LUND UNIVERSITY
School of Economics and Management

Master programme in Economic Growth, Innovation and Spatial Dynamics

Structural Change through Technology and Human Capital in Finland since the 1990s

Eeva Karppinen
Eeva.karppinen.069@student.lu.se

Abstract: The purpose of this thesis is to examine the role of human capital in the case of Finland and its linkages to the Finnish export performance. During the last decades Finland has made a shift from peripheral economy into one of the most competitive countries in the world. Finland is known for its many knowledge-driven companies and relatively educated people. While it is a commonly accepted fact that human capital has positive contributors to economic growth, its linkages to exporting have not been studied in the Finnish case. With that, the purpose of the thesis is to analyze the importance of human capital, especially skilled labour force, in the high-export arena in Finland. Theories on economic growth and its relations to human capital as well as changes in the economic structure in the last decades are discussed. After this, the role of human capital and export value are examined from the Finnish standpoint and highlighting characteristics of innovation, technology and rapid change to knowledge-driven economy. Later chapters are dedicated to the empirical examination, which consists of analyzing export value added and access to human capital in the technology sector 1991 onwards. It is expected that there is a relationship between increased amount of human capital and export success. The hypothesis is that skilled labour force drives export value. This hypothesis is formulated on the basis of the theories on economic growth. The thesis ends with answering the question of the impacts of human capital and moreover, skilled labour, in the Finnish export activity within technology. Furthermore, suggestions for future research are given.

Key words: technology, export, innovation, human capital and structural change

EKHR71
Master thesis (15 credits ECTS)
June 2012
Supervisor: Lennart Schön
Examiner: Anders Nilsson

Table of Contents

1. Introduction

Many scholars have tried to explain the role of human capital in economic growth. While it is commonly accepted that human capital contributes to economic development of a country, scholars have different standpoints on human capital's influence on growth. In addition to this, the recognition of human capital and its interrelations to export performance have sparked a debate in the research frontier. Given this complexity of the subject, measuring this relation is everything but simple.

Export arena includes many different sectors and one of the most interesting sectors is high technology. High technology export branch is intriguing in many respects, since this sector is influenced by factors such as the diffusion of innovation and the aspect of human capital. While there are many factors influencing a country's export success, human capital has been recognised as one of the most influential factors in high exports.

With that, the purpose of this thesis is to examine human capital and its linkages to export success in the case of Finland. The country of Finland was chosen, because it has encountered radical changes in the economy from the 1990s onwards. Finland is a small open economy and export has always been an integral factor for growth. In addition to this, technology and innovation have been highlighted as essential factors when it comes to being competitive in the modern, global markets. First and foremost, the recession in the early 1990s influenced the Finnish society as a whole, which was followed by the rise of many knowledge-intensive enterprises such as Nokia. Secondly, in the modern day Finland, human capital is seen as a national asset, as an increasing amount of people hold a university degree.

Given these two dimensions, the aim of this paper is to analyse the role of human capital in the Finnish high technology export. The aspect of human capital in this analysis is measured by individuals, who hold a tertiary degree and are employed. The export success is examined with value-added content of exports for high technology sector. Given the theoretical standpoint, it is expected that there is causality between the export value and the skilled labour force. In other words, it will be examined whether the increased level of education in Finland has contributed to the skill level of the labour force. Furthermore: is this stock of human capital connected to the export success in the case of Finland? Given these questions, a closer analysis is estimated, which consists of

a part on descriptive statistics and a co-integration analysis, while keeping in mind the theoretical aspects as well as the background information on Finland.

The paper begins with a theoretical review in which frameworks on economic growth and human capital as well as international trade are discussed. This chapter is followed by discussing the case of Finland, which provides insight on the Finnish export arena and the development of human capital and in particular skilled labour force. After this, a quantitative analysis is estimated in order to examine the possible co-integration relation. As previously highlighted, it is expected based on the theoretical standpoint that skilled labour force is linked to export activity. While the hypothesis is that skilled labour is driving export value, this relation could be the opposite that is that export activity is driving skilled labour force. When measuring this relation, longitudinal data (provided by Statistics Finland) is used to examine the linkages between skilled labour force and export value. After formalising this analysis, the results are discussed in greater detail in the 5th chapter of this paper, which provides insight on the importance of skilled labour force in the case of Finland. In other words, the aim of the paper is to explain to answer the question of the impacts of skilled labour force in the Finnish high export arena. In addition to this, suggestions for future research are given in the concluding words.

2. Theoretical Review

This section includes explaining human capital and export nodes through theoretical lenses. Furthermore, it focuses on international trade and export performance.

2.1 Human Capital and Economic Growth

A fundamental puzzle in long-term economic growth of a country often deals with recognition of human capital and its interrelation to economic performance. The wealth of industrialised countries is mainly consisted of intellectual capital, especially human capital (The World Bank, 2005). Today, human capital and its linkages to economic growth of a country is a highly researched field, while it is commonly accepted that human capital is an integral contributor to economic growth. While there are some commonly accepted views on human capital, measuring it is often widely debated.

So what is human capital? Many economists have defined human capital differently. Today, the contemporary theory on human capital is regarded as an endogenous growth theory, which is reflected by the rise of the knowledge economy. One of the most prominent economist Theodore W. Schultz pinpoints that education is an investment in a man, which has consequences to the human as well as to the society (1961). This growth theory and in particular its emphasis on acknowledging human capital and its importance have contributed to economic policies that support life-long learning and education (Kilponen & Santavirta, 2002). Because of this, Schultz's work can be seen as unparalleled in both defining human capital as well as analysing its interconnections to economic activity. Nevertheless, there are many other definitions of human capital, which elaborate human capital on individual as well as firm level. For instance, Epic Kleynhans has defined it as "those elements in humans that enhance the quality of labor, such as skills, knowledge and wisdom, which make it worth more in the production process" (Kleynhans, 2006, p.55). Given this, there are also properties in human capital such as its value and uniqueness, which consist of specialties that the individual carries.

When finding a definition or understanding human capital, one can examine it through looking at the different standpoints of economics. Especially, the role of human capital in these various frameworks such as new growth theories, highlight its importance differently. Key figures in the new growth theories are Romer (1986), Lucas (1988) and Uzawa (1965). First and foremost, Paul M. Romer discusses human capital and its

linkages determining the speed of economic growth in "Endogenous Technological Change" (1986, 1990). For example, Romer examines technological progress and its relation to human capital (1986, 1990), as he builds his theory on long-growth model, in which knowledge is assumed to be an input in production as a factor that increases marginal productivity. Later on Romer, identifies knowledge as an endogenous factor, which reflect to the technological growth as well as human capital. This theory illustrates that increased importance of human capital is even more present in developed economies, which have undergone structural changes. Furthermore, Romer pinpoints that changes in economic activity over the past decades can be understood by technological progress as well as increased demand of skilled labor force (1990). He also states that technology is freely available to everyone like any other public good, while these aspects still hold restrictions regarding patenting and intellectual property rights, which can also encourage investing in human capital (1990). In addition to Romer, Lauri discusses human capital from the endogenous standpoint (2004). For instance, Lauri highlights that economic growth is a result of many factors that increase productivity (2004). Such factors are households that accumulate human capital and learning-by-doing, which boost technological growth (Lauri, 2004 & Arrow, 1962). Economic growth in long-term perspective can therefore be seen as increasing human capital and technology. In essence, human capital is seen as endogenous factor, a different from labor and physical capital (Lucas, 1988). These ideas are presented by Robert Lucas in "On the mechanics of Economic Development", which contributed to Solow-model by adding human capital as explaining economic activity (1988). Lucas (1988) together with Uzawia (1965) discuss human capital's role in increasing individual's efficiency when working as well as on a larger scale.

$$Y = AK(t)^{\beta} H(t)^{(1-\beta)} H_a(t)^{\gamma} \qquad \text{,where } 0<\beta<1$$

In this model above, Lucas states that the accumulation of human capital has an internal influence (H(t)) from which all individuals benefit (1988). On the one hand, technological progress (A) is assumed to be constant along with capital (K(t)). The external factor in this model is (Ha(t)) that accounts for the average human capital within the population. In addition to this, accumulation of capital (H(t)) is thought to be dependent on time (1-u(t)), since one is not able to spend all his or her time gaining knowledge, as naturally some time (u(t)) is used in leisure.

$$h(t)=h(t)^{\phi}\,\delta[1-u(t)]$$

In this function, human capital and its accumulation is influenced by ($h(t)^{\phi}$) that is function's technical part, as the later part explains how much human capital is accumulated with the help of used time (Uzawa, 1965). According to Uzawa, the accumulation of human capital can be described by a linear function, when it is assumed that $\varphi = 1$. Instead, the key point in exogenous growth theories is that ($\varphi < 1$). That is, the model supports the traditional Solow model as the capital can only increase to a certain point (Solow, 1956). On the contrary, these endogenous growth theories suggest that the function does not need to follow this characteristic. In other words, when human capital is at the least linear ($\varphi \geq 1$), human capital can increase in long term. Perhaps, the most intriguing question around the endogenous growth theories is to explain why human capital is a different factor from other factors, stating that it can grow constantly. To answer this question scholars have provided explanation with external factors arising from human capital (Nelson & Phelps 1966, Romer, 1986 & Lucas 1988). While the above discussed endogenous theory differs from exogenous thinking, still some argue that these both theories complement each other (Barro & Lee, 2000).

This neoclassical standpoint could be seen in the Solow model for growth, where investments in physical capital drive growth and economy's labor and capital are forces of production (Solow, 1956). In other words, this model is based on production function $Y=AK\alpha L1-\alpha$, in which Y stands for the total output and K and L stand for capital and labor respectively, whereas α is the weighted factor for capital. This function can also be written as $\Delta Y/Y=\alpha*\Delta K/K+(1-\alpha)*\Delta L/L+TFP$, where TFP represents the total factor productivity and L, K and Y stand for the same meanings as stated above. In this model, production is explained by increasing capital and labor, as technology is exogenous factor (Solow, 1957). While the Solow-model has been widely used when understanding growth and economy as a whole, it has not been able to forecast the changes in the variables in greater detail (Mankiw et al., 1992). As a result of this, the residual in this model, which accounts for the technological change, has later held greater power than labor or capital factors. Given this restriction, endogenous theories have been able to provide more understanding, as they highlight the aspect of human capital as an integral factor.

2.2 Economic Growth and International Trade

As previously mentioned, there are many theories that highlight the importance of international trade for economic growth. The contemporary trade theories often refer to Adam Smith's framework that suggests that countries should develop products that are comparatively better at than other countries (1776). This can be seen in Ricardo's theory as well as in Heckscher and Ohlin's framework, which note that specialisation in the production of goods is influenced by production factors that are available in a location (Heckscher, 1919). Later Ricardo elaborated Smith's ideas on comparative advantage to achieve efficient production methods, which give justification to why countries trade in the first place (Ricardo, 1817). Another famous theory on international trade is developed by Eli Heckscher (1919) and later Bertil Ohlin (1933), which is often referred to the Heckscher-Ohlin or the model on Factor Endowment. This Heckscher-Ohlin (O-H) goes into greater detail as it elaborates the Ricardian model on why certain countries have comparative advantages for certain goods. This theory suggests that specialisation takes place in the area where production factors are abundant and hitherto, a country with abundant stock of human capital will most likely specialise in the production that require knowledge. Because of this, areas that have a great amount of highly educated people and workers specialise in production, which usually requires a abundant knowledge capital (Andersson & Johansson, 1984). However, Hecksher-Ohlin model assumes that trade in goods is a substitute to migration of factors (Marrewijk, 2002) and that consumer preferences are identical in all countries as well as there are no imperfections in market factors (Hecksher, 1919 & Ohlin 1933). Given this strict model, it must be noted that there are other factors that have been pointed out, which can explain international trade or the export performance of a country. For instance, these factors are inputs in research and development as well as technological changes such as innovations (Andersson & Johansson, 1984). However, there are trade models, which consider determinants such as R&D and labour, when looking at comparative advantage. For instance, Grossman and Helpman have formalised a model in which they identify dynamic equilibrium of the world economy and estimate structural factors for the long-run growth. In their results, they found that labour force and productivity drive long-run growth (Grossman & Helpman, 1990). Nevertheless, it has been stated that import nodes can stimulate innovation and product development within a country. This pattern contributes to intra-industry trade, which means that the imported and exported products of a country are from the same branch

(Johansson, 1993). An example of this would be high- technological products in Finland, around which intra-industrial trade has occurred.

