LUND UNIVERSITY
School of Economics and Management

**Master programme in Economic Growth, Innovation and Spatial Dynamics**

# Structural Change and Productivity Growth in the ICT Era: The Finnish Case.

**Alexandra Kolovou**
egi12ako@student.lu.se

*Abstract: The aim of this thesis has been the examination of the productivity growth patterns through the process of structural change and within sectors productivity improvements for Finland over the period of 1975 to 2011. By connecting theories of "General Purpose Technologies", "Creative Destruction", and "Techno-economic paradigm" with the ICT emergence, the notion of ICT intensity sectors had emerged that implies that labour is oriented towards the more productive ICT sectors. The main findings have been that the structural change process had not been as conductive to productivity growth as the within sectors productivity developments and that the reallocation of resources are not occurring largely towards the ICT intensive sectors. Lastly, despite the fact that the ICT producing sector had been the most productive sector in the Finnish economy, labour was oriented largely to the less intensive ICT sectors.*
*Key words:* Structural Change, Productivity Growth, ICT Intensity, Sector Taxonomy

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# 1. Introduction[1]

Over the past century, Finland has undergone a remarkable economic transformation. Terms like "success story" and "economic miracle" (Oinas, 2005; Ojala, Eloranta & Jalava, 2006) have been often used in the academic literature in order to describe Finland's economic performance with approximately 100 years of rapid economic and industrial transformation (Ojala, Eloranta & Jalava, 2006). The role of productivity to this process has been decisive and was the main driving for economic growth. Such claims are justifiable when taking into consideration that from the early 20$^{th}$ century to 2000s living standards in the form of GDP per capita had increased 21 times (Ojala, Eloranta & Jalava, 2006). Academics (Oinas, 2005; Jalava, 2006; Jalava &Pohjola, 2007) argue that this successful economic course largely lies on the grounds of economic transformation and reinterpreting Finland's industrial structure. Therefore, the ability of the Finnish economy to diversify and adjust its economic orientations towards becoming an information society with a strong ICT sector is what stands largely for its current economic state. Technology transfer was the key element for this progression and structural change and productivity growth contributed vastly in this economic performance. (Myllyntaus, 1991, Ojala, et al., 2006). The mid 1990s had been a period of exceptional economic growth with productivity increasing by 2.2% annually. This economic progression has been related to the vast productivity improvements of the ICT sector. However, the current economic state of Finland has been showing signs of decline. The recession of 2008-2009 had significant effects on the economy. Simultaneously, the ICT sector appears also declining signs.

Put in a broader view, the General Purpose Technologies resembling features of the ICTs, have allowed them to diffuse economy wise. The degree, nevertheless, of the use of the technologies intensifies the growth differentials with industries that do not intensively use these particular technologies compared to the ICT intensive ones. The evaluation of this productivity differential that originates from the level of the ICT use has been this thesis main objective.

[1] This study relies heavily on my Research Design final paper course with title "A productivity analysis on the Finnish economy: the ICT as a driving force of growth and productivity."

Through the process of productivity improvements derived from the use of the more efficient technologies under the ICT technological mode, productivity growth is augmenting in an aggregated level. However, this is not the only projection of productivity growth. The process of structural change refers to labour movements within the economic activity depending on the relative productivity of the industrial formation. Given the productivity advancements derived by the ICT and the 3rd Industrial Revolution, structural change would imply that labour would orient towards the more productive ICT sectors and away from the less intensive ICT sectors. For the productivity differential that are occurring the highest ICT using industries are the ICT producing industries.

Given that Finland had emerged as a technologically advanced nation, the abovementioned theoretical orientation appears to be indicative for evaluation. Therefore, the emerging research questions that this thesis will attempt to account for are:

*"Is structural change the driving force of productivity growth for Finland?"*
*"Is labour oriented towards the intensive ICT sectors?"*
*"Is the ICT Producing sector the most contributing sector to Finland's productivity progression"?*

## 1.1 Methodological approach

The method proposed to examine the research questions is a decomposition of the total productivity growth into its driving forces. Therefore a Shift-Share analysis is conducted that decomposes the total productivity growth into the productivity improvements from the new technology's impact on the production mechanisms within the industries of the sectors and the structural change through the reallocation of labour between sectors relative to their productivity. Since evaluating the productivity growth trends that the ICT have generated, an alternative categorization of the three sectors of the economy is proposed. Therefore, according to the degree of each industry's ICT intensity, it contentiously categorized in the corresponding ICT intensity sector. The sectors that are formed are the "ICT intensity producing", "ICT

using", "less ICT" and "other industries"[2]. In order to get a broader view on the industrial productivity processes, the three sector of the economy classification, will be also employed.

