4	3,9	4,5	4,7	5	3,6	2,7	3,1	3,3	3,6	4	3,6	0,9	-3,7	-0,1
France	1,1	2,2	3,5	3,3	3,9	1,9	1	1,1	2,5	1,9	2,2	2,4	0,2	-2,6	1,6
Italy	1,1	1,9	1,4	1,5	3,7	1,8	0,5	0	1,5	0,7	2	1,5	-1,3	-5,2	1,3
Cyprus	1,8	2,3	5	4,8	5	4	2,1	1,9	4,2	3,9	4,1	5,1	3,6	-1,7	0,5
Latvia	3,6	8,3	4,8	3,3	6,9	8	6,5	7,2	8,7	10,6	12,2	10	-4,2	-18	-0,3
Lithuania	5,2	7,5	7,6	-1,1	3,3	6,7	6,9	10,2	7,4	7,8	7,8	9,8	2,9	-14,7	1,3
Hungary	0,7	3,9	4,8	4,1	4,9	3,8	4,1	4	4,5	3,2	3,6	0,8	0,8	-6,7	1,2
Malta						-1,6	2,6	-0,3	1,1	4,7	2,1	4,4	5,3	-3,4	3,7
Netherlands	3,4	4,3	3,9	4,7	3,9	1,9	0,1	0,3	2,2	2	3,4	3,9	1,9	-3,9	1,7
Austria	2,2	2,1	3,6	3,3	3,7	0,5	1,6	0,8	2,5	2,5	3,6	3,7	2,2	-3,9	2
Poland	6,2	7,1	5	4,5	4,3	1,2	1,4	3,9	5,3	3,6	6,2	6,8	5,1	1,7	3,8
Portugal	3,7	4,4	5	4,1	3,9	2	0,7	-0,9	1,6	0,8	1,4	2,4	0	-2,5	1,4
Romania	3,2	-4,9	-2,1	-0,4	2,4	5,7	5,1	5,2	8,5	4,2	7,9	6,3	7,3	-7,1	-1,3
Slovenia	3,6	4,9	3,6	5,4	4,4	2,8	4	2,8	4,3	4,5	5,9	6,9	3,7	-8,1	1,2
Slovakia	6,9	4,4	4,4	0	1,4	3,5	4,6	4,8	5,1	6,7	8,5	10,5	5,8	-4,8	4
Finland	3,6	6,2	5	3,9	5,3	2,3	1,8	2	4,1	2,9	4,4	5,3	0,9	-8,2	3,1
Sweden	1,6	2,7	4,2	4,7	4,5	1,3	2,5	2,3	4,2	3,2	4,3	3,3	-0,6	-5,3	5,5
United Kingdom	2,9	3,3	3,6	3,5	3,9	2,5	2,1	2,8	3	2,2	2,8	2,7	-0,1	-4,9	1,3
Iceland	4,8	4,9	6,3	4,1	4,3	3,9	0,1	2,4	7,7	7,5	4,6	6	1,4	-6,9	-3,5
Norway	5,1	5,4	2,7	2	3,3	2	1,5	1	3,9	2,7	2,3	2,7	0,8	-1,4	0,4
Croatia	5,9	6,5	2	-1	3,8	3,7	4,9	5,4	4,1	4,3	4,9	5,1	2,1	-5,8	-1,8

<u>Source:</u> Own elaboration based on Eurostat data

5.2. ANALYSIS OF TOTAL FACTOR PRODUCTIVITY AND ITS FACTORS

Despite the shortcomings of Solow`s model, growth accounting is the elegant way to derive the sources of growth. The Solow`s residual, total factor productivity (TFP), is a factor known as a representative of technological progress. Based on the theory we can assume the differences among countries and its sustainable growth is through differences in TFP growth. Numerous economic historians have also placed the evolution of technology at the center of modern economic growth. In his studies of the wealth of nations, Simon Kuznets (1966) was quite explicit about his own conviction concerning the preeminence of technology: "We may say that certainly since the second half of the nineteenth century, the major source of economic growth in the developed countries has been science-based technology – in the electrical, internal combustion, electronic, nuclear, and biological fields, among others" Additional prominent authors with similar opinion are Landes (1969), Rosenberg (1982), and Mokyr (1990) (cited by Helpman, 2004).

In order to understand the growth of countries, it is necessary to develop a better understanding of the forces that shape total factor productivity. As William Easterly (2001) stated, we need to better understand TFP and its determinants to more precisely model long-run economic growth and design appropriate policies.

Thus it is important to understand the TFP factor and its determinants. If we combine modern theories, we would be able to derive set of factors that influence the technological advancement.

5.2.1. EVALUATION OF TOTAL FACTOR PRODUCTIVITY OF THE SELECTED EUROPEAN COUNTRIES

There are various methods of growth accounting. However, general problem of models is the inconsistency of data and the heterogeneity of observed countries. For instance, it is hard to measure the same data for such different countries as Brazil, China, USA or European countries.

Table 2 consists of TFP (value added) growth of selected countries based on EU KLEMS database. All values are related to the values of 1995. However, we can then evaluate the trend of portion of GDP growth driven by TFP growth. If the number is higher than 100, it means there is a growth of TFP source of growth. On the other hand, if the following values are below the 100% line of 1995, it means the TFP factor of economic growth is shrinking.

Based on the theory mentioned earlier, the trend of shrinking the TFP as a source of growth is signaling the "unhealthy" growth, which will most likely to be diminished in the future. On the other hand, countries with trend of increasing portion of TFP growth will most likely to sustain the growth, or at least will be able to better resist the external factors influencing growth.

Among countries with trend of shrinking TFP portion of growth is: Belgium, Denmark, Spain, Italy and Czech Republic. However, the trend of TFP portion of growth in the Czech Republic since 2005 is increasing.

There are two countries that sustained greater increasing trend of TFP portion of growth: Finland and Hungary. Additionally, Austria, France, Germany, Netherland, Slovenia and Sweden also sustained increasing trend of TFP portion of growth.

We can notice that despite the fact Ireland`s trend was also increasing, it slowed down in 2003 and then the trend is slightly decreasing. This fact could be first sign of the problem that occurred in 2007 and 2008 when the crisis hit Ireland very hard. This supports the Barry`s trouble (Barry, 2002) about the future growth of the Celtic Tiger.

Table 2: TFP (value added based) growth, related to the year 1995 = 100

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	95.8	97.9	97.1	98.2	100.0	99.8	99.4	101.3	102.8	104.8	103.7	103.5	103.7	105.1	106.2	108.9	111.2
Belgium	100.5	99.5	98.0	99.8	100.0	99.0	99.7	98.8	98.5	98.2	96.9	97.0	97.1	97.7	97.4	97.6	96.6
Czech Republic					100.0	99.9	95.5	92.4	92.1	92.8	94.6	94.6	96.1	97.6	101.1	105.4	107.8
Denmark	96.3	96.5	96.1	99.3	100.0	100.6	99.5	97.3	97.0	98.7	96.9	96.0	96.1	96.9	97.4	97.6	96.7
Spain	99.8	99.7	98.9	99.6	100.0	98.1	97.6	96.6	96.7	96.2	95.6	94.8	94.1	93.4	92.4	91.9	92.1
Finland	92.8	92.8	95.7	99.2	100.0	101.4	104.1	106.7	107.7	110.2	111.1	110.9	111.1	114.0	114.9	118.3	120.4
France	97.9	98.4	97.7	98.6	100.0	99.3	100.2	101.8	102.1	104.2	103.7	104.9	105.6	105.5	106.2	107.8	107.6
Germany	97.3	97.7	97.2	98.6	100.0	101.2	102.4	101.1	101.5	103.6	103.9	104.1	103.7	104.0	105.5	107.8	108.5
Hungary					100.0	105.8	111.9	115.0	115.0	118.2	122.5	124.6	125.7	128.8	131.1	134.6	133.7
Ireland	97.2	94.8	94.9	97.1	100.0	103.0	109.0	108.2	109.0	109.0	111.2	112.6	110.5	110.9	108.6	106.4	107.8
Italy	94.4	94.7	95.4	98.1	100.0	98.9	99.6	98.4	98.0	99.4	99.3	98.0	96.5	96.7	96.2	96.4	96.6
Netherland	100.2	98.5	98.7	99.5	100.0	100.0	100.4	100.6	100.7	102.3	102.1	101.4	101.1	103.2	104.7	106.3	107.2
Slovenia					100.0	101.5	104.3	104.7	104.0	103.6	106.8	107.9	106.1	107.5	108.7	110.4	110.5
Sweden			98.1	99.3	100.0	99.2	100.7	101.3	101.6	103.2	102.0	104.5	105.7	108.2	109.4	111.0	109.9
United Kingdom	94.9	96.5	98.9	99.9	100.0	101.1	101.2	101.2	101.2	101.5	101.5	101.3	101.1	102.3	103.2	104.3	105.1

Source: Own elaboration based on EU KLEMS database

5.2.2. *Factors that influence Gross Domestic Product and moreover Total Factor Productivity in selected countries*

This part defines the TFP by various factors mentioned above based on the theoretical background. For deriving the set of factors, a generalized sum of stylized facts mentioned earlier was used. It is mainly the education, learning by doing (acquired skills, conducted research and development (R&D), sector share of GDP (based on Thirwall, 2002 and 2003) export/GDP ratio, labour productivity, general policy changes inducting shocks (see Rodrik, 2007), fiscal solvency and various traditional (liberal) factors, such as openness of the economy, international trade, patent and intellectual property protection, etc.