Given this intra-industry trade, international trade is said to spark innovation and willingness to invest in knowledge (Krugman, 1994). When there are investments in knowledge, it can lead to innovations and new production methods, which can ultimately lead to monopoly before this knowledge becomes public (Schumpeter, 1961 & Krugman, 1994). As can be seen, knowledge is often pointed out as an essential factor in driving economic growth, fostering innovation and even boosting exports. This importance of knowledge and moreover, skilled labour force is highlighted, for example, in Barro and Lee's theory, which point out that high level of education, specifically university education, is integral when adapting new methods and techniques dealing with technology (2000). Because of this, knowledge becomes even more integral regarding technology.

As previously discussed, human capital and economic growth are connected, although different thoughts are proposed about this relationship. Specifically, the role of education in economic growth is widely debated and researched field. Given the research and many longitudinal studies, one might propose that there is a relation between these two. For instance, the relation has been examined by two well-known empirical studies, which have sparked conversation in the research frontier. According to Aghion and Howitt, endogenous growth theory can be applied in two different ways (1998). Firstly, the approach suggested by Lucas follows the accumulation of human capital and the growth rates of different countries to estimate this relation (1988). Another approach proposed by Nelson and Phelps suggest that human capital should be considered as a new factor that is part of the growth function (1966). With this approach, Nelson and Phelps find that human capital is an indicator of how countries are able to innovate and "catch-up" with other countries (1966). As already mentioned, modeling this relation seems anything but straightforward, which has contributed to the complexity of this issue. Another problem estimating the linkage between these two has been the lack of data (Krueger & Lindalh, 1999). Krueger and Lindalh were able to analyse problematic data in order to conclude that education has indeed a positive impact on economic growth. On the contrary, Benhabibi and Spiegel find that education does not bring any added value to growth but they still identify the importance of human capital in increasing production efficiency (1994). This reasoning goes back to

the idea of technology products and explaining their exporting. Interestingly, Barro and Lee also find correlation between education and growth; however, they only find significant results between men's education and growth (1997). As illustrated, modelling this relation is challenging, which illustrate somewhat contradictory results of pinpointing a connection between education and economic growth. To conclude, as Krueger and Lindalh emphasise, the many problems with data and modelling have resulted in ambiguous conclusions. With that, there is no single approach to model this relation based on the theories (1999).

2.3 Interrelations between Technology, Economic Growth and Labour Market

Technological diffusion is experienced in many developed countries. These technological advancements have impacts on trading and moreover, exporting patterns of a country. As mentioned Schultz has been one of the pioneers in identifying the relationship between human capital, technology and growth. Along with Schultz's famous theories shedding light on human capital, in the same decade of the 1960s, Vernon released his theory on Product Cycle Theory (PLC), which attempts to explain human capital by looking at phases a new product undergoes (Vernon, 1966). With this theory, Vernon also discusses how human capital contributes to new products, which ultimately create an export advantage on a country level or a smaller scale such as regions (Vernon, 1966). Along with Vernon's framework, Green and Lutz also emphasise how new innovative products usually appear in economically advanced countries that also have abundant technological resources and access to R & D (1983). As these theories highlight that there are interconnections between human capital (in particular skilled labour force), technology and economic growth, it is a commonly accepted view that technology is essential for long-term economic growth. Technology has carried an even more essential role in growth in the modern times. For example, growth through technology can be seen among the Asian countries such as South Korea and Taiwan, as much emphasis is put on education and technology when upgrading the economy (Schön, 2009). While there is clear evidence of growth led by technology and education, the extent of its causality can be debated. All in all, economists have reached consensus that information technology has influenced productivity in the past decades and technological solutions have evolved into "General Purpose Technology", which can improve productivity and influence labour market and its demands (Rhode & Tonniolo, 2006). In addition to the trading, technology has shaped the labour market on the macroeconomic scale by restructuring resources and new ways of allocating

resources (Krugman, 1994). Because of this, new jobs are created, as the economy seeks efficiency when it comes to the resources. This basic economic structure is changing all the time, as demand for goods and services alters, innovation takes place and business cycles occur (Piekkola, 2011). This restructuring of the economy takes place at all levels: from firm-level to an individual employer working at a factory. This restructuring is also known as Schumpeterian "creative destruction" (Schumpeter, 1961).

It is evident that the changes in technology towards knowledge-based companies have carried contributions to the labour market as a whole. Throughout the twentieth century shifts in labour demand have favoured more skilled and educated workers (Goldin & Katz, 1999). To be more specific, demand has changed towards skill-biased jobs. There is a trend in the OECD- countries in the past decades that their share of skilled workers has, on the whole, highly increased (OECD, 2007). In addition, they have experienced structural change in both the supply and demand for skills. While it may seem straightforward that there are more educated workers on the labour market, it is pointed out that there is a mismatch between the skills of the workers and the skills required for employment on the firm-level (Pekkala et al. 2005). Dolado et al. state that new kind of "job competition" has taken place, where there are many overeducated people and crowding out has been relevant (2000). Along with this, there are many studies that examine the mismatch on the job market. For example, Katz finds that there are country specific patterns that have influenced the growth of the supply of skills after the 1980s (1994). Given this, there are many opinions and conflicting data on how skills are placed on the job market. Nonetheless, it has been said that high-skilled workers (people with university degree) are more desirable for the jobs that require high input of skills and yet they can also be working in jobs that require low-skill.

While it is easy to identify human capital by looking purely at the university degrees on a country level, there is no straightforward way of measuring human capital stock. To add complexity to this subject, there is also a shortage of data when it comes to stocks of human capital, as it has never been included inside the boundary of the System of National Accounts (SNA93, 1993). However, there are many ways such as looking at schooling years, enrolment ratio or literacy rate to tackle the measurement problem. One of the attempts has been looking at the longitudinal time series by educational level of various countries (Bosworth et al., 2003). Another approach could be considering the

school enrolment ratios. For example, Jonas Ljungberg and Anders Nilsson have analysed school enrolment ratios to calculate the stock for human capital for Sweden in 1870-2000 (2005). With this framework, they have captured human capital by number of people enrolled in education in cohorts of population during this period (Ljungberg & Nilsson, 2005). In addition to this, Ljungberg and Nilsson find co-integration relation with GDP per capita and this human capital stock (2005). Given this, their research gives validation to the linkages of the stock of human capital and economic growth that is measured by GDP.

2.4 Export Growth

Many theories on economic growth highlight that exports are an integral factor in enhancing growth. Particularly, term export-led growth also known as ELG is approached by the neoclassical economists, as they have usually pointed out East Asian Tigers and their successful export policies leading to great growth rates (Krueger, 1990 & Feder, 1983). As many theories acknowledge the role of exports contributing to stable economic growth, Paul M. Romer suggests that stock of human capital links to exports and the speed of growth (1990). For instance, he states that in the period of liberalising trade, human capital is the best way to measure the rate of growth, which is driven by technological change (Romer, 1990). Along with this, Ambler, Cardia and Farazli have identified the importance of export performance for a small open economy (1996). Interestingly, their theory pinpoints that human capital and favourable policies regarding education have a bigger impact on small economies (Ambler et al., 1996). This relates to the case of Finland, as it is a small knowledge-driven open economy. While export performance has been identified as integral for growth, endogenous growth theories highlight import nodes, as they influence export success and trends within economy (Johansson, 1993). Given this, import nodes can change the growth pattern of a country by sparking innovation and learning-by-doing through trading with others (Ollila, 2005). Because of this very fact that import can stimulate new development processes, exports and imports are intertwined, which is relevant considering the case of the Finnish ICT intra-trade.

The main hypothesis for the export-led growth is that export is one of the main factors for economic growth. It is assumed that when an economy operates in free markets, exporting is seen as a positive outcome for the economy when for instance looking at allocating resources as well as influencing labour force positively (Ollila, 2005). Given

this, exporting success can lead to development in production methods, as Ramos has identified that exporting and production have a strong correlation (Ramos, 2001). In addition to this, with the help of exporting, jobs are created on the market (Ramos, 2001). According to this framework, it can be assumed that export performance leads to greater growth rates for a country.

3. Case of Finland and Structural Change

This section focuses on the case of Finland from 1990s onwards, giving an overview of the radical changes in economic structure, historical background and the importance of human capital in high technology and export.

3.1 Structural Change through Innovation and Technology

Before looking at the interrelations of human capital and Finnish export performance, one must take into account the economic development of Finland during the nineteenth and twentieth centuries. First and foremost, Finnish economy was no exception when it comes to the structural change that happened from the 1980s onwards. However, Finland encountered these radical changes in the economy later than, for example, Sweden did (Weinberger, 1997). One hundred years ago Finland was a poor agrarian country with a gross domestic product per capita less than a half of that of the United Kingdom (World Bank, 2010). Until 1980, the industrial sector in Finland was only focused on few sectors. However, from the 1980s onwards knowledge-intensive sectors developed faster than in any OECD-country (Foreign Ministry of Trade, 2010). This radical change in the economy has also been known as the "Finland Phenomenon" to illustrate the major steps that the country took. In the 1980s, technology and the research within electronics and other sectors became important aspects in development strategy, as Tekes (Finnish Institute for Technology Research) was established in 1983 (Lemola, 2001). Tekes represents one of the symbols that strengthened and sparked the role of technology in the Finnish economy later on. In addition to Tekes, Finland for the first time as an independent country saw an opportunity to cooperate with the rest of the Western Europe. An example of this was joining EUREKA, which gave favourable circumstances to cooperate with the rest of Europe. However, not until the 1990s was Finland fully able to enjoy the fruits of technology, which were already rooted in the 1980s structural changes. A prime example of this is that the 1990s Finland is often characterised by the rise of National Innovation System as well as being the golden decade of technology (Lemola, 2001). Given this, technology, its diffusion and commercialisation were looked at through the lenses of innovation. In this decade, especially information and telecom industries within technology sector became one of the main exporters and at the same time the Finnish export arena became diversified and internationalised (Lemola, 2001). While Finland demonstrated great growth rates till the

year of 1990, Finland was faced with a surprisingly deep recession in the 1990s. Before the collapse of Soviet Union, Finland was influenced greatly, as USSR held a tight rope around Finland (Tainio et al, 1999). Because of this, Finnish trading and exporting was heavily influenced by Soviet Union. While Finland was never part of the USSR the relationship with the eastern neighbour was important, which can be seen in the Finnish export value that declined in Russia in the year 1990. The bilateral trade had a great effect on the Finnish economy by contributing 7 percentage points of total GDP before the collapse whereas in 1990 it was only 3 percentage points of GDP (Statistics Finland, 2010).

As already mentioned before, Finnish economy faced a great depression in the 1990s, which was said to be caused by the collapse of Soviet Union and due to a severe bank crisis (Pelkonen, 2004). In the end of 1980s, Finnish GDP experienced growth rates of approximately 5 per cent annually till the recession that started in 1990 (Pelkonen, 2004). While other factors such as fiscal policy influenced the recession, external factors such as the collapse of Soviet Union contributed to its roots. In the case of Sweden, it has been pointed out that external factors can promote structural changes and affect the industrialisation of the economy (Schön, 1997). While there are always world market influences, according to Lennart Schön, they can also influence the distribution of income and wages (1997). In this structural cycle, rationalisation phase takes place, where the share of wages peaks, as this is affected by increasing competition and falling prices. In the end, these culminate into a structural crisis, where old industries are vanishing and new capital and labour reallocate to new sectors, which are able to pay higher wages (Ljungberg, 1997). While in this thesis wages are not going to be analysed in more detail, with the help of wages, market dynamics can be understood better. For example, as Jonas Ljungberg states that "rising wages were important for the growth of the domestic market that formed a basis of growing consumption industries. Without these structural changes Sweden would have stuck to her stagnating export industries, and stayed dependent on low wages, thus remaining at the periphery of industrial Europe" (Ljungberg, 1996, p.266-267). Given this reasoning, wages may be seen as contributors to the export-led growth. While Schön and Ljungberg discuss the case of Sweden, one can draw a parallel to Finland, as these two countries have a similar economic structure. In the case of Finland, wages have increased since 1990s and especially wages among engineers have increased since the 1990s (Statistics Finland, 2007).