After conducting the three sector and the ICT intensity shift share analysis, the results suggest that the structural change effect has not been as conductive to total productivity growth, as the within productivity change effect, although present and affecting productivity growth until the 2000s. In addition to this, the reallocation of labour from the "low productivity" sectors, to the "highly productive" heavy users of the ICTs, as structural change dictates, cannot be largely confirmed.

### 1.2 Contribution of the study

To my knowledge, despite the several studies that are dealing with the role of structural change and productivity growth issues for Finland, the post 2008 period has not been examined under the ICT intensity sector categorization for the total economy. Therefore, this study will prolong the existing literature on the progression of the structural change contribution to total productivity growth by giving insights on how the ICT era has influenced the industrial formation of Finland. Furthermore, having in mind the "productivity bonus" (Wang & Szirmai, 2008) effect of structural change to the total productivity growth, this study could also give insights for future policy making decisions and implementations concerning productivity growth and augmenting economic processes.

In the upcoming sections, a historical synopsis and the theoretical framework are taking place. Contentiously, previous studies, the method, and the results from the shift share analysis are being presented following by the discussion of the results and the concluding remarks.

## 2. Theoretical Framework

In this section, an attempt is made towards the linking of productivity growth with four basic theoretical frameworks that appear to give an explanatory basis and

[2] For the complete classification of the ICT intensity industries see the Appendix.

interrelate with the evolution of productivity patterns. The general purpose technologies (Bresnahan & Trajtenberg, 1992), the process of "creative destruction", (Schumpeter, 1939) the techno-economic paradigm (Perez, 1985; Perez & Freeman, 1988) and the structural change process (Wang & Szirmai, 2008; Fagerberg, 2000) are used in this direction.

Having in mind the vast effects of technologies like the steam engine, electricity and the combustion engine it appears that there is a close connection with economic growth and the diffusion of economy-wide pervasive technologies that contributed to the 1st and 2nd Industrial Revolutions. The economic activity has undergone tremendous changes that have as a critical consequence the redirecting of resources away from the dependency on agriculture and into manufacturing and services. Through this transition, economic growth and living standards accelerated and augmented, with productivity growth being the driving force.[3]

Technologies as such, have characterized as General Purpose Technologies (GPT). The main argument behind this definition is their throughout the economy diffusion effect. The GPTs are considered as the basic technologies that evolve around new and preexisting technological functions and their common characteristic is their vast application that has significant economy wide impact. Their incorporation to the economy in the early stages of development is limited but through constant technological improvements, their efficiency becomes higher and their diffusion accelerates. It could be argued, therefore, that a main characteristic of the GPT is their enhancing productivity ability that triggers economic growth (Bresnahan & Trajtenberg, 1992). The gains on productivity in accordance with the vast application potential gives incentives for the diffusion of the GPT which in the long run they generate cost decreasing conditions for the products and industries that are using the particular technology. Consequently, the technology itself is subject to cost reductions that endows with the wider spread of the technology. The nature of a given GPT creates growth differentials in the industrial coherence since it is promoting those industries that make intense use of the technology initially in productivity terms that contentiously result in economic growth (Bresnahan & Trajtenberg, 1992). This economic incentive is a crucial step for the further diffusion

[3] For an account over the transition of labour between the economic sectors see Broadberry (1998), Temin (2002)

process to other sectors that results in a generalized use of the technology in a larger sectorial scale.

The latest Industrial Revolution involves the semiconductor and its technological evolution through incremental innovative processes in the electronics field that constitutes the Information and Communication Technologies (ICT). What distinguishes these particular technologies from others of smaller scale and bring them closer with the 1st and 2nd Industrial Revolutions' technologies is their impact in the socio economic environment as well as their broad field of application. They are responsible for creating new modes of technological trajectories that reorient the economic and industrial activity through their wide diffusion by promoting new opportunities for enhanced economic performance. More specifically, the microprocessor allowed and broadened the innovative procedure since it was able to link complementary older technologies and make them more efficient. Furthermore, the cost reductions of the microprocessor applications over the years allowed for their inducing throughout the economy and society, but even more importantly, it gave incentives for constant innovative process that resulted in the generation of new technological trajectories and applications, based on this GPT. It could be thought, therefore, that the semiconductor not only caused the improvement of pre-established forms of technologies, but it also expanded towards new frontiers (Bresnahan & Trajtenberg, 1992).