Because of the focus on European countries, several factors can be omitted thanks to characteristic homogeneity of European countries in several features. It is namely intellectual property protection, legal background (with exception of Great Britain), openness of the economy and international trade that could be taken as similar. It is not meant these factors in EU are homogeneous, but they are much more rather similar then for instance Brazil-France-US-China comparison.

Based on the theory, several factors have been chosen. European countries are then evaluated based on these factors. As it has been already mentioned, the labels "Winner" and "Loser" are used for quick and simple evaluation of the country based on the data. At the end, these labels are compared to show whether some pattern can be found. There will be compared following factors:

- Employment in technology and knowledge-intensive sector
- High level education
- Patents as a proxy for innovation
- Research and Development as a proxy for innovation
- Export dependency

Such multi-factor comparison is needed to understand all features of TFP growth and its sources.

5.2.2.1. Employment in technology and knowledge-intensive sector

Data on employment in technology and knowledge-intensive sectors is based on national accounts. Economic policy can influence technological and industrial innovation, increase productivity by making full use of economies of scale, learning curve effects and spin-offs from innovations elevate qualifications in the workforce and improve human capital. In regards of TFP, which is often named as a technological residual, it is assumed the share of employment in technology and knowledge-intensive sector would have the impact on TFP and its growth.

This indicator does not however fully represent the scope of the arrangement of the economy by sectors. Thus, the number of people employed in knowledge-intensive sector can be used as a proxy. We can then name losers and winners if we compare European countries based on this indicator.

Among countries of high percentage of workers in technology and knowledge-intensive sector are mainly Scandinavian countries (Sweden, Norway, Denmark), small and semi-isolated countries such as Ireland, Iceland and some countries of the New Europe. Scandinavian countries are traditionally oriented in high-tech industries as it is reflected in the table. Additionally, Iceland and Ireland have shifted its policy towards high tech and production of high value-added products to keep its competitive advantage.

High numbers of some countries from the new Europe (Czech Republic, Romania, Slovenia and Baltic countries – Latvia and Estonia) could be explained by the Heritage of post-soviet era, which can be characterized by high production of engineers and scientists that should serve in the industrial base.

However, man can find countries of old Europe with low performance in this indicator. It is Belgium, Greece, Spain, France and Italy. This fact could reflect the structural problems of the named countries.

Table 3: Employment in technology and knowledge-intensive sector, in 1 000 000 population

Country	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Belgium	0.38	0.38	0.39	0.40	0.39	0.39	0.39	0.39	0.40	0.40	0.41	0.41
Bulgaria	0.31	0.32	0.33	0.36	0.35	0.36	0.37	0.38	0.39	0.41	0.43	0.43
Czech Republic	0.48	0.47	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.47	0.48
Denmark	0.50	0.50	0.51	0.51	0.50	0.51	0.50	0.51	0.51	0.51	0.51	0.52
Germany	0.43	0.43	0.44	0.44	0.44	0.44	0.43	0.43	0.44	0.45	0.47	0.47
Estonia	0.44	0.44	0.42	0.42	0.42	0.43	0.44	0.44	0.45	0.48	0.49	0.49
Ireland	0.39	0.39	0.41	0.43	0.43	0.44	0.43	0.43	0.45	0.47	0.47	0.47
Greece	0.35	0.37	0.37	0.37	0.37	0.38	0.39	0.39	0.39	0.40	0.40	0.40
Spain	0.33	0.34	0.36	0.38	0.39	0.39	0.40	0.41	0.43	0.44	0.44	0.44
France	0.36	0.37	0.37	0.38	0.38	0.38	0.39	0.39	0.39	0.39	0.40	0.40
Italy	0.35	0.36	0.36	0.37	0.37	0.37	0.38	0.38	0.38	0.38	0.39	0.39
Cyprus	0.38	0.39	0.40	0.41	0.43	0.43	0.43	0.44	0.44	0.45	0.47	0.47
Latvia	0.38	0.41	0.41	0.40	0.41	0.43	0.44	0.45	0.45	0.48	0.49	0.50
Lithuania	0.40	0.42	0.43	0.41	0.40	0.41	0.43	0.42	0.44	0.44	0.46	0.46
Hungary	0.35	0.36	0.37	0.37	0.38	0.38	0.39	0.39	0.39	0.39	0.39	0.39
Malta	0.37	0.37	0.36	0.36	0.37	0.37	0.37	0.36	0.36	0.37	0.38	0.39
Netherlands	0.46	0.47	0.48	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.51	0.51
Austria	0.45	0.45	0.46	0.46	0.46	0.45	0.46	0.44	0.46	0.47	0.48	0.49
Poland	0.39	0.40	0.39	0.38	0.37	0.36	0.36	0.36	0.37	0.38	0.40	0.37
Portugal	0.44	0.47	0.47	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Romania	0.49	0.48	0.48	0.49	0.48	0.44	0.43	0.43	0.42	0.43	0.44	0.44
Slovenia	0.45	0.45	0.44	0.45	0.46	0.46	0.45	0.47	0.47	0.48	0.48	0.47
Slovakia	0.38	0.41	0.40	0.39	0.39	0.39	0.40	0.40	0.41	0.43	0.44	0.45
Finland	0.09	0.09	0.45	0.46	0.46	0.46	0.46	0.45	0.46	0.46	0.47	0.47
Sweden	0.44	0.45	0.46	0.46	0.49	0.48	0.48	0.48	0.48	0.48	0.49	0.49
United Kingdom	0.46	0.46	0.45	0.46	0.46	0.46	0.47	0.47	0.47	0.47	0.47	0.47
Iceland	0.51	0.52	0.53	0.55	0.55	0.54	0.54	0.52	0.52	0.53	0.55	0.56
Norway	0.49	0.50	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.50	0.51	0.52
Croatia	0.32	0.32	0.33	0.33	0.34	0.34	0.34	0.35	0.35	0.36	0.36	0.37

Source: *Own elaboration based on Eurostat data*

5.2.2.2. High level education

Since Total factor Productivity can also be interpreted as the ability to utilize labour and/or capital in a meaningful way, education is one of the factor that influence TFP. Education is one of the factor representing the path to the "knowledge economy" that is technological advanced. Therefore we assume education has the positive impact on TFP.

The aim is to observe the tertiary level of education, and additionally the level of education in science and technology. We can assume that TFP is higher in more sophisticated and technical industries/companies that are on higher technological level thanks to education levels.

Despite the fact total expenses indication cannot measure the effectiveness of the money spent on education, it is reflecting the governmental policy towards education and the build-up of the knowledge-based economy.

The expenditure on tertiary education as a portion of GDP is a presented in the Table 4. Among countries of high expenses on education (as a share of GDP) is Denmark and Norway and followed by Finland and Sweden. All these countries are from the group of Scandinavian countries. These "winners" are then followed by Belgium, Germany, France, Cyprus, Netherland, Austria, Slovenia, Ireland and Iceland.

Among "losers", there is Bulgaria, Czech Republic, United Kingdom, Spain, Italy, Baltic countries, Poland, Slovakia and Croatia. The presence of United Kingdom in the group of "losers" can be possibly explained by it characteristics. Tertiary education in United Kingdom is paid by students, who are however eligible to apply for government loans. Overall, there is a bigger portion of private capital in education in UK.