The overall trend among the Nordic countries of Europe is that they were fully able to take advantage of this wave of IT and globalisation that took off in the1990s. These new conditions for growth are most significantly seen in countries in the North-western Europe (Lorenz & Valeyre, 2006). These factors can also be seen as integral in the case of Finland when looking at the 1990s. As discussed earlier, it is argued in Finland that this downturn is argued that it had sparked innovation in later years (Saarinen, 2009). While many have pointed out the positive outcomes such as establishing the Finnish Innovation System after the downturn, the recession caused also permanent impacts on the economy. As a result of this deep downturn, unemployment rose remarkably fast from being one of the lowest ones in the whole of Europe (Statistics Finland, 2011). This transition from almost full employment to high unemployment is a unique phenomenon among the OECD countries (Kantola, 2002). Besides the high unemployment, Finland survived the recession as quickly as it had been sucked into it (Lemola, 2001). This was mainly due to a high increase in exporting (Pyykkö & Blunders, 2005). While paper, chemical and metal exports increased in the beginning, Finnish exports soon shifted towards high technology (Pyykkö & Bunders, 2005). Furthermore, Finland experienced radical changes and many innovations came about in the 1990s, which influenced both the export branch as well as the labour structure of the Finnish economy. These innovations that later influenced the export sphere were the results of Finnish National Innovation System, which was able to create systematic policies enforcing technology (Saarinen, 2009). Funding that was allocated from the government towards innovation and R & D contributed to the increasing innovation levels as well as growing productivity (Saarinen, 2009). For instance, one of the milestones, recognised by many scholars, is the breakthrough of GSM-technology as well as the rise of new ICT technology in the mid 1990s, which later on became even more important to the Finnish society as a whole. As demonstrated, a policy response to the economic downturn in the early 1990s to invest in innovation in order to reach long-term growth can be seen as fruitful. The outcome of this was enforced in the early 2000s, as the ICT cluster had reached the position of the largest industrial cluster in the country by holding increasing shares of exports (Pelkonen, 2004). Because of this change from forest and metal industries to technology driven-products, export sphere of Finland changed radically with regards to the surplus value of high technology trade (ETLA, 2010). While it is clear that radical changes have taken place towards

knowledge intensive economy since the Finnish recession, high unemployment remains present still till today (Statistics Finland, 2011).

Fundamental changes have happened from 1980s onwards in Finland, which have transformed the economy: a recession occurred in the early 1990s, however, innovation continued through this downturn. Consequently, these have also brought challenges to Finland. As Finland has previously focused on purely innovating through technology, strategies that deal with understanding the markets and their demand better are enforced today (Saarinen, 2009). One of the aspects on innovation that needs to be acknowledged is the diffusion of innovation, which fosters the competition on markets (Schön, 2009). This diffusion leads to standardisation of the products and widening of the markets (Schön, 2009), which influence export flows and give other economies possibilities to enter the market. Given this reasoning from transformation to standardisation of technology, these forces have implications for the export markets in Finland. A prominent example of this would be the case of GSM technology and its early standardisation (Pelkonen, 2004). Hitherto, it can be argued that innovation and in particular the diffusion of innovation not only influence growth rates but also export flows and profits.

In addition to the changing market dynamics, another obstacle could be the European integration and the monetary union. Since the introduction of the Euro, the Finnish trading has been influenced. Firstly, it must be noted that Finland's allocation of export is mainly to non-euro countries. These countries such as Sweden and Russia are not part of the Euro-zone, however, exporting to Euro-countries has increased since the introduction of Euro (IMF, 2009). Moreover, European integration has also influenced governmental structure and liberalising trading (Jussila et al., 2009). While there have been positive implications from Euro, it has also brought challenges to trading and labour markets in Finland. Future challenges such as Euro crisis, recession and globalization of the economy will provide obstacles as well as new growth opportunities for Finland. These factors may have implications for the export arena and may ultimately influence job creation or the labour dynamics in general.

3.2 Example of One Enterprise—on the footprints of Nokia

As discussed, the most interesting in the modern Finnish trading history is the rapid transformation to knowledge-driven industries. An example of an enterprise that must

be pointed out in the Finnish case is Nokia, as it has been a driving force behind the skyrocketed economic growth in the 1990s (Pelkonen, 2004). While Nokia does not serve as an only example of boosting growth, it was a front-runner in fostering specialised knowledge-based industries. Nokia is also a prime example of enterprises that were influenced by rapid industrial restructuring in the 1990s (Steinbock, 2003). Some have even claimed that it is hard to identify another case in the post-war period that a single branch or an enterprise had influenced a country's economy as strongly as Nokia has. To demonstrate Nokia's role in the Finnish export arena, in the end of 1990s, it represented a fifth of Finnish total exports, as the same time its stock worth was about 300 $ billion (a more than any other enterprise in Europe) (Pelkonen, 2004). Because of Nokia's success story, it has held a great importance and it has also been very influential in Finnish society.

While it is clear that Nokia has affected on Finnish trading to a great extend, it has also strengthened the Finnish National Innovation System by starting the cooperation within universities, local businesses as well as with public sector (Ali-Yrkkö & Hermans, 2002). When the demand for skilled labour force increased in the 1990s, Nokia's role in education and its politics assumed a more important role. For instance, Nokia attempted to influence increasing starting places in universities, especially in electronics, ICT and other engineering faculties (Ali-Yrkkö & Hermans, 2002). In the 1990s the amount of university students increased by 2,5 % annually as the Finnish government decided to increase the places for the universities (Statistics Finland, 2007). Especially, technical universities in Helsinki and Tampere increased their intakes, as it was forecasted that the demand for skilled labour would increase (Ali-Yrkkö & Hermans, 2002). In addition to this, Nokia has also been influential when driving for Nordic cooperation within the telemarketing technology, which ultimately led to the region becoming one of the first multinational cellular networks in the world; after this, Nokia was able to expand to European level (Steinbock, 2003). Behind these successful products, Finnish government contributed to the success of Nokia, as policies changed toward market-driven, innovation focused and more decentralised economy. All in all, given these elements together, Nokia was able to succeed as well as maintain its competitive advantage in the 1990s. This "Nokia phenomenon" demonstrates hands on example of the rise of the Finnish ICT and re-structuring of the economy. It needs to be acknowledged that Nokia does not only contribute to the mobile communication sector in Finland but it has also helped enforced a cluster around the mobile communication

sector. As a prime example of this would be 3 000 other subcontractors and other enterprises developed around the success of Nokia (Pelkonen, 2004). As a result of this, Nokia and the whole ICT cluster have created many jobs and especially influenced the high skilled labour force markets in Finland (Pelkonen, 2004). While there are many positive implications that have arisen from the success of Nokia, a criticism on Nokia's influence on the welfare state have gained prominence in recent years. Because Nokia has been dominant and very influential in Finnish society, it has also affected Finnish politics by having an effect on the state by considering corporate taxing. Another example of the changes this radical ICT boom has caused would be the availability of services that require access to Internet and hence, it has brought new tensions and tendencies towards new exclusions (Pelkonen, 2004). In addition, this ICT boom has also carried effects in the regional development of the country, as the regional polarisation between the capital region and the peripheral regions has increased (Hanell et al., 2002). Until today, the debate on the ICT politics and its implications can be seen greatly discussed in the public arena.

Nokia's story cannot only be depicted as a rosy success tale, as from 2006s onwards its market value has dropped dramatically. It can be argued that the global competitors have performed better, when the standardisation and mass production of mobile phones (and other ICT-related products) have taken place (Maliranta et al., 2011). When technologies become standardised, they can diminish the value of enterprise specific knowledge and of skills (Schön, 2009). This can be seen in the case of Nokia as well. As a result of this, decreasing prices of standardised ICT products has influenced Nokia's production as well as exporting negatively, which have carried overall consequences to a small economy (Maliranta et al., 2011). Because the Finnish ICT-cluster is developed around the biggest player, Nokia, the whole ICT cluster has suffered from Nokia's downturn. It is premature to forecast what will happen in the future and whether Nokia will achieve profits on a global scale. Nonetheless, it is highly unlikely that Nokia will gain a leading position on the world market given the other players in the market.

3.3 Knowledge as a Driving Force?

Before World War II, the average educational level of the Finnish people was quite low (Statistics Finland, 2011). Since that time, the expenditure on education per year has

increased significantly (Böckerman, 2000). It needs to be remembered that nearly all education is provided by the public sector and therefore, Finnish government funds it. Today, Finland is considered an exemplary country of education: in the global PISA-tests, Finland consistently scores in the top countries (Pekkala et al., 2005). One of the ways of looking at the increased educational level of the population would be examining the funding of education in Finland. This way, however, can be problematic, since there have been many structural changes in the educational system in Finland between 1975 and 2005 (Pekkala et al., 2005). While the expenditures for education have increased in the past decades, during the recession in the early 1990s, expenditures were cut in order to tackle the downturn of the economy (OECD, 2007). All in all, when Finland is compared to international standards, it ranks in the mid-cast on educational expenditures (OECD, 2007). In other words, for a long time it has accounted for 6 percentage of GDP (OECD, 2007). Simply because of these facts, one might assume that there is an accumulation of knowledge and skills, which had contributed to the radical changes and development of Finnish economy. The graph below demonstrates how education has changed over time in Finland. As can be seen, the share of tertiary degrees obtained has increased subsequently.

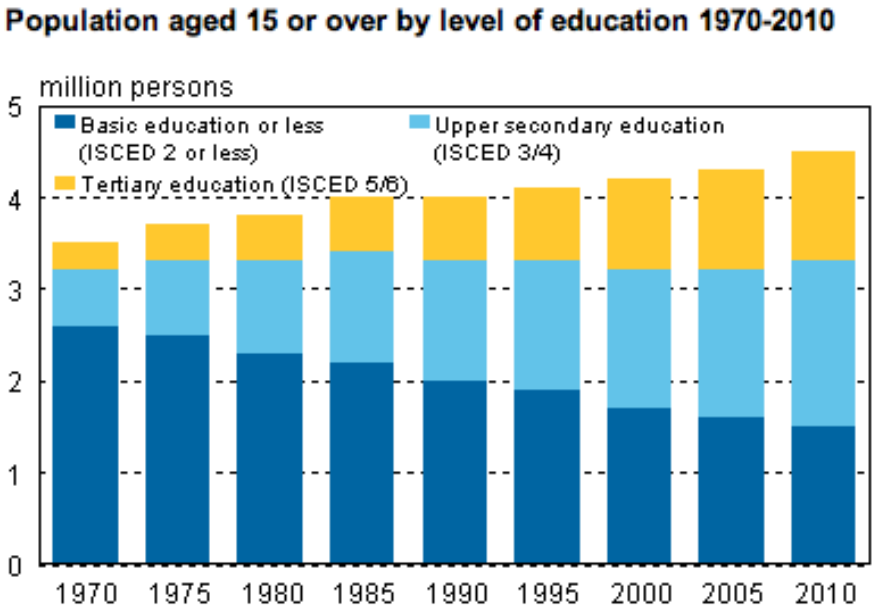


Figure 1. Population and education (Statistics Finland, 2011)

Given this overview, many historical events and changes in the economic structure have occurred, which have echoed to the labour force as well as its skill density. In the 1980s, liberalisation of trade started influencing the Finnish investment and capital markets. From the 1980s onwards, Finland's labour structure has changed and, in particular, the demand for skilled labour increased (Lindmark & Vikström, 2003). The recession in the early 1990s influenced structural change within the labour force. For instance, jobs disappeared within heavy industries and manufacturing branches as technically-profiled jobs as well as jobs within health care and medicine rose in the period of 1990 to 2000 (Piekkola, 2011). After the recession in the early 1990s, job creation rate for the highly skilled workers magnified (Böckerman, 2000). On the contrary, the job creation rate for the least qualified workers or labour force with no education after high school remained very low in 1991 to 1993 (Böckerman, 2000). Based on these statistics, it can be seen that job creation rate favoured the highly skilled workers compared to the situation before the recession. To put it differently, job creation and the loss of jobs for less skilled workers show that structural change of the economy and labour markets were present in the 1990s, as it continues till today. In addition to these changes in labour dynamics, recession boosted growth in production levels with a time lag, as many inefficient production methods disappeared. These changes as well as the growth in productivity go back to the previously mentioned Schumpeterian "creative destruction".

While changes in the economy have influenced labour dynamics and job flows, science and technology politics have held a place in contributing to the aspect of human capital and labour market by intervention. The policy re-enforcing the role of science and technology in the Finnish economy has pushed education towards technology-biased schooling. While there has been shift towards certain industries, which require knowledge, the demand for skilled labour force has increased in the past decades. Because of this, changes on the geographical scale have taken place, as many of the jobs are found in the bigger cities (or mostly in the capital region) (Levine, 1996 & Ritsilä, 2000). While migration on the national borders has been persistent, migration of educated people also foreshadows the international scale (Adams Jr., 2003). This notion of brain drain can be justified in the name of maximising the economic benefits (Sjaastad, 1962). On the other hand, there is skilled labour force coming to Finland, who is contributing to the Finnish economy with adding knowledge.