The generalized, however, use of a GPT is neither fast nor presumed, nor is its continuous impact on productivity and economic growth permanent. In order for such a technology to diffuse into the economy and generate economic and societal effects, the need for complementary infrastructural and institutional adjustments capable to support the new form of the technology needs to take place. In addition to this, new learning processes oriented towards the new technological state are vital for its establishment. Consequently, they stimulate economic growth through productivity gains after the necessary adjustments in learning processes are made. When it comes to the progression of a GPT, one main argument that made by Bresnahan and Trajtenberg (2000), however, is that the impact of a GPT in the economic activity is not infinite and its contribution to productivity and economic growth reaches a depletion point. They emphasize that the constant technological advancements generate new technological frontiers that could impose the

replacement of the previous GPT era with the new one. The technological renewal therefore appears to be of great significance for the economic growth continuum.

The works of Schumpeter (1939), however, highlight that the succession of technological breakthroughs is not a smooth process. The diffusion of the new technology in the economic activity appears to have two directions. Firstly, it opens up new economic trajectories for firms that are making use on the new technology and at the same time, their diffusion create an economic environment where old processes in the production and firms that are technologically obsolete are discarded by the new-technology oriented ones; a process of "creative destruction" (Schumpeter, 1942). For this economic transformation, the role of the "entrepreneur" (Schumpeter, 1939) is critical. The main argument is that the "entrepreneur" (Schumpeter, 1939) through the funding from capital markets is taking advantage of the new technological advancements and induces innovation and technology in the economic activity under the incentive of enhanced profits. The orientation of investments towards the new technological status causes a state of "disequilibrium" (Schumpeter, 1939) where resources are channeled to the new innovative firms. This resource reallocation towards industries where the economic activity is intensified based on innovative technologies, underlies the significance of productivity. Industries that intensively use the new technologies obtain productivity gains and, therefore, incentives for the channeling of resources to these industries are established. This state that creates changes in the labour composition in the industrial formation of the economy is highlighting the process of structural change. The "productivity bonus" (Wang & Szirmai, 2012 p. 846) of the process of structural change refers to the liberation of labour from less productive sectors to sectors that productivity is augmenting. The productivity differentials between industries is what creates structural tensions that have intensified their economic activity through productivity gains derived by the incorporation of new technologies, contrary to others that are resistant to embrace the new technological status, is what determines the viability and success of the industries. The process, therefore, of creative destruction and structural change appears to be highly relevant, if not synonymous.

In this direction the works of Perez (1985), Freedman and Perez (1988) and Schön (2010) emphasize the role of the diffusion of innovative processes in the production. These technological breakthroughs, what Perez refers to as "techno-

economic paradigms" (Perez, 1985 p. 3,) need time to be cultivated in the economic activity and characterize the form of growth. Their establishment involves a parallel upbringing of new infrastructures and institutions that have both an economic but also a social impact. What distinguishes the "techno-economic paradigm" with GPTs is the former's firm focus on both the pervasiveness of the emerging technology and the parallel emerging of broader institutional formations. Dahmén (Henriksson & Carlsson 1991) is referring to this as the creation of "development blocks" (Henriksson & Carlsson, 1991 p.137) which are associated with the generation of complementarities within the economic and social structure that the new technological process is demanding. Previous modes of technology and institutions need to be readjusted and reinvented in order to support the new technological trend. Therefore, the "development blocks" (Henriksson & Carlsson, 1991 p.137) are signifying the progression from a state of disequilibrium that the new technological advancements generate to a state of complementarities inducing balance (Edquist, 2006).

Despite the belated results of the new technology in the economic indicators, once their diffusion in the economy is made, they create the upswing of the wave formation of growth. In this sense, productivity is augmenting throughout the economic sectors (Perez, 1985, p. 3). However, the intensity of the use of the technology in particular economic sectors emphasizes the notion of the prominent sectors in the economy.