Table 4: Expenditure on tertiary education as % of GDP

Country	2001	2002	2003	2004	2005	2006	2007
Belgium	1.34	1.32	1.31	1.29	1.29	1.32	1.31
Bulgaria	0.82	0.83	0.83	0.80	0.76	0.73	0.68
Czech Republic	0.79	0.86	0.94	0.94	0.89	1.23	1.07
Denmark	2.71	2.70	2.50	2.51	2.38	2.26	2.29
Germany	1.10	1.16	1.19	1.16	1.14	1.11	1.14
Estonia	1.03	1.08	1.02	0.86	0.92	0.91	1.07
Ireland	1.22	1.19	1.09	1.10	1.11	1.14	1.14
Greece	1.07	1.16	1.10	1.32	1.46		
Spain	0.97	0.97	0.99	0.97	0.95	0.95	0.99
France	1.21	1.22	1.23	1.21	1.19	1.20	1.23
Italy	0.80	0.85	0.78	0.77	0.76	0.77	0.76
Cyprus	1.14	1.38	1.55	1.48	1.58	1.65	1.61
Latvia	0.89	0.85	0.74	0.68	0.88	0.91	0.93
Lithuania	1.33	1.40	1.00	1.06	1.03	1.00	1.01
Hungary	1.08	1.23	1.22	1.01	1.03	1.04	1.03
Malta	0.88	0.90	0.81	0.53	1.07		0.95
Netherlands	1.36	1.34	1.42	1.45	1.47	1.50	1.45
Austria	1.37	1.29	1.31	1.44	1.49	1.48	1.50
Poland	1.04	1.05	1.02	1.15	1.19	0.96	0.93
Portugal	1.03	0.95	1.00	0.83	0.98	1.00	1.20
Romania	0.78	0.70	0.68	0.70	0.81		1.12
Slovenia	1.28	1.27	1.30	1.31	1.25	1.23	1.21
Slovakia	0.82	0.87	0.85	0.98	0.81	0.90	0.79
Finland	1.99	2.02	2.06	2.07	2.01	1.96	1.85
Sweden	2.00	2.10	2.11	2.04	1.92	1.84	1.77
United Kingdom	0.79	1.05	1.04	0.99	1.20	1.10	0.94
Iceland	1.07	1.25	1.33	1.39	1.45	1.36	1.39
Norway	1.84	2.08	2.29	2.40	2.27	2.07	2.16
Croatia		0.59	0.73	0.71	0.76	0.88	0.81

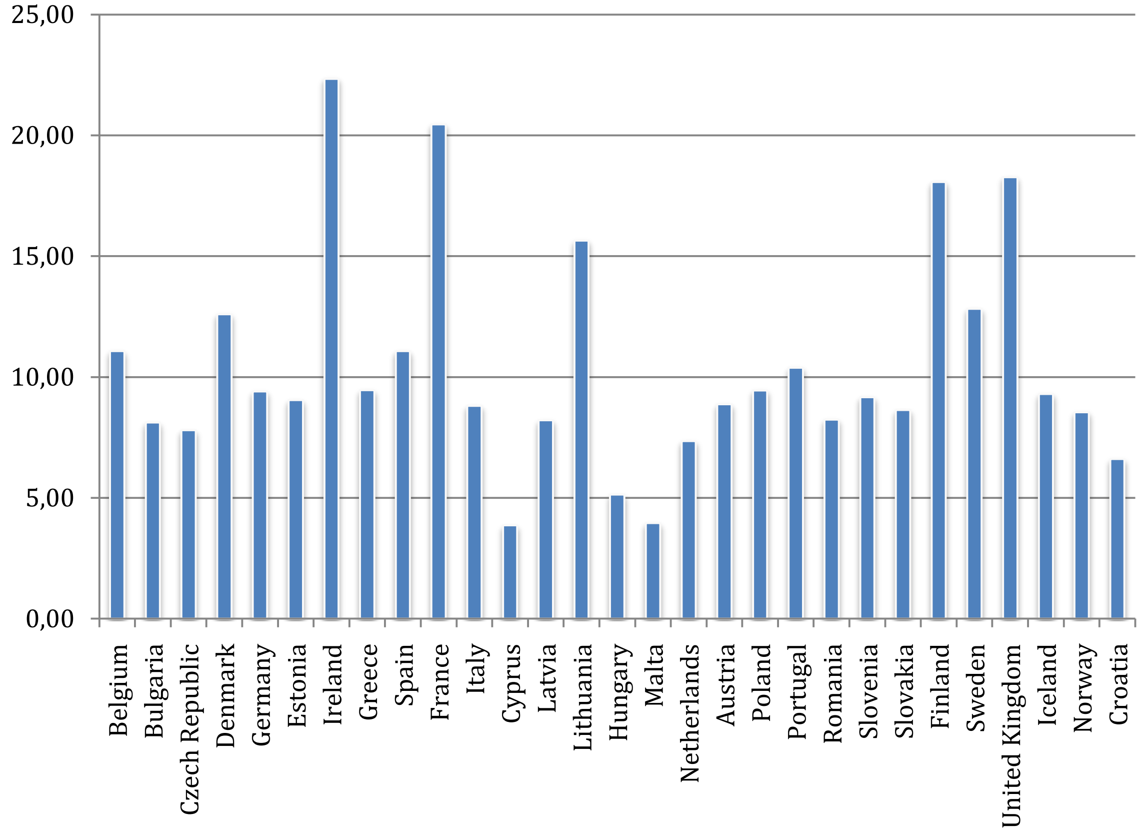
<u>Source:</u> Own elaboration based on Eurostat data

However, to critically assess the impact of the expenses and also the "content" of the statistics, we have to evaluate the graduates of tertiary education. Moreover, for the need of TFP and its factors science and technology graduates have to be assessed. Data is presented in the Figure 8.

Among countries with high production of technical and science-based degrees is Denmark, Ireland, France, Lithuania, Finland, Sweden and United Kingdom.

The fact that United Kingdom is present in the "winner" group support the previously mentioned theory about the expenditure on tertiary education in UK.

Figure 8: Tertiary graduates in science and technology per 1 000 of pop. aged 20-29 years



Source: *Own elaboration based on Eurostat data*

If we compare Table 4 and Figure 8, we can partly derive the characteristics of the education and its focus. For instance, despite the fact Cyprus spend relatively high portion of GDP in tertiary education, it produces very low number of scientists, Netherlands as well.

On the other hand, Spain produces relatively high number of scientists despite the relatively low expenses on tertiary education.

The debated inconsistency in statistics shows the importance of comparison several statistics for deriving the real trends.

5.2.2.3. Patents as a proxy for innovation

It is assumed innovation plays crucial role in the technological progress. As it was defined earlier, we use innovation as a factor representing various inter-dependent factors such as patents, R&D, learning by doing (set of acquired skills), and others.

Despite the fact patents are most like not the best way, how to measure innovation, it is important to search for the pattern in this statistics as well. Because of the thesis focus more on the technological side of the growth, data about high-tech patents were assessed. The data refers to the ratio of patent applications made directly to the European Patent Office (EPO) or via the Patent Cooperation Treaty and designating the EPO (Euro-PCT), in the field of high-technology patents per million inhabitants of a country. The definition of high-technology patents uses specific subclasses of the International Patent Classification (IPC) as defined in the trilateral statistical report of the EPO, JPO and USPTO[22].

From Table 5, man can notice countries with high patent application statistics: Belgium, Denmark, Germany, France, Netherlands, Austria, Finland and Sweden. These countries have multiple numbers of high-tech patent applications than the rest of countries.

From the bottom, Bulgaria, Czech Republic, Greece, Spain, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Portugal, Romania, Slovenia, Slovakia and Croatia are countries that lag behind.

The statistics in absolute numbers shows overall supremacy of Germany and France.