As illustrated, labour markets are always changing and never on "sleep mode", as structural change occurs at all periods in time. In the Finnish case, knowledge has often been highlighted as one of the driving forces and as a national asset. Overall, the amount of people with a higher degree (university or polytechnic) has increased over 20 % over from the period of 1975 to 2004 (Statistics Finland, 2011). However, it has not been really studied in greater detail on how these educated people are placed in the labour market within the technology sectors. All in all, Finland is generally known to be abundant in human capital and having a relatively skilled labour force. Nevertheless, the amount of skilled workers in different sectors can differ greatly (Statistics Finland, 2011). Interestingly, Finland is ranked one of the lowest in the whole of Europe when it comes to employing young people with scientific degree (OECD, 2010). Often it has been pointed out that the universities and private sector should be collaborating more in order to meet the demand of skilled labour and secure international competitiveness.

It can also be seen that since the rise of the ICT sector in Finland, the inequalities have risen (Pelkonen, 2004). A proof of this is the report by European Commission that shows that regional differences have increased even in Finland (2010). Differences in the many regions of Finland can vary as well, when it comes to skilled labour and mobility. Obviously, age and other factors affect the distribution of human capital (Karhunen, 2008). However, skilled labour force is more present in areas where universities and applied science colleges are located. These institutions are found in the capital-region, southern and western parts of Finland (Karhunen, 2008). In addition, many high-technology firms as well as ICT-clusters of Finland are found in these regions. This notion of centralisation of knowledge is caused by urbanisation, which can lead to inequalities of human capital between the different regions (Fujita & Thisse 2002). On the contrary, it can also foster regional growth in the long run (Fujita & Thisse 2002). Human capital in Finland is not distributed evenly among the regions in Finland. However, this notion is typical for a country such as Finland that is geographically quite big on European scale as well as being sparsely populated. In addition to spatial differences, human capital is not evenly allocated among age groups and genders, which will have an effect on the labour force as well (Karhunen, 2008).

As discussed, one way of measuring human capital is looking at the educational density. However, human capital is not the only factor behind the Finnish economic growth, as it

is to be noted that Finland was one of the catching up countries and thus, increases in growth rates can seem more radical. Influences that may contribute to the growth rates from 1980s onwards could be the opening of the Finnish economy in 1967 and benefiting from the latecomer positing in industrialisation (Hjerppe, 1989 and Pekkarinen & Vartia, 1993).

3.4 Linkage Between Human Capital and Exporting

The report on European innovation level and competitiveness forecast illustrate how innovation is closely connected to competitiveness (European Commission, 2010). Furthermore, this report pinpoints the importance of research & development and skilled labour force to foster country's competitiveness. With that, the Finnish government's mission in the past years has been to emphasise the role of high technology and innovation in order to boost competitiveness. When it comes to the research and development statistics, Finland ranks one of the top countries in the Europe (European Commission, 2010). However, when examining the amount of patents in Finland, it does not rank as high, as it would be expected by its high innovation and R & D scores (European Commission, 2010). While statistics do not reveal the whole picture of the economy and its condition, in the case of Finland these facts demonstrate that innovation and technology are emphasised. This importance in innovation and technology can also be seen in government's aims to enforce competitiveness, sustain long-term economic growth as well as strengthen welfare state. As a result of these, export has always been essential for both sustaining economic growth and creating jobs in Finland.

While today the export and human capital can perhaps be more closely intertwined, the structural change from the 1980s has strengthened this relation in Finland. Naturally, the changes in industrial sphere toward knowledge-driven has also pushed the demand for higher skilled labour. In the case of Sweden (that can be compared to Finland because of the similar economic structure), it can be seen that the accessibility of skilled workers is a prerequisite for development (Johansson & Karlsson, 1990). The trend in Nordic countries has usually been product competition, as price competition has never really existed (Johansson & Karlsson, 1990). Because of these product driven markets, R & D and skilled labour force are essential. In addition to the challenges dealing with market competition, skilled labour force and the future for attracting skilled workers in Finland can be seen problematic. Although higher education is a national asset in

Finland, a closer connection between the universities and industries should be highlighted to enhance technological growth. On the other hand, high taxing and northern location often work for Finland's disadvantage when attracting skilled labour force (Fagerberg et al., 2005). Unfortunately, these factors can negatively influence the Finnish trading regarding global investors or skilled labour force. As illustrated, knowledge can be seen as a common nominator.

4. Skilled Labour Force Determining Export Success in Finland

This chapter is dedicated analysing the human capital and its impact on export performance in the Finnish case. This part aims to explain the role of skilled labour in export success within the technology branch. It is assumed by the economic theory that an increase in human capital contributes to growth of exports, or vice versa. This very fact and its direction of causality will be analysed by analysing the long-run as well as the short-run perspectives. It is expected that human capital that is skilled labour drives the export.

It must be noted that there are various factors contributing to the increased export value and affecting skilled labour in the case of Finland. Since these different factors cannot always be estimated, the results should be evaluated carefully. In this data, it can be seen that a country can educate a great deal of people and yet having a high academic unemployment (Statistics Finland, 2011). In addition to this, Statistics Finland reveals that there is an increasing amount of students who are employed before they have graduated with a degree (Statistics Finland, 2011). Because of this notion, there can be many more workers who are almost done with their degree, however because of the limitations of the dataset these workers are not considered. As a result of this, it can be assumed that there is more skilled labour within technology branch than this dataset can capture. In addition to measuring skill within labour market, skill can also be obtained from other sources than universities. For example, working experience and other courses such as those provided by the employer can increase the level of skill. These ways of improving the level of skill are hard to measure and gather data on. It must be mentioned that many Finns have completed the mandatory schooling, however, skills that are required in high technology or related fields can usually be obtained only from colleges. Consequently, skilled labour is measured by the post high school diplomas and therefore only individuals with a university degree will be considered as skilled in this analysis.

Given this brief summary, the analysis will be performed from the theoretical standpoint. In other words, it will be examined whether the increased level of education has contributed to the skill level of the labour force. Furthermore, it will be analysed whether this stock of human capital is connected to the export success in the case of Finland.

4.1 Data

The first source of the data is the Longitudinal Census of Statistics Finland. This longitudinal data includes data on people who are employed in the private sector in Finland. The data is collected on questionnaires from enterprises and universities research and development units. In addition, the data is being updated annually and released approximately 10 months from the end of the statistical reference year.

This data set includes a great deal of information on personnel working in various industries and their personal characteristics. For this data analysis, the only sectors used are sectors within high technology, which are biotechnology, electrical engineering, robotics, telecommunications, aerospace and nanotechnology. The personnel data includes individual's education level and years worked in research and development. The education levels include: doctorate, licensiate, research educated people, master's and bachelor's degrees, polytechnic degrees and people with no education after the mandatory schooling. In short, the schooling system of Finland, similar to other Nordic countries, covers comprehensive schooling till the age of 16, which is followed by high school and vocational institutions (Statistics Finland, 2011). After this basic education, many people choose to continue to universities, polytechnics or applied science universities from where one can obtain bachelor, master, licentiate or doctor's degrees. The educational paths in Finland are explained in Appendix in more detail.

In this analysis, human capital is measured by individuals who have obtained tertiary degrees. This kind of reasoning is one of the most typical ways to measure human capital within a country (Barro & Lee, 2000). While human capital can be calculated in different ways, this analysis focuses on expressing human capital as a number of educated employees working in different technology sectors. It is assumed that the positive impact of education does not exist until this human capital or knowledge is used in practice and thus, it contributes to the export performance. It must be noted that this variable does not taken into account the years of experience a worker has obtained. In addition to the data on the labour force on private sector in Finland, data is also included on information on technology foreign trade. This data is retrieved from the Statistics of Finland and it includes value added for fixed prices (Euros). Data is complied by both product group and country of export and import and it is being updated annually.

Given this data, an econometric model will be estimated to observe the returns to education and export performance in technology sector in Finland. Firstly, measurements of human capital will be conducted. After these measurements, which demonstrate the changes in the economy that happened from the 1990s onwards, co-integration can be observed. Co-integration will be examined in order to observe which affect which. It must be kept in mind that when looking at the causality other factors such as accessibility to R&D and innovation might of course have an effect on the export performance. However, this thesis focuses on the role of human capital, particularly education, and its impacts on export.

4.2 Measurements of Human Capital and Export

Human capital and particularly skill can be measured in many ways. In the figure below (Figure 2), one can see the amount of university degrees obtained in the whole country as well as the percentage working in industries, holding a tertiary degree. The mandatory education (explained in Appendix) is not considered when accounting for the stock of human capital. It can be observed that more and more people are educated, as this trend can be seen in other OECD-countries as well (The World Bank, 2005). However, the amount of university degrees obtained among the workers from different sectors vary from 30% to 39%, as there cannot be seen any clear trend. Nevertheless, there is noticeable slope during the worldwide financial crisis in 2008.

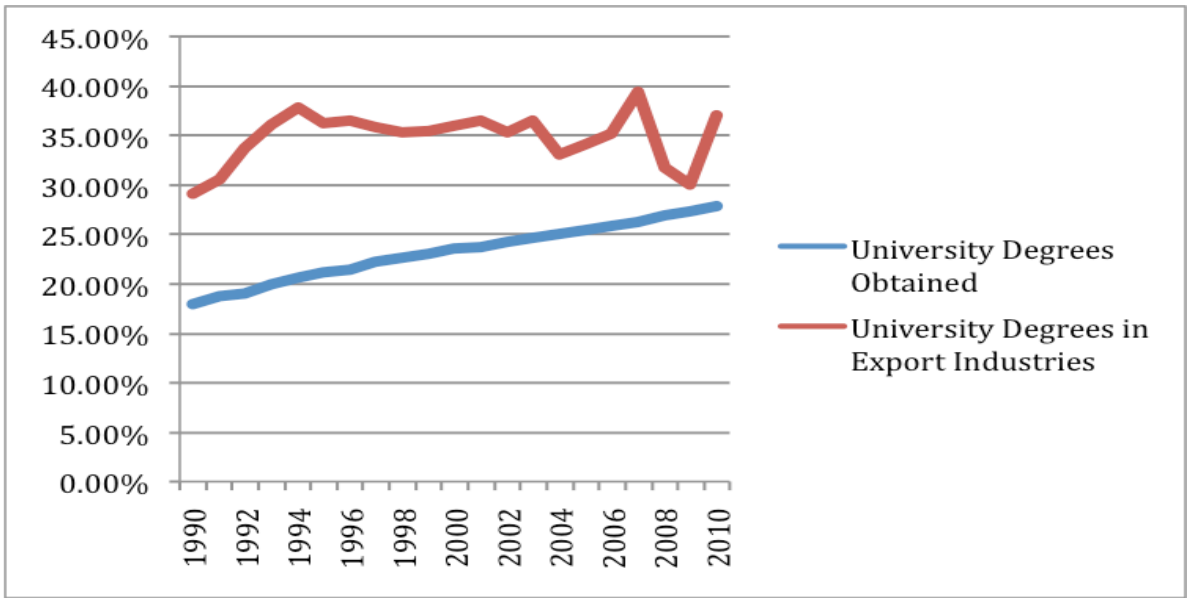


Figure 2. University Degrees obtained overall in Finland and in export industries in percentagewise (Statistics Finland, 2011). *(This graph demonstrates the percentage share of the individuals who hold a tertiary degree in exporting sectors as well as in the whole population)*

As can be seen from figure (2) above there is an overall upward trend among education in general, but different branches will of course have different volatility when it comes down to their skilled labour force. With that, it can be seen that educational capital is not always distributed evenly. A person can be educated and yet not participating in the labour force. It can be expected that people who are working are also able to maintain and possibly increase their level of knowledge through working experience. The human capital here is examined as a number of workers in each industry, as this labour force will be contributing to the trading in Finland, which will be analysed later on. It must be noted that educated people as a percentage working in export industries can be expected not to carry a specific trend, as it includes industries of different kinds and the share of exporting has increased as well. However, it can be observed that still the percentage of human capital is higher among the people working in export industries than among the whole population (percentagewise).

After this figure, one can see significant differences when it comes to the stock of human capital in various sectors. In the figure below (figure 3), one can see that skilled labour force has increased significantly in information and communication branch, as it can be expected. As a comparison, sectors such as agriculture, forestry and fishing and chemical industry were taken into consideration, as these make up for the next biggest

export sectors after information and communication. When looking at these three sectors, it is noticeable that agricultural sectors and chemical industry remain somewhat steady when it comes to their human capital, as information and communication sector has increased subsequently in the period of 1991 to 2010.