What could be drawn upon from the abovementioned theoretical frameworks is that all theories stress the notion of the leading economic sectors. After the induction of a technological breakthrough in the economy, the intense use of the new mode of technology will display higher productivity gains the intensively using sectors.

Apart from the rather intuitive link of productivity gains derived from the incorporation of a new technological advancements in the economic activity where efficiency gains are accumulated, it is important to illustrate how productivity is evolved in the different sectors of the economy and what that means for the aggregated productivity. As stressed before in this section, the meaning of leading sectors in the economy is critical for productivity. Lundquist, Olander and Henning (2007) are referring to the significant role of the renewed companies, which are the productivity forerunners due to their strong connection to the current technology shift

of the ICT era. They manage to surpass industries more rigid to the absorption of the new technological climate. The process of creative destruction is highly important since the industries that do not manage to adjust to the technological and, as the diffusion of the technology progresses, the organizational and institutional parallel block that is created in line with the new economic-technological trajectories, are becoming obsolete and die away. In this study's conceptual framework leading sectors are created through the higher intensity of the use of a certain type of GPT compared to other sectors. However, in these high intensity sectors the productivity gains are greater not merely from the use of the technology but also from the parallel reallocation of resources towards these industries that comprise the sectors. The process therefore of structural change appears to give an explanatory background for the further productivity gains in the economy.

As stressed in Fageberg (2000) with the words of Salter (Fageberg, 2000) the ability of an economy to reallocate resources in a fast pace when a technological opportunity arises through a "flexible structure of production" (Fageberg, 2000, p. 394) is what rapidly increases productivity growth. In this sense, Grossman and Helpman (1991), acknowledge that in a country level, the current GPTs' influence is offering rapid productivity growth opportunities.

# 3. Previous research

Productivity growth and the role of structural change as a mechanism of its acceleration, have been examined by several studies. Fourastié (Kruger, 2008), through the three sector hypothesis, stylized the economic activity transformation through the process of industrialization where technological improvements are the driving forces of productivity and structural change. He develops a "linear sequence" (Szirmei, 2012 p. 25) transition scheme of growth for the three economic sectors where the shift of the economic activity is passing from agriculture to manufacture and contentiously from manufacture to services. Under this notion, Kuznets (1957) examines the move of economic activity from agriculture to manufacture under a global perspective[4] for the first half of the 20$^{th}$ century. The transition of labour to the

[4] United Kingdom, Ireland ,France, Germany, Switzerland, Netherlands, Denmark, Norway, Sweden, Italy, Spain, Hungary, United States, Canada, Union of South Africa, Japan, Australia, and New Zealand

more productive manufacture sector was responsible for the vast portion of total productivity and income per capita growth was by 0,68% statistically significant to labour reallocation. Temin (2002) also linked economic growth with structural change. He tests the reallocation of labour out of agriculture as a possible explanation for the emergence of economic growth in the post war era, the Golden Age of growth for Europe. From 1955 to 1977, the contribution of the reallocation of the excess labour from agriculture had been the main source of economic growth. Especially for Germany, it had contributed over a half of the 1,3% difference in growth of the period. One study that strides away from Fourastié norm of successive to the sectors reallocations was conducted by Broadberry (1990) in which he doubts the generalization of the linear transition between the sectors. He suggests that the acceleration of Germany and the US for the period of 1871 to 1990 in the catching up process with the 19$^{th}$ century leading economy Britain was due to resource reallocation from agriculture to services. Manufacture did not augment at the expense of agriculture sector.

After the shift to manufacture has ended, the dominance of the service sector has raised some discussion over the fear of aggregated productivity slowdown. The rationale behind this argument is based on the limited productivity growth abilities of the tertiary sector. Baumol (1967) gives a pessimistic projection over the augmenting of the services ("stagnant") in the total economy. Given the low productivity growth potential of the tertiary sector due to the absence of technological advancements for its output generation relative to the secondary sector ("progressive") (Baumol, Blackman & Wolff, 1985 p. 806) that only uses labour, there is a significant productivity differential that is not mirrored at the production costs and prices of the tertiary that are increasing. The shifting of resources to the "stagnant" tertiary sector due to increasing demand has a negative impact on the total productivity growth in the long run, due to the taking over of the unproductive tertiary. However, according to Fageberg (2000) the emerging of the ICT era appears to have imposed an alternative environment for productivity patterns.