[22] *More at Eurostat website:* http://epp.eurostat.ec.europa.eu/tgm/download.do?tab=table&plugin=1&language=en&pcode=tsc00010 *accesed 16.3.2011*

Table 5: European high-technology patents (Per million inhabitants)

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Belgium	13.175	19.691	24.003	30.894	25.653	26.805	32.292	24.871	31.07	31.216	26.917	21.805
Bulgaria	0.039	0.12	0.193	0.062	0.173	0.36	0.19	0.351	0.281	0.838	1.011	
Czech Republic	0.148	0.3	0.487	0.482	0.482	0.811	0.622	0.989	1.462	1.489	1.841	0.887
Denmark	23.165	26.712	39.181	43.645	44.448	44.289	42.823	45.294	44.375	41.586	36.358	20.213
Germany	25.117	30.773	37.537	43.809	49.734	49.037	46.37	39.673	42.965	38.659	37.612	25.491
Estonia		0.235	1.242	1.269	0.853	3.051	0.955	5.479	1.725	3.614	8.865	5.162
Ireland	5.412	7.839	12.635	16.934	15.107	20.561	16.726	12.544	13.626	13.665	16.593	8.837
Greece	0.237	0.411	0.493	0.923	1.125	1.246	1.649	1.982	1.395	1.461	1.255	0.559
Spain	1.395	1.637	2.1	2.945	3.144	3.655	3.606	3.021	3.405	3.978	4.421	2.16
France	16.343	20.871	25.893	29.954	29.301	30.611	29.65	29.64	30.029	29.107	28.776	17.724
Italy	5.125	5.602	6.556	6.494	8.23	7.077	8.575	8.413	8.397	9.195	7.984	4.275
Cyprus		1.501		0.527	2.172	7.641	2.367	6.922		0.614	1.735	5.997
Latvia				0.083	0.369	0.127	0.682	0.322		0.867	0.218	1.021
Lithuania	0.138	0.092		0.424	0.578	0.401	0.095	0.482	0.447	0.38	0.882	0.688
Hungary	0.451	0.696	1.087	2.681	3.296	2.792	1.65	2.485	2.847	2.276	4.499	1.915
Malta							2.534			2.483	2.963	
Netherlands	34.697	42.772	51.084	62.278	77.997	100.15	72.043	44.712	63.359	55.628	51.925	21.304
Austria	9.638	10.561	13.294	18.566	18.275	23.075	26.801	24.22	23.21	27.463	35.086	18.044
Poland	0.051	0.097	0.071	0.095	0.116	0.254	0.306	0.379	0.532	0.613	0.59	0.642
Portugal	0.232	0.367	0.264	0.609	0.417	0.855	0.466	0.945	0.776	3.245	2.337	2.722
Romania		0.124	0.015	0.03	0.089	0.178	0.115	0.115	0.117	0.27	0.261	0.34
Slovenia	1.005	1.535	4.297	0.591	2.148	3.899	6.163	3.343	1.503	1.952	2.521	6.964
Slovakia		0.232	0.34	0.849	0.256	0.889	1.277	0.6	0.572	0.479	1.412	0.71
Finland	58.282	75.143	86.198	126.458	121.59	119.883	115.138	106.803	127.993	115.804	104.694	39.665
Sweden	38.885	54.796	59.947	69.896	72.549	56.613	52.004	48.658	59.329	59.74	73.898	36.365
United Kingdom	17.658	19.438	24.863	28.936	31.534	28.863	25.792	22.856	22.949	21.202	20.111	9.17
Iceland	13.062	18.083	28.233	72.358	40.996	27.421	34.72	45.065	14.179	17.372	17.673	9.751
Norway	5.943	11.576	12.711	13.059	17.691	15.206	17.988	14.509	17.735	17.493	15.142	3.465
Croatia	0.218	0.044	0.441	0.294	0.073	0.376	0.787	0.074	0.315	0.412	1.621	0.54

Source: *Own elaboration based on Eurostat data*

5.2.2.4. Research and Development as a proxy for innovation

Research and Development (R&D) plays crucial role in the modern theories of the Economic growth. R&D expenditures and policies are one of the most important factors and despite the fact of the promise in the EU's Lisbon Agenda, the actual expenditures have not risen in the past years.

R&D is the most frequently used as a proxy of innovation. According to Eurostat, Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D expenditures include all expenditures for R&D performed within the business enterprise sector (BERD) on the national territory during a given period, regardless of the source of funds. R&D expenditures in BERD are shown as a percentage of GDP (R&D intensity).

Research and Development expenditure by % of GDP is shown in Table 6.

Countries with high expenditures on R&D are Denmark, Germany, France, Austria, Finland, Sweden and Iceland. Among this group of "winners" Finland and Sweden lead the group. Increasing trend can be also seen in Norway, Slovenia, Spain, Portugal and Ireland. On the other hand, among "losers" is Bulgaria, Greece, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovakia and Croatia.

It must be noted expenditure on RD is among observed indicators of agenda Europe 2020[23]. Europe 2020 is the EU's growth strategy for the coming decade including set of five ambitious objectives - on employment, innovation, education, social inclusion and climate/energy - to be reached by 2020.

Interestingly, only Denmark, Germany, Austria, Finland and Sweden are reaching the goal of 4% of GDP.

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[23] *http://ec.europa.eu/europe2020/index_en.htm accessed 15.3.2011*

Table 6: Research and Development expenditure by % of GDP

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	1.94	1.97	2.07	1.94	1.88	1.86	1.83	1.86	1.90	1.96	1.96
Bulgaria	0.55	0.51	0.46	0.48	0.48	0.49	0.46	0.46	0.45	0.47	0.53
Czech Republic	1.14	1.21	1.20	1.20	1.25	1.25	1.41	1.55	1.54	1.47	1.53
Denmark	2.18	2.24	2.39	2.51	2.58	2.48	2.46	2.48	2.58	2.87	3.02
Germany	2.40	2.45	2.46	2.49	2.52	2.49	2.49	2.53	2.53	2.68	2.82
Estonia	0.68	0.60	0.70	0.72	0.77	0.85	0.93	1.13	1.10	1.29	1.42
Ireland	1.18	1.12	1.10	1.10	1.17	1.23	1.25	1.25	1.29	1.45	1.77
Greece	0.60		0.58		0.57	0.55	0.59	0.58	0.58		
Spain	0.86	0.91	0.91	0.99	1.05	1.06	1.12	1.20	1.27	1.35	1.38
France	2.16	2.15	2.20	2.23	2.17	2.15	2.10	2.10	2.07	2.11	2.21
Italy	1.02	1.05	1.09	1.13	1.11	1.10	1.09	1.13	1.18	1.23	1.27
Cyprus	0.23	0.24	0.25	0.30	0.35	0.37	0.40	0.43	0.44	0.42	0.46
Latvia	0.36	0.44	0.41	0.42	0.38	0.42	0.56	0.70	0.59	0.61	0.46
Lithuania	0.50	0.59	0.67	0.66	0.67	0.75	0.75	0.79	0.81	0.80	0.84
Hungary	0.67	0.79	0.92	1.00	0.93	0.87	0.95	1.00	0.97	1.00	1.15
Malta				0.26	0.26	0.53	0.56	0.61	0.58	0.57	0.54
Netherlands	1.96	1.82	1.80	1.72	1.92	1.93	1.90	1.88	1.81	1.76	1.84
Austria	1.90	1.94	2.07	2.14	2.26	2.26	2.45	2.46	2.52	2.67	2.75
Poland	0.69	0.64	0.62	0.56	0.54	0.56	0.57	0.56	0.57	0.60	0.68
Portugal	0.69	0.73	0.77	0.73	0.71	0.75	0.78	0.99	1.17	1.50	1.66
Romania	0.40	0.37	0.39	0.38	0.39	0.39	0.41	0.45	0.52	0.58	0.47
Slovenia	1.37	1.39	1.50	1.47	1.27	1.40	1.44	1.56	1.45	1.65	1.86
Slovakia	0.66	0.65	0.63	0.57	0.57	0.51	0.51	0.49	0.46	0.47	0.48
Finland	3.17	3.35	3.32	3.37	3.44	3.45	3.48	3.48	3.47	3.72	3.96
Sweden	3.58		4.13		3.80	3.58	3.56	3.68	3.40	3.70	3.62
United Kingdom	1.82	1.81	1.79	1.79	1.75	1.68	1.73	1.75	1.78	1.77	1.87
Iceland	2.30	2.67	2.95	2.95	2.82		2.77	2.99	2.68	2.65	
Norway	1.64		1.59	1.66	1.71	1.59	1.52	1.52	1.65	1.64	1.80
Croatia				0.96	0.96	1.05	0.87	0.75	0.80	0.90	0.84

<u>Source:</u> Own elaboration based on Eurostat data

5.2.2.5. Export dependency

The amount of export per capita could be used to show the orientation of the country as a for-export economy, and indicate its openness that could lead to better knowledge and technology spill-over.