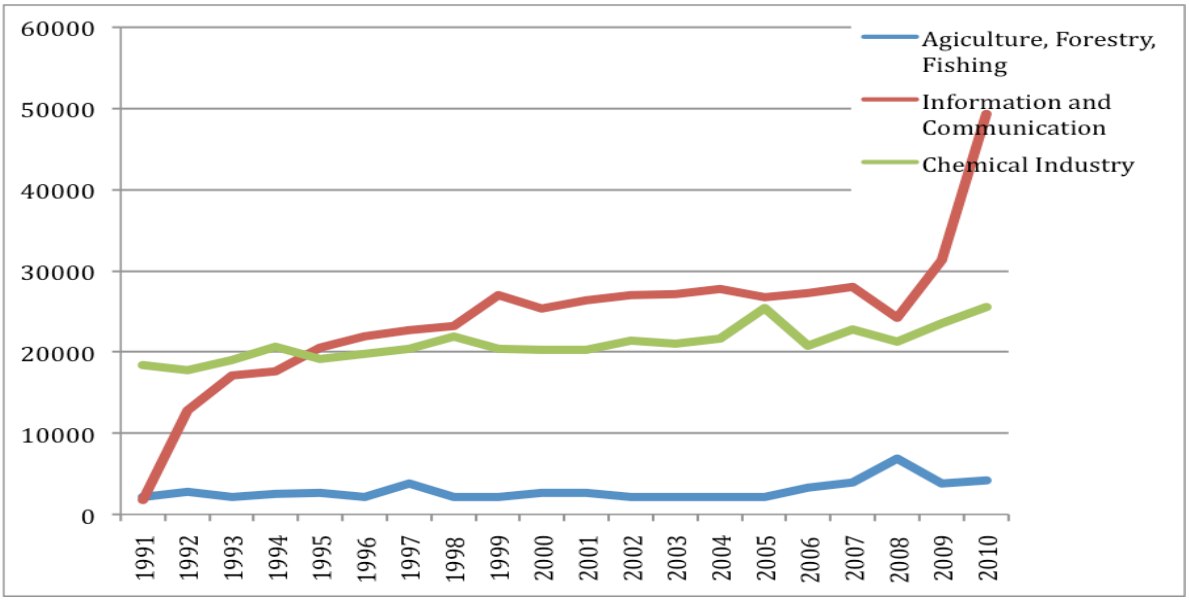


Figure 3. Number of Skilled Labour in three different branches (Statistics Finland, 2011)

As illustrated in Figure 3, there is a clear shift observed when it comes to skilled labour force and its density especially in information and communication sector that is known to be knowledge intensive. Knowing the changes in the Finnish economy towards knowledge-driven industries, this trend is not surprising. Taking into forces such as Nokia, Linux (software) and other technology companies who have also hired a great deal of university graduates, human capital in information and communication has increased since the 1990s. It is also ought to be mentioned that there is a great increase in the 2009 to 2010 when it comes to ICT-sector. This interesting shift after the global recession in 2008 demonstrates that the number of skilled labour has almost doubled after the small dip in 2008.

In addition to measuring skill within the labour force and export sectors, figures below demonstrate the shares of export from the year of 1991 to 2010. In the Figure 4, export and imports of high technology are illustrated over the period of 1991 to 2010 by value-added (in fixed prices) in billion Euros. The value of Finnish exports of high technology

has increased significantly since 1991 by reaching its peak with almost 12 billion euro in 2000. At the same year, high technology exports accounted for about 23 percent of all Finnish exports (Figure 5). From all the high export products the share of electronics and telecommunications was about 80 percent of the share of high technology (Statistics Finland, 2012). Different trends can be seen within the Finnish imports as their share from the total imports decreased over the period, while when measured in billion Euros, the imports have accounted from ca.7 up to ca. 10 billion Euros in total. However, most of the high technology imports increased due to aerospace products, however since the input to this industry is so costly the increase can be mirrored in the import values (National Board of Customs, 2012). Overall, the balance of Finland's foreign trade in the high technology sector has been very much positive. For instance, in 2005 the surplus reached almost 4 billion Euros, as it demonstrated nearly 1 billion growth from 2004. The export-import ratio is steady until 2008 when the financial crisis hit Finland.

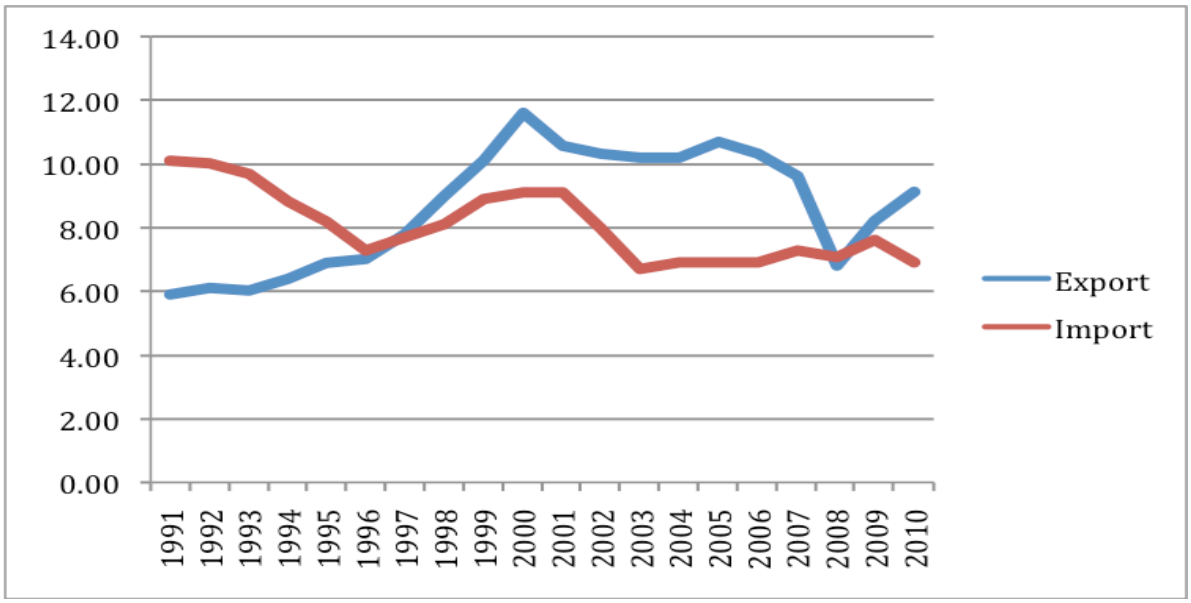


Figure 4. Foreign Trade in High Technology, values of export and import in billion Euros (Statistics Finland, 2011)

In addition to export value in billion Euros, in the Figure 5, one can see in greater detail the shares of high technology export in percentages. Given this, a greater difference can be seen when comparing it to the Figure 4. These shares illustrate that exports within high technology show growth, whereas the share of import has declined. With that, one can see that there is direction of export-led growth within technology in Finland. These

adaptations in import and export nodes (4 and 5) also pinpoint to structural changes in the Finnish economy from 1990s onwards.

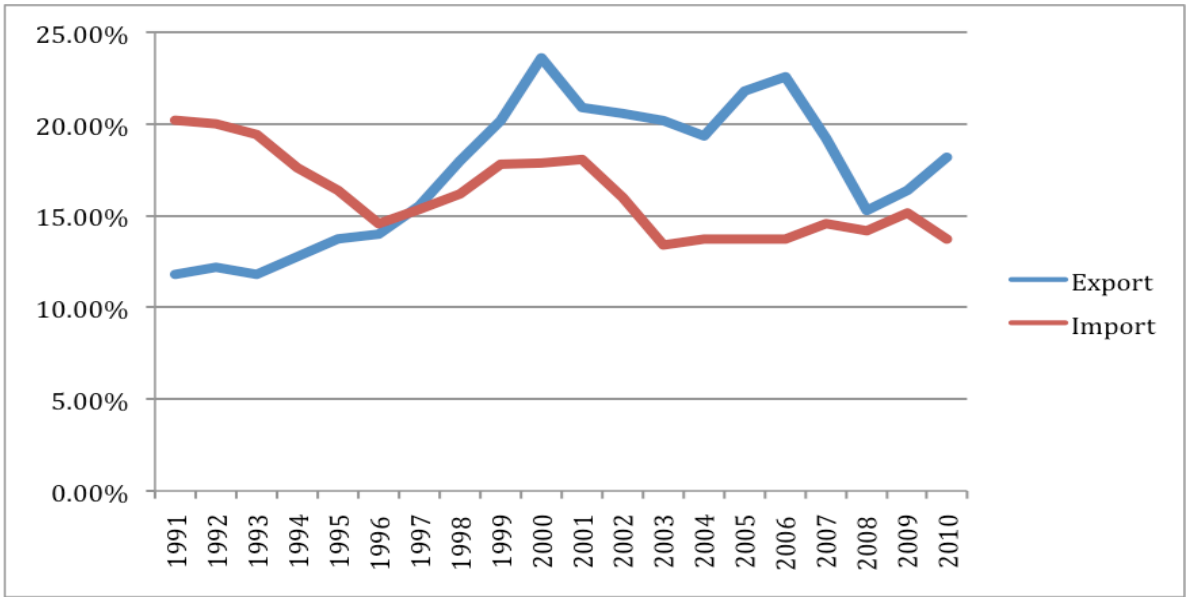


Figure 5. Foreign Trade in High Technology, export and import shares of Finland's total exports and imports (Statistics Finland, 2011)

As demonstrated, the high export arena has increased and is also highlighted one of the keys to maintain Finnish competitiveness. As the focus of the Finnish export arena in the last decades has mainly been on technology, other sectors have suffered, which have influenced the overall export arena. On the world trade scale trading in addition to ICT products, export for chemical products have increased (Pyykkö & Bunders, 2005). In contrast, those produced by using conventional techniques such as paper, wood and metal products have decreased since 1990s. Until the ICT boom in the 1990s, conventional sectors dominated the export arena (Pyykkö & Bunders, 2005). In addition, perhaps the success of Nokia can be seen in these trends for export and the hiring of skilled labour force (Ali-Yrkkö & Hermans, 2002). Nokia's golden years so far were from 1996 to early 2000s, when it reached its status of being the leader in mobile related products (Maliranta et al. 2011). This notion could perhaps be observed in the export value, as it has skyrocket during this period. Along with this, perhaps the on-going globalisation and new market competition can be seen in these figures when it comes to the period from 2006 to 2009. Nokia's weakened role from 2006 onwards could be seen in the decline in the value-added for export due to the standardisation of

ICT-products and falling prices caused by mass production. Interestingly, export value shows growth again in 2010 after recovering from the global financial crisis. When comparing these export trends to the skilled labour force in 21st century, one can see that in 2009 and 2010 there has been a surge for skilled labour. Perhaps this investment in human capital could be seen as a way to tackle the new competitive markets. Given these adaptations, exporting and skilled labour are constantly changing and influenced by external factors as well as structural change.

4.3 Estimating Model

Given the expectations based on the theory and previous research, the causality between the increased level of education and export value is examined. To test these hypotheses, statistical tests will be conducted to analyse possible co-integration relation. First and foremost, while many econometrical tests can be formalised from this time series data, it is integral to conduct tests to observe the data, while keeping in mind the background and structural changes, which took place in Finland. As previously mentioned, some breaks in the data must be taken into account such as the global financial crisis in 2008 and the standardisation of GSM-technology. While the data could be divided into different sub-sets according to years, in this analysis the period from 1991 to 2010 is analysed, as it is already quite short period for time-series estimation. Because of the data restrictions, the time period analysed is includes only years between 1991 and 2010. However, it would have been interesting to examine the structural change since the 1980s in order to capture a longer time period. Within this time frame, export rate in fixed prices and the amount of skilled labour force are first examined by ocular inspection and followed by testing the nature of these series.

Before proceeding looking at the relationship between export value and skilled labour force, it is essential to determine whether the series are stationary or not. First and foremost, these time series seem to be non-stationary, as they do no fluctuate around the mean. This was tested with Augmented Dickey Fuller-test, which examines lags when testing for autocorrelation (Dickey & Fuller, 1981). The null hypothesis is that the data is non-stationary, which will be tested using a standard t-test on critical values. In these tests 0,05 significance level will be used to minimise a type I-error (Hill et al., 2008). In these tests, lag length and existence of constant and trend were considered. However, based on Dickey Fuller test, the results seem to confirm the fact that the data is non-stationary and thus, one cannot reject H_0. (See Appendix for the results).

Since the data was non-stationary with its logarithmic original values, differences of these values were tested with Phillips-Perron test using Newey-West's suggestions in order to see whether the series are stationary in their differences (Newey & West, 1987). With this Phillips-Perron test, it can be concluded that the series are stationary on the first differences and can be used for regression later on (see results Appendix) (1988). In other words, the order of integration is (I)=1.