For Jorgernson and Timmer (2011), the need for further investigation of the detailed industrial formation, under the ICT revolution influence, was crucial. In a disaggregated level analysis, there are service industries that portray high productivity growth like the "distribution services" i.e. trade and transportation,

while, other tertiary industries, that are related to personal services, financial and business, followed the Baumol pattern of low productivity and high employment shares and output prices. At the same time, ICT intensive service industries had contributed to productivity growth while other industries with lower ICT influence had not. He suggests that the beneficial towards the aggregate productivity growth influence of the ICT revolution is an important productivity-enhancing factor for the total economy, since it is affecting both manufacturing and services. Therefore, the authors do not agree with the characterization of services as stagnant nor unproductive sector. The significant productivity differentials within both the secondary and tertiary sectors bring about augmented aggregated productivity growth that distances from Baumol's (1967) standpoint.

In recent years, given the transition of labour overwhelmingly towards the tertiary sector, studies of structural change under the notion of the three sectors division appear to lose their relevance (Jorgenson & Timmer, 2011). However, this does not imply that the process of productivity growth through structural change has lost it importance or that it does not take place. The across industries productivity differentials create incentives for labour shifts that still place attention towards structural change (Kruger, 2008).

In this sense, Fagerberg (2000) examines the productivity growth patterns of the manufacturing sector of 39 countries for the period 1973-1990 where the annual productivity growth of the countries was 2,3%. He suggested that the industries that had achieved high productivity growth were "science-based" (Pavit, 1984, p.353) industries, like the electronic machinery that had displayed the highest productivity growth in the period, and chemicals including the pharmaceutical industry. Despite the high productivity growth, the process of structural change was limited. He suggests that the underlying reason for this state is not the decrease of the level of the labour reallocations, but rather the change of the interrelation of output and input with productivity. In the early 20$^{th}$ century, the leading technologically industries were augmenting in productivity, output, and labour input terms altogether. In the second half of the 20$^{th}$ century, the emergence of the ICT revolution loosened the connection between output, labour input, and productivity. As an ICT intensity representative, the electronics machinery industry, performed remarkable productivity growth while its labour share remained small. Industries that increased

their labour input where mainly the less productive, less ICT intensive industries. This progression highlights the difference in the industrial trajectories of past technologies and the ICT era.

The 1995 onwards productivity acceleration in the US, has been linked with the ICT diffusion in the economy. After a long period of stagnating performance starting in the 1970s until the 1980s, the overwhelming ICT investments in the 1980s and 1990s appear to have paid off. The acceleration of labour productivity, as well as, the TFP growth was linked to the ICT significant decrease of the relative prices of the ICT products (Jorgenson & Stiroh, 2000). Colecchia and Schreyer (2001) results suggest that for the 1990s ICT had increased the annual growth of the nine OECD under examination. Especially for the late 1990s, the contribution of ICT to economic growth was ranging up to 0,9% per year. It should be however noted that the performance of countries was not identical. Only the US had managed to have the highest contributions to growth from ICT.

The question that rose was whether the productivity acceleration is solely attributed to ICT producing industries, rather than the whole economy. It was a matter of whether the ICT using industries were contributing also to growth through the ICT diffusion. Gordon (1999) has been rather reserved on role of the ICT investments as a driving force of the productivity acceleration for the US in the post 1995 period. He suggests that, despite the fact that productivity levels after 1995 had indeed increased due to the diffusion of the ICT, the increased productivity was attributed to the limited ICT producing industries and cyclical productivity growth.

For the US, Stiroh (2002) stressed the argument that the productivity growth of the 1995 onwards was not a cyclical intervention, but rather a "real phenomenon" (Stiroh, 2002 p. 1575). In addition, he has shown that the ICT producing industries and the ICT using industries have been responsible for the total productivity acceleration while industries that were not ICT users contributed negatively to productivity growth.