Based on the traditional trade theories, countries must have some comparative advantage (resource, production factors, or technological superiority to other economies). Otherwise, based on the new trade theory, such country should benefit from network effects and also possess some technological advantage. Additionally, this requirement is even more needed within the common (and highly competitive) market of EU.

Table 7 shows the exports of goods and services by EUR per inhabitant. Countries with high exports of goods and services are: Belgium, Denmark, Ireland, Netherland, Austria, Sweden, Iceland and Norway. Countries with low exports are: Bulgaria, Greece, Spain, Latvia, Lithuania, Italy, France, Hungary, Poland, Portugal, Romania, United Kingdom and Croatia. Man can observe several countries from the New Europe with increasing trend of exports: Czech Republic, Estonia and Slovakia.

However, such statistics show only incomplete view on the openness of the economy and capabilities of inter-country technological spin-offs. If we compare the statistics with the data of exports of high technology products as a share of total exports (Table 11 in supplements), several countries pop up from this statistics. Namely France, Hungary, Cyprus and Malta move from the group of "losers" into "winners". Possible explanation for this shift of Malta and Cyprus is not the exceptional growth of exports of technology, but rather the tax-favorable economical conditions that attracted businesses. Additionally, there is low barrier to shift from less to more favorable country for technological companies such as IT businesses. This feature could explain high numbers of Malta and Cyprus. On the other hand, exceptional performance of France, Hungary and possibly Czech Republic can indicate smart orientation in accordance of the New Trade Theory.

Table 7: Exports of goods and services (EUR per inhabitant)

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Belgium	14,000	14,000	15,100	15,600	16,300	19,300	19,700	20,000	19,800	21,400	23,200	24,800	26,300	27,600	22,900
Bulgaria	500	500	600	600	800	900	1,000	1,000	1,100	1,400	1,200	2,100	2,400	2,700	
Czech Republic	2,100	2,300	2,500	2,900	3,000	3,800	4,400	4,700	4,900	6,100	7,100	8,500	9,900	10,900	9,000
Denmark	10,000	10,400	11,000	11,200	12,500	15,100	15,800	16,200	15,800	16,500	18,700	20,900	21,800	23,400	19,300
Germany	5,700	5,800	6,400	6,800	7,200	8,400	8,900	9,300	9,300	10,300	11,200	12,800	13,900	14,300	12,000
Estonia	1,400	1,600	2,300	2,700	2,700	3,800	4,100	4,100	4,400	5,200	6,400	7,200	8,000	8,600	6,700
Ireland	10,900	12,400	15,600	18,400	21,500	27,100	30,300	31,200	29,300	30,800	31,900	33,000	34,900	33,800	32,400
Greece						3,100	3,200	3,000	3,100	3,700	3,900	4,300	4,600	4,900	3,900
Spain	2,600	2,900	3,400	3,600	3,900	4,500	4,800	4,800	4,900	5,100	5,400	5,900	6,300	6,300	5,400
France	4,600	4,800	5,400	5,700	5,900	6,800	6,900	6,800	6,600	6,800	7,100	7,600	7,900	8,100	6,800
Italy	3,900	4,300	4,700	4,800	4,800	5,700	5,900	5,800	5,700	6,100	6,300	7,000	7,500	7,500	6,000
Cyprus	5,400	5,700	6,100	6,300	6,900	8,000	8,600	8,000	7,700	8,200	8,700	9,100	9,800	9,900	8,500
Latvia	600	800	1,000	1,200	1,200	1,500	1,600	1,700	1,800	2,100	2,700	3,100	3,900	4,400	3,600
Lithuania	700	900	1,300	1,300	1,100	1,600	1,900	2,300	2,400	2,800	3,500	4,200	4,600	5,800	4,300
Hungary	1,500	1,700	2,200	2,600	2,900	3,700	4,200	4,400	4,500	5,100	5,800	6,900	8,100	8,600	7,200
Malta	6,100	5,900	6,400	7,000	7,800	10,000	9,000	9,600	9,000	8,900	9,200	10,800	12,000	12,200	11,000
Netherlands	12,300	12,600	13,800	14,300	15,400	18,400	18,800	18,500	18,500	20,000	21,900	24,100	25,900	27,800	24,000
Austria	8,000	8,200	9,000	9,800	10,500	12,000	12,800	13,300	13,400	14,800	16,100	17,700	19,400	20,100	16,600
Poland	600	700	800	1,000	1,000	1,300	1,500	1,600	1,700	2,000	2,400	2,900	3,300	3,800	3,200
Portugal	2,400	2,600	2,800	3,000	3,200	3,600	3,700	3,700	3,800	4,000	4,000	4,700	5,100	5,300	4,400
Romania		300	400	400	400	600	700	800	800	1,000	1,200	1,500	1,700	2,000	1,700
Slovenia	4,000	4,200	4,700	5,000	5,000	5,800	6,300	6,800	7,000	7,900	8,900	10,300	11,900	12,400	10,100
Slovakia	1,600	1,700	2,000	2,200	2,200	2,900	3,200	3,400	4,200	4,700	5,400	7,000	8,800	9,900	8,200
Finland	7,100	7,300	8,200	8,700	9,200	11,100	11,100	11,200	10,800	11,600	12,500	14,300	15,600	16,300	12,000
Sweden	8,700	9,500	10,600	11,000	11,800	14,100	13,200	13,300	13,600	14,900	16,000	17,900	19,200	19,300	15,100
United Kingdom	4,300	4,800	5,900	5,900	6,300	7,500	7,500	7,500	7,100	7,500	8,000	9,200	9,000	8,700	7,100
Iceland	7,100	7,800	8,800	9,400	9,900	11,300	12,000	12,300	11,500	12,400	14,100	14,100	16,600	14,300	14,400
Norway	9,900	11,700	13,100	11,400	13,200	18,900	19,400	18,500	17,600	19,100	23,500	26,700	27,600	31,200	23,900
Croatia	1,200	1,500	1,600	1,800	1,700	2,200	2,500	2,600	2,900	3,200	3,400	3,800	4,100	4,500	

Source: Own elaboration based on Eurostat data

5.2.3. THE OVERVIEW OF THE FACTORS

The observations from the previous research are collected in the Table 8. The analysis could to some extent help to predict the sustainability of current growth and thus the future growth.

Table 8: The overview of the factors

Country	GDP growth	S	E	P	I	X	TFP growth	Comment
Belgium	1.87	L	W		W	W		*sporadic results*
Bulgaria	2.69	L	L	L	L	L	N/A	***match***
Czech Republic	2.66	W	L	L			increase	***match, potential***
Denmark	1.43	W	W		W	W		*sporadic results*
Germany	1.27			W	W	W		*sporadic results*
Estonia	5.00		L	L			N/A	*unsustainable growth*
Ireland	5.01					W		***match***
Greece	2.77	L		L	L	L	N/A	***match***
Spain	2.77	L	L					***match***
France	1.75	L	W	W	W		increase	*potential*
Italy	0.83	L		W				***match***
Cyprus	3.11		W	L	L		N/A	*unsustainable growth*
Latvia	4.51			L	L	L	N/A	*unsustainable growth*
Lithuania	4.57			L	L	L	N/A	*unsustainable growth*
Hungary	2.51	L	L		L			*unsustainable growth*
Malta	1.86	L	L	L	L		N/A	***match***
Netherlands	2.25	W	W	W		W	increase	*potential*
Austria	2.03	W	W		W	W	increase	***match***
Poland	4.41	L	L	L	L	L	N/A	*unsustainable growth*
Portugal	1.87	W	L	L			N/A	*sporadic results*
Romania	2.67	W	L	L	L	L	N/A	***match***
Slovenia	3.33	W	W	L				***match***
Slovakia	4.39		L	L	L		N/A	*unsustainable growth*
Finland	2.84	L	W		W	W		***match***
Sweden	2.56	W	W	W	W	W	increase	***match***
United Kingdom	2.11	W	L	W			increase	***potential***
Iceland	3.17	W	W	L	W	W	N/A	***match***
Norway	2.29	W	W			W	N/A	*sporadic results*
Croatia	2.94	L	L	L	L	L	N/A	*unsustainable growth*

Source: Own research

Where:

S…Employment in technology and knowledge-intensive sector

E… Expenditure on tertiary education

P…Patents as a proxy for innovation

I…Research and Development as a proxy for innovation

X…Export dependency

Sporadic results…Observed performance was not confirmed by data

Match… Observed performance was confirmed by data

Unsustainable growth…Based on the performance, it is probable that growth is not sustainable

Potential…There is a potential for growth

Increase (TFP growth)…Increasing trend of TFP growth

From the table, several observations can be made. First, the overall performance test is a mixed bag. On one hand, analysis has confirmed some growth trajectories of several countries according to the performance based on the technology factor. Additionally, analysis predicts some unsustainable growth tendencies in several countries that will probably result in lower growth rates in the future.