After these complusry checks of the data series, Granger causality was used to see whether there is any possible of variables that could have a causal relationship. In addition to this, Schwartz information criteria was tested for the possible lag-length of the model. In the Granger causality test, interestingly p-value for the skilled labour-variable is lower, which could suggest that skilled labour force would be driving the export performance. These results seem signifficant, when looking at the p-value for skilled labour (Table 1). It must be noted that Granger-causality test only examines the short-run impacts on the changes of the variables. After this, once again ADF-tests were performed to see whether the residuals are stationary.

Granger Causality Wald tests	**Chi2**	**Df**	**Prob>ch2**
Skilled_Labour	7.8137	4	0.001
Export Value	6.2584	4	0.181

Table 1. Granger Causality Wald test

Finally, these test were followed by co-integration tests (Engle & Granger, 1987), which were performed in order to see whether there is feedback between skilled labour force and export performance. As the series are integrated in order of one, I(1), they can make a linear combination that is I(0) (Engle & Granger, 1987). The cointegration cannot contain I(0) variables. If this is true, it could be concluded that the two variables are co-integrated (Engle & Granger, 1987). To investigate this relationship in greater detail Vector Autoregressive Model is used, which was developed by Johanson (1988) and Juselius and Johanson in 1990. Given this, further examination of long-term impacts is possible when analysing the disequilibrium of the forces, which keep the variables together. This reflects back to the theory that export performance and skilled labour

force are intertwined and therefore, co-integration potentially exists. Because of this, Johansen co-integration was performed with using the lag length suggested by Schwartz criteria (SBIC) that was 1. These results for the lag criteria can be seen in Appendix. The hypothesis here is that there is no co-integration, as the alternative hypothesis is that there is at least one co-integration relationship. Based on the results for Johanson's test, there is in fact co-integration found within skilled labour force and export performance, which was expected by the theoretical standpoint.

After test of co-integration, the VAR-model is conducted in order to examine the relationship and perform a regression on the variables. VAR, also known as Vector Autoregression, was formalised as normal regression would cause statistical inferences and spurious regression. When running this model, the specification of the number of lags is needed. For this, the information criteria for Schwartz was used. After estimating this model, tests on residuals were performed with stability test for the model as well as Lagrange-multiplier test, which checks the correctness of the model. These results confirm that the model is adequate. After estimating these, the main interest was to find out whether there exists a long-run equilibrium between skilled labour force and export value. Assuming that there is a long-run relationship between skilled labour force and export value, the VEC model is estimated. With the tests estimated earlier (Johansen test, see Appendix), it is expected that there can be one co-integration relationship. With this VEC-model, one could possibly observe that the variables are depended on their own lagged value. Based on the information criteria, the optimal number of lags is 1, which was suggested from earlier tests. In addition to this, it is assumed that there are no structural breaks, misspecification, no heteroskedacity and no autocorrelation in the residuals (Hill et al., 2008). These assumptions are tested with Jarque-Bera as well as observing the kurtoisis and skewness of the residuals (see Appendix). The post-model estimations of the model demonstrate adequate results, which proves that there were no mistakes made earlier when testing the stationary of the data.

The basic model for Vector Error Correction Model: $\Delta y_t = \delta + \phi_1 y_{t-1} + \delta_0 x_t + \delta_1 x_{t-1} v_t$

The model for the vector: $y_t = (\text{skilled\_labour}_t, \text{export\_value}_t)$

Presented above is the Vector Error Correction model. With the help of this model, long-term relations as well as speed of adjustment to equilibrium can be examined. In

this analysis, variables are ordered according to the results of the co-integration test. This model allows the long run behaviour of the endogenous variable to diverge to the co-integrating relationship and yet at the same time yield a range of short run dynamics. With that, the co-integrating term also referenced as error correction term is corrected by the short run adjustments in the model. After performing this model, the earlier mentioned post-estimation tests were proceed in order to check the correctness of the model. The obtained results show both insignificant as well as significant observations on the long-run relationships. However, these results that are discussed in the results section, which confirm that the role of human capital is important in the Finnish economy.

5. Results and Discussion

As the theories on human capital and economic growth highlight the importance of skill in the modern economies, it is argued that human capital is the ultimate cause for technological development of an economy. It is a fact that an ever increasing number of people are obtaining tertiary degrees and that technological change is taking place on a global scale and at all points in time. In the Finnish case, it is quite evident that economic development in the last decades is related to the accessibility of human capital. In other words, as human capital has always been highlighted as an integral part in the Finnish society, the aim of this paper was to discover whether the increased education (skilled labour force) has, in the last decades, had a connection to the radical changes in the economy and particularly to the export performance in the high technology branch.

Looking through the lenses of these facts, the causal effect was analysed in order to indicate the connection between education and export value. This analysis was done by examining the possible co-integration relation and with the help of various statistical methods. In order to estimate the dynamic interrelationship between skilled labour force and export value in short-run perspective, a model (VAR) was estimated. In the short run, skilled labour force seems to be dependent on its own lagged value. On the other hand, export value shows interesting results, since in the short-run range it is demonstrated to depend on human capital, in other words, skilled labour. That is, the change in skilled labour force growth rate in previous period on 1% will lead to growth in export value growth rate in current period for 0.016% (coefficient=.016222). Given this result on the short-range dynamics, it can be concluded that human capital and export value in the high technology branch are intertwined.

In addition to these results, the aim of the paper was to examine the long-run connection between these two variables. This estimation was done by specifying a VEC-model. This model appears to be adequate as, for instance, there is no autocorrelation. Skilled labour force has significant p-value of 0,000 and it can be seen that if skilled labour force increases 1%, the effect on the export value was c. 2,5 % increase (Table 2). In other words, there is a long-run equilibrium relationship between human capital (skilled labour force-variable) and export performance, as the series do not move independently of each other and at the same time they do not diverge too far away from each other. It

needs to be acknowledged that these variables are co-integrated according to the results. Furthermore, in the short-run there is an adjustment process, which prevents significant errors. Given these results, it can be concluded that there is indeed a strong positive input of skilled labour force in export performance in Finland. In other words, hypothesis that was stated in the beginning of this paper cannot be disregarded. It is clear that Finland is a knowledge-driven economy and human capital contributes to export success in technology, which is highlighted to carry importance in the competitiveness of Finland.

Beta	**Coef.**	**Std.error**	**Z**	**P>|z|**	**95% Conf. Interval]**	**95% Conf. Interval]**
Export	1					
Labour	-2.505361	0.126325	-19.83	0.000	-2.752953	-2.237768
_Cons	15.05177					

Table 2. Significant result for long-run equilibrium for VEC

When reflecting on these results through the theoretical framework presented in the first and the second chapter, they are in line with the hypothesis that human capital and in particular skilled labour force contribute to export performance. In greater detail, human capital variable drives export value, which can partly explain exporting success in technology branch in Finland. Nonetheless, other factors such as accessibility of R&D and world markets may influence the export arena in Finland. As Heckscher-Ohlin theory emphasises that a country specialises in the products that support the resources in the country: this is clearly seen in the Finnish case. Finland has abundant human capital and is specialised in the export products that are known to require skill. While the human capital is examined by the amounts of workers who have obtained a tertiary degree, it poses limitations to the model, which need to be taken into account when evaluating the results. However, descriptive statistics reveal that as a whole skilled labour has increased in private sector in this observed period. Again, the stock of human capital is difficult to calculate and one of the ways is looking through it by education (Barro & Lee, 2000). It needs to be mentioned that there may be workers who are passive students in the university without ever planning on graduating. As a result of this, these skills that may be obtained through working experience or from university

without graduating are difficult to account for and henceforth they are not considered in this analysis.

In addition to these trends in the development of human capital, the structural change is clearly present when it comes to labour dynamics and export products. While the data analysis does not regard other sectors such as forestry or metal, the importance of the growing export value within high technology can be observed, as can be seen in the percentage increase in high technology when compared to other sectors. In addition to this, the job creation within this sector has increased and yet at the same time there is more highly educated people working in technology over the period of 1991 to 2010. Given this clear change in the export arena and development of human capital over time, radical changes can be discerned in the Finnish economy from 1990s onwards, which were expected by the theoretical standpoint. Furthermore, according to Romer the output per worker has risen, which is due to both technological progress and more effective labour force (1990). This line of reasoning could be explained by the increases of human capital stock, which is evident in the Finnish case.

Along with these results obtained, descriptive statistics on export value and skilled labour force illustrate interesting trends. First and foremost, both export value and the increasing skilled labour force demonstrate significant growth throughout the 1990s. Secondly, analysing export value and skilled labour in the 2000s becomes problematic, as the skilled labour force has increased significantly and the export value has changed over the period. Perhaps this could be explained partly by Nokia's downfall since 2006. The underlying causes of this decrease in exporting could be due to the standardisation of GSM-technology and falling prices in ICT, which have resulted from mass production and other global competitors entering the market. This evidence goes back to the theory on the diffusion of innovation effecting to the export flows (Schön, 2009). As a result of this, Finnish ICT-cluster has suffered and the capital stock has declined (Maliranta et al., 2011). On the other hand, skilled labour force has not followed the same patterns, because it has increased throughout the 2000s, with its high peak in 2010. At the same time, given the export decline it could be argued that skilled labour is an investment to reach stronger position in the market. One can even draw a parallel to the 1990s, as human capital is closely linked to export growth that followed. Furthermore, human capital also contributes to the levels of innovation and it can lead to new production methods (Schumpeter, 1961 and Krugman, 1994). Perhaps this same

trend of innovations coming out after downturn could occur in the near future, as human capital is emphasised in 2009 and 2010. On the other hand, it is difficult to forecast since restructuring of the economy occurs at all times (Schumpeter, 1961). Given this and taking into consideration the rapidly changing nature of ICT, it is hard to forecast the trends on export and the role of human capital in the case of Finland. However, it is necessary to highlight the possible growth opportunities and allocation of the resources to high productivity sectors in order to create jobs as well as provide security to the economy.

As mentioned earlier, there are other factors besides human capital that influence exporting of a country. Because of this very fact, it would had been interesting to see how factors such as investments in R&D may have contributed to export performance. Another interesting contributor to this analysis would be examining this human capital and export in regional perspective and whether, the results would be different in for instance, in the capital region. Furthermore, it would have been interesting to observe how the aging structure of the population as well as the young university graduates are placed within technology sector given the Schumpeterian structural changes, which keep shaking the economy. Given these dimensions, much interesting research on the interrelations between labour dynamics as well as export branch are to be examined. While this thesis only touches upon one aspect of the structural change by examining technology sectors through human capital, it still sheds light on the importance of human capital that has brought export success to a small economy such as Finland. In other words, with the help of knowledge and technology, Finland has been able to gain comparative advantage and demonstrate long-term economic growth.

All in all, the results indicate that human capital is essential for the Finnish exporting, which would ultimately contribute to the competitiveness in the world market. As previously addressed, exporting and in particular high technology products have been seen as essential for Finnish growth. However, some challenges remain in the future when it comes to human capital and driving for performing well in exporting. These challenges could be the lack of skilled labour force or the aging structure of the labour market. Another challenge is to how the stock of human capital can be increased in Finland so that it would contribute to the demands of labour markets and ultimately improve the competitiveness of Finland. This topic and its many interrelations have sparked debate among the researchers. As a result of this, many policies regarding

strengthening the relationship between private sector and university have been proposed to improve the labour market for university graduates as well as private sector benefiting from increased amount of human capital is important in the Finnish economy.

6. Conclusion and Future Research

In this thesis, the causal relationship between human capital (skilled labour force) and export performance was examined by looking at the co-integration relationship of these variables and formalising both VAR and VEC. The motivation behind this was to investigate whether, first of all, a relationship exists between them and if so, to examine the nature of this relation. The results of these tests and models suggest that there indeed exists a long-run positive affiliation between skilled labour and export value. Furthermore, descriptive statistics reveal interesting results when it comes to skilled labour that has skyrocketed in 2009 and 2010. On the contrary, export value has decreased since 2006, which could be due to standardisation of GSM technology as well as other competitors entering the market. Perhaps, this surge for skilled labour could be seen as a tactic to achieve global competitiveness in ICT and gain profits in the world market. Given the results obtained, human capital is a crucial element for the Finnish production in high technology. In order to maintain the competitiveness and the highlighted export success in technology products, focus on knowledge must be emphasised. Given this, it is highly probable that in the future a closer connection between the universities and industries will become even more essential in order to strike the balance of supply of skilled workers and the demand for the different sectors contributing to the international competitiveness.