Bulgaria: Weak performance in all indicators suggests unsustainable sources of growth and therefore low GDP growth. GDP growth is probably driven more by linkages to other economies and increasing linkages with European economies.

Czech Republic: Analysis of factors is not persuasive. However, each factor has increasing tendency and reaching higher values. Thus it is possible to predict the potential for healthy economic growth. This prediction is supported by the analysis of Total Factor Productivity, which is increasing since the year 2000 onwards.

Estonia: The analysis of factors predicts the growth is not sustainable. This feature can be supported by the fact that how hard was Estonian economy hit by the global financial crisis. The dip of the GDP growth was in the year 2009 the third largest in Europe (-13.9%).

Ireland: Analysis predicts sustainable growth. However, the trend of several indicators is declining. It is also reflected in the trend of GDP growth and the current struggle of Irish government to deal with the impacts of the crisis on the Irish economy only pinpoints the trend. On the other hand, Analysis has shown Ireland has been able to manage strong ground for further redirection back to the increasing growth path.

Greece: Analysis has found the unsustainable growth source. Current events in Greece only support this observation. However, the semi-bankruptcy of the state was not generally cause by the lack of the performance in the selected factors. The Greece crisis was rather fiscal-based. Nevertheless, according to the analysis, Greece has not been able to make the conditions for sustainable growth.

Spain: Spain growth has been relatively high in several time periods in the last 15 years. However, it is important to establish conditions for the long-last growth. According to the analysis, Spain has not yet been able to do so. Man can predict only mediocre growth in the near future. This direction is also supported by the analysis of TFP growth.

France: Despite of the mediocre growth, analysis of factors identified the potential for the growth in the future. This prediction is also reinforced by the analysis of TFP growth.

Italy: Analysis has shown only average growth. This fact is also supported by the analysis of factors and also by TFP growth.

Cyprus: Based on the fact of relatively high growth, it is possible that such growth was cause by unanalyzed factors such as tax regimes that allowed country to gain its competitive advantage – the ability to attract foreign businesses thanks to tax incentives and low corporate tax. However, growth on this basis is not seen as a sustainable growth.

Latvia: Despite the fact of relatively high growth, the analysis of factors shows the unsustainable trails in growth. This feature can be supported by the fact that how hard was Estonian economy hit by the global financial crisis. The dip of the GDP growth was in the year 2009 the largest in Europe (-18%).

Lithuania: The analysis of Lithuania economy has shown similar results to the Estonia and Latvia growth and its sources. The dip of the GDP growth was in the year 2009 the second largest in Europe (-14.7%).

Hungary: Albeit relatively high growth in the past, latest GDP growth statistics shows that the increase of growth stopped 2006. It could signal that the unsustainable sources of growth (among other structural problems) occurred. However, TFP analysis has shown some improvements. There is then the possibility of reaching the original path of increasing GDP growth.

Malta: Analysis has shown average growth in the past 15 years with the increasing trend. Nevertheless, analysis of factors has shown Malta did not focus on support of high-tech sectors or knowledge-oriented economy.

Netherlands: Statistics has shown average growth of GDP. Yet, analysis has shown potential for further growth. This prediction is also supported by the analysis of TFP growth.

Austria: Relatively stable trend of GDP growth is supported by analysis of factors, which has shown a potential for further growth.

Poland: The analysis of factors has shown the unsustainability of growth. It is likely the EU membership and thus the access to the EU markets that allowed using Poland comparative advantages such as mass agriculture production with low costs of production factors. However, the advantage diminishes with time and the growth of the economy itself. It is probable that the lack of intensive knowledge and technological build-up will cause the sluggish growth performance in the future.

Romania: Despite of the relatively high growth, analysis of factors has identified the potential threat for the growth in the future. There is probability the growth will be slowed down based on the analysis of factors.

Slovenia: The analysis of factors has shown stable ground for continuous increasing trend of economic growth. This prediction is strengthened by the analysis of TFP factor.

Slovakia: Based on evaluation of all factors, the analysis has shown unsustainable growth of Slovak economy. The trend of GDP growth supports the prediction only partially. It is more likely the growth of the economy is a result of tax and other incentives offered by the government for foreign direct investments. However, theory states such growth is not sustainable.

Finland: The average growth of Finland economy is supported both by the analysis of factors and TFP analysis.

Sweden: Analysis of factors has shown a great potential for growth of Swedish economy. This fact can be seen in 2010, when preliminary data indicates the highest growth (5.5% growth) among European countries just two years after the begin of the global financial crisis. Such performance could be explained by the quality basis of the knowledge-oriented economy. Moreover, the analysis of TFP supports the trend.

United Kingdom: Despite of the average growth, analysis of factors identified the potential for the growth in the future. This prediction is also reinforced by the analysis of TFP growth.

Iceland: Analysis has shown a potential for growth. However, it appears global financial crisis has hit Iceland very hard. Thanks to its size and relative dependence on European markets, it is unlikely Iceland will quickly recover.

Croatia: Weak performance in all indicators suggests unsustainable sources of growth and therefore low GDP growth. GDP growth is probably driven more by linkages to other economies and increasing linkages with European economies.

Other countries have mixed results that contradict with the reality. This fact reflects the possibility of such analysis to capture all trends and factors influencing GDP growth. Additionally, broader sample of TFP data would be useful for improvements in the analysis.

5.3. European Innovation Scoreboard comparison

European Innovation Scoreboard[24] is a well-established and recognized tool for assessing innovation performance in EU Member States. The latest 2010 Scoreboard uses 25 research and innovation-related indicators and covers the 27 EU Member States, and also Croatia, Serbia, Turkey, Iceland, Norway and Switzerland.

The Scoreboard places Member States into the following four country Gross. The results of 2010 Scoreboards define:

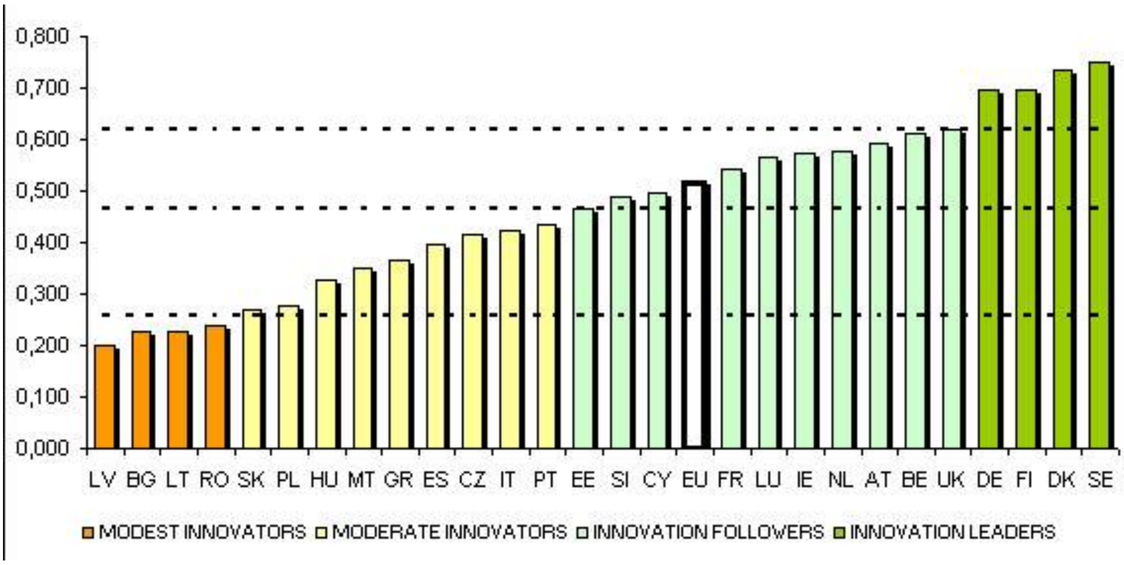
- **Innovation leaders**: Denmark, Finland, Germany, Sweden
- **Innovation followers**: Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, Netherlands, Slovenia and the UK
- **Moderate innovators**: Croatia, Czech Republic, Greece, Hungary, Italy, Malta, Poland, Portugal, Slovakia and
- **Modest innovators**: Bulgaria, Latvia, Lithuania and Romania

[24] *European Innovation Scoreboard, Available at: http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/index_en.htm Accessed 24. 3. 2011*

The advantage of EIS is that it compares all aspects of innovation. In other words, EIS compares inputs (R&D expenditures), outputs (Patents, etc.), and also the internal activities within companies and other actors.

If we compare the results of EIS 2010 with results of conducted analysis of factors, we can notice some similarities. Figure 9 contains the results of EIS 2010:

Figure 9: European Innovation Scoreboard 2010



<u>Source:</u> European Innovation Scoreboard 2010

All countries with poor performance in analysis (Latvia, Lithuania, Bulgaria, Romania, Greece, Hungary, Malta, Poland, Slovakia, and Croatia) are among Modest innovators and Moderate innovators in EIS 2010.

The analysis of factors only diverges in the prediction of Estonia, which is seen in EIS as an Innovation follower in contrary to the results of the analysis. Additionally, analysis probably overrates the prospects of Czech Republic. On the other hand the analysis correctly identified high innovative performance countries in relation of EIS 2010, namely: Denmark, Sweden, Finland and Germany.

However, unlike EIS, conducted analysis evaluated only small sample of data.

5.4. INNOVATION AS A FACTOR OF ECONOMIC GROWTH

Based on the evaluation of factors from previous chapter, it is worth trying to construct a possible model based on analyzed factors. The aim of the model formulation is to support the theory that innovation is a crucial source of the economic growth. The intent is to develop a model that would explain the dependency of GDP growth on the technological factors analyzed earlier.

Econometric model quantifies the relationship among economic variables. Therefore, we obtain the unknown parameters of the model and test whether the economic hypothesis derived from theory is consistent with facts in the form of economic data.

In general, there are many ways to measure innovation. Two major indicators are used the most often: R&D and the number of patents. For the purpose of the model, patents as a proxy of Innovation were used.

5.4.1. MODEL FORMULATION

Economic model is derived from theoretical base and represents proposed economic relationships. The theoretical arguments are expressed mathematically as follows:

y1t = f (x1t, x2t, x3t, x4t)

by variables:

GDP = f (S, P, E, X)

Econometric model is formulated based on economic model so that its parameters can be estimated if one makes the assumption that the model is correct. There are explanations of the economic theory underlying the economic phenomena under consideration. These assumptions upon which the model is based note the implications and limitations:

I. **The amount of accumulated knowledge positively effects GDP.**
II. **The use of technology positively effects GDP.**
III. **Innovation conducted within country positively effects GDP.**
IV. **Expenditure on education positively effects accumulated knowledge.**
V. **The amount of workers in knowledge-intensive sectors reflects the accumulated knowledge and technological level.**
VI. **The number of patent application can be used as a proxy of innovation.**
VII. **Exports of goods and services represent the openness of the economy.**
VIII. **Openness of the economy induce knowledge and technological progress transfer.**

The econometric model is follows:

y1t = γ11x1t + γ12x2t + γ13x3t + γ14x4t + u1t

by variables:

$$GDP = \gamma_1 S_{1t} + \gamma_2 P_{2t} + \gamma_3 E_{3t} + \gamma_4 X_{4t} + u_{1t}$$

thus in logaritmic form:

$$lnGDP = \gamma_1 lnS_{1t} + \gamma_2 lnP_{2t} + \gamma_3 lnE_{3t} + \gamma_4 lnX_{4t} + u_{1t}$$

5.4.2. DECLARATION OF VARIABLES:

Unlike in the descriptive analysis, absolute numbers have been used in the model. Additionally, model is using logarithmic versions of data.

Dependent

y1t Gross Domestic Product (l_GDP_A)

Independent

u1t dummy variable (const)

X2t Employment in Science and Tech (l_S_A)

X3t Total European patent applications (l_P_A)

X4t Expenditure on education in current prices (l_E_A)

X5t Exports of goods and services (l_X_A)

Additionally, general overview of the factors and its features are incorporated into Table 9:

Table 9: Overview of used variables

Proxy	Name	Variable	Unit
GDP	GDP	Gross Domestic product	EUR
Sector share	S	Number of workers	Number
Innovation	P	Number of patent applications	Number
Education	E	Expenditure on education in	EUR
Export dependency	X	Exports of goods and services	EUR PPS

All values are based on the Eurostat database.

Values of all variables have been inserted in the form of panel data into open source econometric program GRETL[25]. Next stage was evaluation of the multicollinearity via the correlation matrix. As regards the theory, multicollinearity is present when there is a near or perfect linear association between any two or more explanatory variables. It exists when there are little variations in the values of the regressors over the sample period. In other words, multicollinearity means there is the linear relationship between variables.

[25] *GRETL, available at: http://gretl.sourceforge.net/ Accessed 20. 3. 2011*

However, based on the correlation matrix (see Figure 10 in supplement), man can say multicollinearity occurs. Thus there is inter-dependency among variables.

Nevertheless, it is highly probably multicollinearity occurs in the model containing such variables. From the logical point of view, used variables are connected in the real world so there must be some level of collinearity in the model. Therefore this fact was omitted.

5.4.3. *MODEL RESULTS*

Parameters' estimation by software GRETL brought the following results that shows table below.

Table 10: Fixed-effects, using 150 observations

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	6.99499	0.700562	9.9848	<0.00001	***
l_S_A	0.079631	0.0334836	2.3782	0.01884	**
l_P_A	0.105014	0.0349209	3.0072	0.00316	***
l_E_A	0.293446	0.0461895	6.3531	<0.00001	***
l_X_A	0.417993	0.0448772	9.3141	<0.00001	***

Fixed-effects, using 150 observations
Included 15 cross-sectional units
Time-series length = 10
Dependent variable: l_GDP_A

The quantified model is:

$$\ln y_{1t} = 0.079631 \ln x_{1t} + 0.105014 \ln x_{2t} + 0.293446 \ln x_{3t} + 0.417993 \ln x_{4t} + 6.99499$$

5.4.4. *STATISTICAL VERIFICATION*

As regards statistical verification the hypothesis is as follows:

Ho: $\gamma=0$

A: $\gamma\neq0$.

The aim is check the significance of parameters, therefore it is desirable to reject the Ho hypothesis.

According to the Table 10, all of the parameters were significant on the level of 0.1 level of significance that is based on methodology in software Gretl where is described that *** is equal to 0.1 level of significance. Only parameter for l_S_A has a significance on the level of 0,05.

R2 (coefficient of determination) is 0.998326. It shows by which percentage the variation of independent variable is explained by the analysed equation.

Durbin – Watson test is in the model 0.618351. In the case of no autocorellation Durbin – Watson test should be approximately 2. Therefore, the model does not meet the criteria of zero autocorrelation.

5.4.5. *ECONOMIC VERIFICATION*

Parameters show how dependent variable changes, if explanatory variable changes by 1 percent (estimation is in logarithmical form). Based on the estimated equation:

Intercept is 6.99499. Such high number suggests that the model is missing some substantial variables.

If the number of workers in technology and knowledge intensive sectors increases by 1%, it results in GDP increase by 0.0796%. The estimate of the impacts of technology and knowledge-intensive sector positively impacts GDP has been confirmed.

If the number of patent applications increases by 1%, then GDP increases by 0.105%. This estimate is according to the assumption that innovation result in higher GDP. However, the value itself is hard to evaluate.

If the expenditure on education increases by 1%, then GDP increases by 0.2935%.

If the exports of goods and services increase by 1%, the GDP increases by 0.41799%. This estimate corresponds to the fact that openness of the economy spurs knowledge and technological transfer. However, there is interdependence among these variables from the economic point of view.

Economic verification of the model confirmed all assumptions (I-VIII). Despite the fact statistical verification of the model has shown some flaws, the model can be seen as a functional model. Further analysis must be done to develop better model without autocorrelation characteristics.