7. References:

1. Aghion, P. & Howitt, P. (1998) Endogenous Growth Theory. MIT Press. Cambridge.

2. Adams Jr., R, H. (2003), *International Migration, Remittances, and the Brain Drain*. A Study of 24 Labour-Exporting Countries. The World Bank Publications.

3. Ambler, S. Cardia, E., and Farazli, J., (1996), *On Export Promotion and Growth*, The Canadian Journal of Economics, Vol. 29, and Special Issue: Part 2, pp. S366-S370.

4. Andersson,.E & Johansson B., (1984). *Knowledge Intensity and Product Cycles in Metropolitan Regions*, International Institute for Applied Systems Analysis, Laxemburg.

5. Ali-Yrkkö, J & Hermans R. (2002), *Nokia Suomen Innovaatiojärjestelmässä*, Yliopistopaino, Helsinki.

6. Arrow, K. J. (1962), *The Economic Implications of Learning by Doing*. Review of Economic Studies. 29. 155-73.

7. Barro, R & Lee, J.W. (1997), *Schooling Quality in a Cross-section of Countries*. NBER Working Paper No. 6198.

8. Barro, R & Lee, J.W. (2000), *International Data on Educational Attainment Updates and Implications*. NBER Working Paper No. 7911.

9. Benhabib, J. & Spiegel, M.(1994) The Role of Human Capital in Economic Development: *Evidence from Aggregate Cross-Country Data*. Journal of Monetary Economics.vol.43. p.143-174.

10. Bosworth, Barry and Susan Collins (2003). The Empirics of Growth: An Update. Brookings Institution. Mimeo.

11. Böckerman, Petri. (2000). *Elinkeinorakenteen muutosnäkökulma 1990-luvun murrokseen*. Labour Institute For Economic Research. Discussion Papers 4, Helsinki.

12. Dickey, D.A. and Fuller, W.A., (1981), *Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root*. Econometrica, Vol.49, pp.1057-1072

13. Dolado, J., Felgueroso F. & Juan F. Jimeno (2000), *Youth labour markets in Spain: Education, training and crowding out.* European Economic Review, 44, 943-956. [26].

14. Green R.T &Lutz, J.M. (1983). *The Product Life Cycle and the Export Position of the United States*. Journal of International Business Studies, Vol.14, No 3.

15. Goldin C. & Katz L.(1999), The Shaping of Higher Education: The Formative Years in the United States, 1890 to 1940, Journal of Economic Perspectives, American Economic Association, vol. 13(1), pages 37-62, Winter.

16. Grossman, G & Helpman E.(1990), *Product Development and International Trade* (October 1990). NBER Working Paper Series, Vol. w2540, pp. -, 1990. Available at SSRN: http://ssrn.com/abstract=425567

17. Engle, R.F. & Granger, C.W.J. (1987), Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica* 55, 251-276.

18. ETLA, The Research Institute of The Finnish Economy (2010), *Suhdanne* 2010:2.

19. European Commission. (2010), *European Competitiveness Report 2010*. 28 October 2010.

20. Fagerberg, J. and Srholec, M., (2005). *Catching up: What are the Critical Factors for Success?*, Industrial Development Report, UNIDO

21. Feder, G. (1983), *On exports and economic growth, Journal of Development Economics* 12, 59-73.

22. Foreign Ministry of Trade in Finland (2010). *Annual publication on Finnish trading. vuosijulkaisu*. Helsinki, Finland.

23. Fujita, M & Thisse, Jacques-François. (2002), *Economics of Agglomeration: Cities, Industrial Location, and Regional Growth.* Cambridge University Press.Cambridge.

24. Hanell, T., Aalbu, H. and Neubauer, J. (2002): *Regional Development in the Nordic Countries 2002*, Nordregio Report 2002:2.

25. Hill, C.A, Griffits E.G, Guay C.L,(2008), *Principles of Econometrics*, Fourth edition. New York.

26. Heckscher, Eli. 1919. "The Effects of Foreign Trade on the Distribution of Income," Ekonomisk Tidskrift, Vol. 21, pp. 497-512.

27. Hjerppe, Riitta. (1989), *The Finnish Economy 1860-1985, Growth and Structural Change.* Bank of Finland Publications, Studies on Finlandís Economic Growth XIII, Helsinki 1989

28. IMF (International Monetary Fund Database).(2009): From: http://www.imf.org/external/pubs/ft/weo/2009/01/weodata/index.aspx, [referred: 17.2.2012]

29. Johansson, B. (1993), *Ekonomisk dynamik I Europe- Nätverk för handel, kunskapsimport och innovationer*, Liber-Hermods, Malmö with cooperation with Future Studies.

30. Johansson, B. &Karlsson C. (1990). *Innovation, Industrial Knowledge and Trade, A Nordic perspective*. European Networks: 1990:1

31. Johansen S.(1988), *Statistical analysis of cointegration vectors*, Journal of Economic Dynamics and Control, vol.12, pp.231-254.

32. Johanssen, S and Juselius, K. (1990), *Maxium likelihood estimation and inference on co-integration with the application to the demand for money*, Oxford Bulletin of Economics and Statistics, vol.52, pp.169-210.

33. Jussila, Nevakivi, Hentilä. (2009), *Suomen poliittinen historia 1809-2009*. WSOY, Helsinki

34. Kantola, Anu. (2002) *Markkinakuri ja managerivalta: poliittinen hallinta Suomen 1990-luvun talous- kriisissä*. [Market control and managerial power: political governance in economic crisis in the 1990s.] Helsinki: Loki-kirjat

35. Katz, Lawrence F. (1994), Active Labour Market Policies to Expand Employ- ment and Opportunity. A Symposium Sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming, August 1994, 239-290.

36. Karhunen, Hannu. (2008). *Alueellinen koulutuspääoma Suomessa 1970-2005*, University of Jyväskylä, discussion papers vol5.

37. Kilponen, J. & Santavirta, T. (2002), *Taloudellinen kasvu, innovaatiot ja kilpailu – katsaus kirjallisuuteen ja politiikkasuosituksiin*, VATT keskustelualoitteita 289, 1-22.

38. Kleynhans, Epj (2006), The Role of Human Capital in the Competitive Platform of South African Industries. *Journal of Human Resource Management* 4 (3): 55-62.

39. Krueger A. (1990). *Perspectives on Trade and Development*. University of Chicago Press. Chicago.

40. Krueger, A. B. & Lindahl, M. (1999), *Education for Growth in Sweden and the World*. NBERWorking Paper No. 7190. Swedish Economic Policy Review, Vol. 6, no. 2 (Autumn 1999): 289-339

41. Krugman, P. R. (1994), *Rethinking International Trade*, MIT Press, Cambridge, Mass

42. Lauri, P. (2004), *Human Capital, Dynamic Inefficiency and Economic Growth.* Helsinki School of Economics. Helsinki

43. Lemola T, (2001), *Katsastus Suomen tiede- ja teknologiapolitiikan lähihistoriaan*, Tiedettä, teknologiaa ja innovaatiota kansakunnan parhaaksi. VTT, Teknologian tutkimuksen Ryhmä ISSN 1239-0259

44. Levine J. (1996), *Welfare, Work, and Choices: Expanding Notions of Economic Incentives*, presented at the University of Chicago Workshop on Urban Inequality, Spring 1996.

45. Lindmark, Ma. & Vikström P. (2003), *Growth and structural change in sweden and finland, 1870-1990: a story of convergence*, *Scandinvian Economic History Review* **51**(1), 46–74.

46. Ljungberg, J. (1996). Catch-up and static equilibrium: a critique of the convergence model. *Scandinavian Economic History Review* 44, 265-75.

47. Ljungberg, J. (1997). The impact of the great migration on the Swedish economy. *Scandinavian Economic History Review* 45, 159-89.

48. Ljungberg J. & Nilsson A. (2005), *Human Capital and Economic Growth Sweden 1870-2000*. Department of Economic History, Lund.

49. Lorenz, E. & Valeyre, A. (2006). Organizational forms and innovative performance: a comparison of the EU-15. In: E. Lorenz & B. Å. Lundvall (Eds), *How Europe's economies learn. Coordinating competing models*. New York: Oxford University Press.

50. Lucas, R. (1988), *On the mechanics of economic development*, Journal of Monetary Economics, Vol.22

51. Mankiw, G, N., Romer, D. & Weil, D, N. (1992) *A Contribution to the Empirics of Economic Growth*. The Quarterly Journal of Economics, Vol. 107, Nro. 2, s. 407-437

52. Maliranta, M. & Määttänen, N. (2011). "Luova tuho" yrityssekto- rilla – tuottavuuden avain ja politiikan haaste. Kansantaloudellinen aikakausikirja, 107(3), 234-255.

53. Marrewijk, C. van (2002), International Trade and the World Economy, Oxford University Press, Oxford, U.K. (ISBN: 0-19-925004-9; p.386)

54. Nelson, R. R. & Phelps, E. S. (1966), *Investment in Humans, Technological Diffusion, and Economic Growth.* Cowles Foundation Paper 236. Reprinted from American Economic Review, (1966), 56(2).

55. Newey, W.K. and West, K.D., (1987), *A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix*, Econometrica, vol.55, pp. 703-8.

56. OECD (2007), *Education at a Glance 2007*. Paris.

57. OECD (2010), *The Role of Human and Social Capital.* Paris

58. Ohlin, Bertil (1933*), Interregional and International Trade*, Harvard University Press, Cambridge, 1933.

59. Ollila J. (2005), *Vientivetoinen kasvu*, Pro Gradu-tutkielma. University of Tampere, November, 2005.

60. Pelkonen A. (2004), *Questioning the Finnish model- Forms of Public Engagement in Building the Finnish Information Society*. University of Helsinki, Departement of Sociology. Stage, discussion Paper 5, June 2004.

61. Pekkala S, Intonen N, Maija-Liisa Järvi. (2005). Education Expenditure in Finland in the Twentieth Century and in the Future, *Discussion Papers 365, Government Institute for Economic Research*, Helsinki 2005, p. 44

62. Pekkarinen J. & Vartia J. (1993). *The long-run growth policy in Finland*. (in Finnish), WSOY, Juva 1993

63. Phillips, P.C.B. and Perron,P., (1988), *Testing for a Unit Root in Time Series Regression*, Biometrika, Vol.32, pp.301-318.

64. Piekkola, H. (2011), *Aineeton pääoma – avain menestykseen*. The University of Vaasa. Discussion Papers, 169.

65. Piekkola, H. (2011), *Intangible capital agglomeration and economic growth: An Analysis of Regions in Finland*, Inno-drive Working Paper No. 20.Helsinki

66. Pyykkö, H., Bunders, M. (2005). Suomen ulkomaankaupan rakenne. Euro & Talous. Volyymi n:o 7. Paper n:o 3, s.83-89 [electronic]. Available<http://www.bof.fi/NR/rdonlyres/59C4805E-D948-480D-95AE-8ADF8D939029/0/3_UlkomaankaupanRakenne.pdf>

67. Ramos, F.F. (2001), *Exports, Imports, and Economic Growth in Portugal: Evidence from Causality and Cointegration Analysis*. *Economic Modeling* 18, 613-623

68. Rhode, P. & Tonniolo, G. (2006). *The global economy in the 1990s: a long-runperspective*. New York: Cambridge University Press.

69. Ricardo, D.(1817). *Principles of Political Economy and Taxation*, vol. i, p 278, in: Sraffa (ed.), 1951, The Works and Correspondence of David Ricardo, 10 vol. (1951– 55), Cambridge: Cambridge University Press.

70. Ritsilä, J. (2000), *Where do the Highly Educated Migrate? Micro Level Evidence from Finland*. University of Jyväskylä. School of Business and Economics. Working Paper 222/200. Jyväskylä.

71. Romer, M. P. (1986), *Increasing Returns and Long-Run Growth*. The Journal of Political Economy, Vol. 94, No. 5, pp. 1002-1037

72. Romer, P.M. (1990), *Endogenous Technological Change*, Journal of Political Economy, 98(5) pp.71-102

73. Saarinen, J. (2009), *Innovating through the downturn*, Helsinki: PriceWaterhouse Coopers

74. Schumpeter, J. A. (1961), *The Theory of Economic Development*. An Inquiry Into Profits, Capital, Credit, Interest, and Business Cycle. Oxford University Press.

75. Schultz, T,W. (1961), *Investment in Human Capital*. The American Economic Review, Vol.51, No. 1. pp. 1-17.

76. Schön, L. (1997), Internal and external factors in Swedish industrialization. *Scandinavian Economic History Review*, 209-223.

77. Schön, L. (2009), *Technological Waves and Economic Growth- Sweden in an International Perspective 1985-2005*. Paper no. 2009/06. Circle Lund University.