6. DISCUSSION

The proposed model can offer an explanation whether innovation is important source of economic growth. Test of the model showed that the economic hypothesis derived from theory is to some extent consistent with facts in the form of economic data.

The model has shown the education as a stronger driving factor of growth than the number of patents. It suggests that for invested 1 EUR into education system, we gain much greater impact on GDP then by investing into patents. However, this fact can confirm the question whether patents are a good proxy for innovation and additionally whether patents spur, or slow the economic growth, as it has been questioned by many (for example Vivek Wadhwa). Nevertheless, both cooficients were positive, which confirms the assumptions I, III, IV and to some extent VI).

Finally, the model has shown that the strongest factor in the model is exports. In other words, it could be interpreted as the openness of the economy has radically positive impact on the economic growth (assumptions VII and VIII)

However, there are some flaws of the model. At first, greater length of data span should be used to increase the validity of data. Additionally, the interdependency of variable should be avoided by some better model construction. However, it was not possible to construct model with longer data table due to the limited statistical data. There is also a question whether Patents are a good proxy for innovation statistics.

Despite series of tests, it was not possible to use TFP data from KLEMS as a dependent variable. It is probably due to the unresolved mystery of the content of TFP. Nevertheless, I was able to overcome this problem by using variables that have been confirmed as in important factors influencing TFP and thus GDP. It will probably take more research that will enable us to fully understand the TFP factor.

The outcomes of the analysis can be compared with some other research to evaluate if its validity holds. In general, the comparison of the outcomes with European Innovation Scoreboard (EIS) revealed the Innovation evaluation of countries based on selected factors brings similar evaluation to EIS.

7. Conclusions

The research has shown the importance of innovation as a source of economic growth. Despite the fact there are flaws incorporated in the statistics and model construction that have to be further improved, constructed model supported the descriptive analysis of factors and confirmed the Importance of Innovation and its effects on growth. The results of the descriptive analysis are mostly in par with the TFP analysis based on KLEMS data and also European Innovation Scoreboard.

Further attempts to improve the model would rely on the quality of gathered data. Provided data were available only thanks to serious European effort to monitor innovation and other factors of growth. Due to the lack of innovation within the whole EU, European Union lag behind rapidly-growing economies of Asia, South America and USA in the means of GDP growth, entrepreneurship and innovative spirit.

Nonetheless, EU conducts various researches that could lead to policies improving innovation and thus economic growth. In reality "innovation policy" covers a broad range of different policy fields including research, industrial regulation, education, employment, taxation, environmental regulation, intellectual property laws, health standards, quality control, etc.

Even though funding instruments are important element for supporting R&D and innovation in firms, but also the fiscal, institutional and regulatory environment, as well as all measures and mechanisms within the control of government that can encourage the interaction between actors involved in producing, distributing and applying various kinds of knowledge.

As Burda and Severgnini (2008) already stated, whether interpreted either as technological improvement or increased factor efficiency, as the acquisition and implementation of new technologies or simply a move to the efficient frontier, sustained total factor productivity growth via innovation is a key to long-run economic development.

The analysis of factors has shown the GDP growth of new EU member states generally exceeds the average growth, especially the growth of the old EU countries. However, the analysis has also shown the possible weak sources of such growth. Based on the theory, man can then conclude the exceptional growth of the new EU countries is based on rather simple catch-up of the old countries. Such conclusion can be also supported by the convergence theories that predict such behavior.

In order to sustain high level of economic growth in the long run, new EU countries have to embrace the policy of knowledge economy and support industries that produce products or services with high added value. There is still significant gap between old and new EU countries in this matter.

Moreover, not only new EU countries do significantly lack behind the best performing countries. The analysis has shown several old EU countries do not perform well in the matter of innovative capacities and thus economic growth.

In order of remain competitive with USA and high-growing Asian countries, the Europe must embrace the policy of knowledge economy and innovation policy and continuously evaluate its performance.

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10. TABLES AND FIGURES

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11. SUPPLEMENTS

Figure 10: Correlation coefficients, using the observations 1:01 - 15:10

l_GDP_A	l_S_A	l_P_A	l_E_A	l_X_A	
1.0000	0.9113	0.9721	0.9600	0.9521	l_GDP_A
	1.0000	0.9069	0.9092	0.8504	l_S_A
		1.0000	0.9711	0.9274	l_P_A
			1.0000	0.9187	l_E_A
				1.0000	l_X_A

Table 11: Exports of high technology products as a share of total exports

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	5,617	6,221	6,251	6,616	7,855	8,685	8,984	7,495	7,423	7,120	7,048	6,661
Bulgaria		2,339	2,298	1,863	1,708	1,636	1,767	2,561	2,914	2,537	2,911	3,340
Czech Republic	4,990	6,688	7,200	7,803	7,847	7,776	9,099	12,322	12,369	13,663	11,665	12,735
Denmark	9,577	10,034	11,649	11,853	13,879	14,426	13,988	15,018	13,454	13,322	14,858	12,751
Germany	11,643	11,697	12,565	13,232	14,192	16,076	15,796	15,153	14,761	15,357	14,788	14,062
Estonia	4,060	6,037	6,006	7,945	10,269	25,122	17,091	9,830	9,364	10,039	10,285	7,993
Ireland	32,882	38,132	37,524	37,163	39,398	40,544	40,804	35,347	29,913	29,080	29,538	29,008
Greece	3,092	3,053	3,097	4,632	5,469	7,458	6,190	6,556	7,519	7,120	5,948	5,708
Spain	5,814	6,000	5,401	5,490	5,942	6,371	6,107	5,707	5,908	5,704	5,649	4,924
France	15,217	15,092	17,045	18,270	23,964	25,465	25,599	21,882	20,736	20,068	19,072	17,884
Italy	7,428	7,199	6,946	7,396	7,512	8,535	8,579	8,215	7,097	7,082	6,942	6,350
Cyprus	5,862	5,746	2,594	3,080	4,012	3,044	3,991	3,457	4,197	15,894	31,562	21,346
Latvia	3,016	3,182	3,773	2,333	2,326	2,246	2,241	2,268	2,752	3,211	3,210	4,205
Lithuania	2,119	2,166	2,299	2,036	2,058	2,554	2,917	2,438	3,021	2,722	3,199	4,650
Hungary	4,764	4,117	13,894	16,851	19,445	23,110	20,611	21,453	22,334	21,921	19,692	20,325
Malta	56,873	53,212	49,569	55,357	55,704	64,396	58,130	56,531	55,490	54,955	48,248	53,785
Netherlands	15,190	17,001	19,528	21,417	21,862	22,823	22,279	18,743	18,808	19,100	20,247	18,271
Austria	7,824	7,857	9,632	9,865	11,889	14,052	14,659	15,737	15,331	14,756	12,812	11,169
Poland	2,048	2,279	1,993	2,341	2,264	2,843	2,707	2,448	2,706	2,731	3,198	3,114
Portugal	4,529	3,735	3,646	3,602	4,374	5,573	6,940	6,356	7,477	7,495	6,851	6,991
Romania	1,918	1,415	0,970	1,465	2,808	4,631	4,966	3,090	3,307	3,077	3,107	3,846
Slovenia	3,249	4,069	3,867	4,064	3,748	4,464	4,831	4,864	5,796	5,202	4,263	4,662
Slovakia	3,313	3,358	3,357	3,363	3,496	2,874	3,166	2,633	3,433	4,683	6,402	5,823
Finland	12,352	13,668	16,065	18,942	20,689	23,480	21,136	20,903	20,584	17,774	21,344	18,121
Sweden	12,950	14,425	15,574	16,313	17,833	18,708	14,232	13,705	13,122	14,138	14,231	13,395
United Kingdom	22,519	22,390	22,694	24,541	27,348	28,896	29,795	28,644	24,428	22,803	22,135	26,484
Iceland	1,923	2,321	2,359	1,842	2,059	1,690	1,296	1,670	1,986	2,347	6,553	8,919
Norway	3,762	3,455	3,702	4,833	4,484	3,298	3,602	4,559	3,698	3,466	2,931	2,963
Croatia	4,522	5,655	6,633	6,040	6,318	6,339	7,651	8,964	8,994	9,588	7,962	6,795

Source: *Eurostat*

Description: This indicator is calculated as share of exports of all high technology products of total exports. The total exports for the EU do not include the intra-EU trade.