78. Sjaastad, L.A. (1962). *The costs and returns of human migration*. *Journal of Political Economy* 70(1): 80-93.

79. Smith, A (1776). *Wealth of Nations, vol 1.* Publisher:W.Strahan and T.Cadell, London.

80. SNA93 (1993), *System of National Accounts 1993*, UN, OECD, EU, IMF and World Bank.

81. Statistics, Finland (OSF). (2010). Collection of Gross Domestic Prodcut at market Prices. Tilastokeskus Helsinki.

82. Statistics Finland (OSF). (2011), *Educational structure of population [e-publication]*. ISSN=2242-2919. Helsinki: Statistics Finland [referred: 1.5.2012].

83. Statistics Finland (OSF). (2011), *High technology foreign trade [e-publication*]. Helsinki: National Board of Customs [referred: 30.5.2012]

84. Statistics, Finland (OSF).(2007), *Kunnat ja kuntapohjaiset aluejaot 2006*. Käsikirjoja 28. Tilastokeskus Helsinki.

85. Statistics, Finland (OSF). (2007). *Koulutuksen talous 2005*. *[e-publication]*. http://www.stat.fi/til/kotal/2005/kotal_2005_2007-05-16_tau_001.xls. Helsinki: Statistics Finland. [referred: 18.1.2012]

86. Statistics Finland (OSF) (2011), Labor Market, Employment Service Statistics. *Release on job vacancies and unemployment*. Helsinki: Statistics Finland [referred: 30.5.2012]

87. Steinbock. *The Nokia Revolution*.(2003), *[e-publication*]. From: http://msl1.mit.edu/CMI/tp5/2003/students/Nokiapres.pdf. Helsinki. [referred: 18.1.2012]

88. Solow, R. M. (1956), *A Contribution to the Theory of Economic Growth*. Quarterly Journal of Economics. Vol.70. No.1, pp: 65 – 94

89. Solow, R. M. (1957), *Technical Change and the Aggregate Production Function*. Review of Economics and Statistics, 39:312-320.

90. Tainio, R., Pohjola, M. & Lilja, K. (1999), *Economic performance of Finland after the Second World War*, in: S. Quack, G. Morgan, & R. Whitley (Eds) National Capitalisms, Global Competition, and Economic Performance, pp. 77–88 (Amsterdam: John Benjamins).

91. Uzawa, H. (1965), *Optimum technical change in an aggregative model of economic growth*. International Economic Review 6, 18-31.

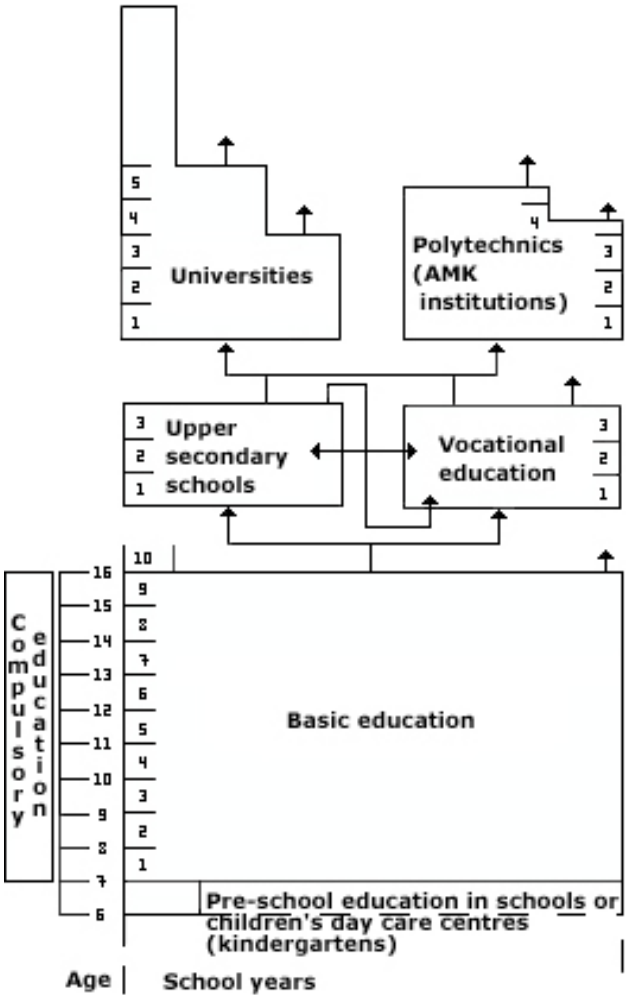
92. Vernon, R. (1966), Capital Formation by Education, Journal of Political Economy, Vol. 68, No.6,p 571-583.

93. Weinberger, H. (1997), *Nätverksentreprenören: En historia om teknisk forskning från den Malmska utredningen till Styrelsen för teknisk utveckling.* Stockholm: Avdelningen för teknik- och vetenskapshistoria.

94. The World Bank (2005). *Where is the Wealth of Nations?*,Conference Edition. New York.

95. The World Bank (2010), World Development Indicators. New York.

8. Appendix



Appendix 1, Finnish Education System in 2010 (Statistics Finland, 2011)

Variable	Specification	Lags	T-value	Critical-value 5%	Conclusion	Nr of Obs
skilled_labour	trend& Intercept	1	-2,874	-3,497	cannot reject H^0	18
skilled_labour	constant	2	-3,079	-4,146	cannot reject H^0	17
skilled_labour	trend& Intercept	3	-3,43	-3,499	cannot reject H^0	16
skilled_labour	trend& Intercept	4	-2,448	-3,5	cannot reject H^0	15
skilled_labour	trend& Intercept	5	-3,011	-3,504	cannot reject H^0	14
skilled_labour	trend& Intercept	0	-2,466	-3,496	cannot reject H^0	13
export_value	trend& Intercept	5	-2,331	-3,504	cannot reject H^0	13
export_value	constant	4	-1,885	-3,5	cannot reject H^0	14
export_value	trend& Intercept	3	-1,542	-3,499	cannot reject H^0	15
export_value	trend& Intercept	2	-1,236	-3,498	cannot reject H^0	16
export_value	trend& Intercept	1	-1,242	-3,497	cannot reject H^0	17
export_value	trend& Intercept	0	-1,266	-3,496	cannot reject H^0	18

Appendix 2. Results for ADF-Test, *When implementing the ADF-test, lag length must be considered. In this examination 5 different lags were tested with constant and trend and without trend. With Augumented Dickey Fuller-test. Based on Augumented Dickey fuller-test the time series are non-stationary. The tests were performed with trend and constant and also without a trend. However, the results were the same in all the cases. This summarizes the tests performed, which all conclude that the data is non-stationary.*

Variable	Specification	Lags	T-value	Critical-value 5%	Conclusion	Nr of Obs
Skilled_Labour	Constant	0	-7,243	-1,95	reject H_0	18
Skilled_Labour	trend & Intercept	0	-7,321	-3,497	reject H_0	18
Export_Value	Constant	0	-5,389	-1,95	reject H_0	18
Export_Value	trend & Intercept	0	-5,588	-3,97	reject H_0	18

Appendix 3. Phillips-Perron test for testing the differences. *Results confirm that the differences are stationary.*

Lag	LL	df	LR	p	FPE	AIC	HQIC	SBIC
0	3.87959	4		.002711	-.234949	.230004	-.230004	-.138375
1	35.3657	4	62.972	0.000	000088	-3.6707	-3.7412*	-3.38099*
2	40.1428	4	9.5543*	0.049	000083	-3.765*	-3.65587	-3.28498
3	43.9943	4	7.703	0.103	000092	-3.7428	-3.71467	-3.07327
4	45.7574	4	3.5263	0.474	000143	-3.4696	-3.42517	-2.60051

Appendix 4. Selection Criteria *(SBIC= Schwartz Criteria that is being used in this analysis)*

Max Rank	Parms	LL	eigenvalue	Trace stat	5-% Critical value
0	0	4.435698		43.6136	12.53
1	3	18.31948	0.76810	2.8461*	3.84
2	4	26.242507	0.56569		

Appendix 5. Johanssen test for Co-integration. Trend is constant. Number of obs: 1. Lags used 1.

Skilled Labour	Lag1	Coef.	Std.Err	z	P>|z|	[95% Conf. Interval]	95% Conf. Interval]
-labour	1	.1186895	.0594687	2.00	0.006	.002133	.235246
-export	1	-.245793	.419609	-0.59	0.358	-1.068212	.5766251
-cons		.0757871	.0444561	1.70	0.088	-.0113453	.1629194
Export							
-labour	1	.016222	.034956	0.46	0.000	-.0522904	.0847344
-export	1	.1007929	.2466479	0.41	0.283	-.3826281	.5842139
_cons		.0644193	.0261315	2.47	0.014	.0132026	.115636

Appendix 6. Vector Autoregression *(includes coefficients)*

Equation	Parms	RMSE	R-sq	Ch2	P>ch2
Skilled labour	3	.123843	0.2005	4.512694	0.1047
Export	3	.072795	0.0195	.3575082	0.8363

Appendix 7. Vector Autoregression Equations

Export		Coef.	Std.error	z	P>|z|	95% Conf. Interval]	95% Conf. Interval]
	L1	-0.011382	0.0122062	-0.09	0.926	-0.0250619	0.0227854
	Cons_	0.0758937	0.0171135	4.43	0.00	0.0423519	0.1094355
Labour							
	L1	0.3294285	0.0211312	15.59	0.000	0.2880121	0.3708448
	_cons	0.0002622	0.0296267	0.01	0.993	-0.057805	0.0583295

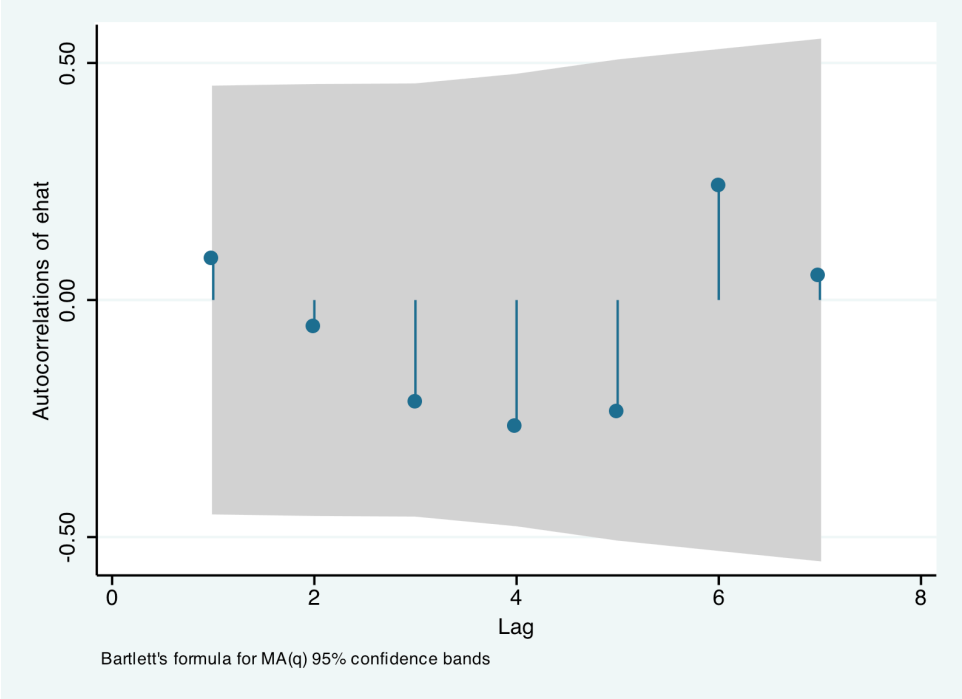
Appendix 8. Vector Error Correction, Coefficients

Equation	Parms	Ch2	P>chi2
	1	393.3342	0.0000

Appendix 9. Cointegration equations

Beta	Coef.	Std.error	Z	P>|z|	95% Conf. Interval]	95% Conf. Interval]
Export	1					
Labour	-2.505361	0.126325	-19.83	0.000	-2.752953	-2.237768
_Cons	15.05177					

Appendix 10. Johansen normalization restriction imposed



Appendix 11. Post-model examination for autocorrelation

	Skewness	df	Prob > chi2
Export	0.392	2	0.0021
Labour	0.678	2	0.0034
ALL	1.137	4	0.004

Appendix 12. Jarque-Bera test

Lag	Chi2	df	Prob > chi2
1	0.3577	4	0.0012
2	3.7828	4	0.456

Appendix 13. Lagrange-multiplier test. *No autocorrelation at lag order.*