It appears, therefore, that there are strong reasons to accept the wide spread ICT diffusion hypothesis for the ICT producing and ICT using industries. However, this claim cannot be easily generalized outside the US. The case of the European economic transformation into the "new economy" seems to be sluggish when compared in productivity growth terms productivity performance (van Ark, Inklaar

& Mcguckin, 2003a) The acceleration of the US productivity growth for the 1995 to 2000 period, was 2,5%. In contrast, Europe had faster productivity growth in the 1990 to 1995 period, rather than the 1995 to 2000. One possible explanation for this productivity differential is offered by van Ark et al (2003a) after conducting a modified shift share analysis on productivity growth under the notion of ICT sectors on the productivity growth differential for the US and Europe[5] for the period of 1995 to 2000. One conclusion derived from the study is that the vast amount of differences between the two countries productivity growth rates, is attributed to the ICT using service industries and the ICT producing industries differentials in productivity growth. Under a more detailed examination, it is implied that, the productivity growth of the ICT using services in the US, was faster than in the corresponding sector in Europe. The contribution of the higher level of employment share on the ICT producing industries for the US industries compared to European's also played a role on the productivity differentials of the two countries. It should be noted that for Europe, the most contributing to productivity growth industries, were the ICT producing industries and the non ICT industries while for the US were by far the ICT using industries. One European country however, that managed to accelerate its productivity growth and even surpass the US during the 1995 to 2000, was Finland.

From a historical perspective, Jalava (2006) addresses two main perspectives of the industrial productivity performance in the three sectors of the economy. The general outcome of the study is that labour productivity had played an important role to the overall Finnish economic performance, since labour input has considerably decreased over the last century. When it comes to the structural change, its contribution had been limited compared to the within sector productivity. Reallocation of resources accounts approximately for 50% of the productivity growth only in the interval of 1861-1949. After that period, the effect had been insignificant.

When it comes to the Finnish ICT frond, Jalava and Pohjola (2007) estimated that the ICT revolution enhanced labour productivity by 2.87% which could be interpreted as 65% of the growth of GDP/ hour worked. Moreover, 20% of the GDP growth was derived from producing electronic equipment in the period of 1995 to 2005. When it comes to ICT capital intensity, in a comparison with the US even if

[5] The countries examined in the study are Austria, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain and Sweden.

Finland's ICT capital is augmenting directly the economic growth, contributing by 13.95%, still, it is lower than the corresponding figure for the US. They are skeptical about the future prospects of the ICTs and if the upward productivity trend that has been portrayed is actually sustainable. In addition, one worrisome progression has been Finland's dependency on ICT production and the continuous towards cheaper countries outsourcing for the production of ICT equipment (Jalava & Pohjola, 2007).

# 4. Methodological approach and data

## 4.1 The model

Productivity is defined as the total output of an economy divided by the total input. In this sense, labour productivity could be derived by the total value added divided by total hours worked. With the shift share analysis labour and output are set to portray the changes of productivity growth in the period under examination and define the processes that are contributing the most for the total productivity growth, the internal sectoral improvements by the technological advancements and the reallocations of labour inputs.

This method used in this study, captures the effects of productivity growth within and between sectors that contribute to the total productivity change. According to the model of shift share analysis presented by Wang and Szirmai (2008) total productivity change could be seen as a summation of three distinct productivity patterns. To start with, the "within sector productivity" is the first part of the summation and it refers to productivity changes that occur in different sectors of the economy assuming that the labour inputs are constant. It implies that only improvements in productivity within the industries of the sectors take place that contribute to the total productivity growth. It "isolates", therefore, productivity changes from the structural change effect. The second term, the "static shift", accounts for changes in the employment shares, while productivity levels of the sectors are constant. It represents the productivity growth that is achieved solely by relocation of labour between sectors. Its positive sign means that the labour share of the sector is augmenting, and therefore, labour is shift to more productive sectors. Lastly, the third term is assuming that neither the productivity level nor the

employment share are constant and, consequently, accounts for the interaction of the within and static effect in total productivity growth. It is expressing the reallocation of resources to sectors with higher productivity growth rates. The summation of the static and the interaction effect, delivers the portion of the total productivity growth that is attributed to reallocation of resources, i.e. structural change.

$$\frac{P^t - P^0}{P^0} = \frac{\sum_{i=1}^{n}(P_i^t - P_i^0)S_i^0}{P^0} + \frac{\sum_{i=1}^{n}(S_i^t - S_i^0)P_i^0}{P^0} + \frac{\sum_{i=1}^{n}(S_i^t - S_i^0)(P_i^t - P_i^0)}{P^0}$$

Where $P_i^t$ signifies the labour productivity of the sector i in the year t , $P_i^0$ the labour productivity in the year 0 and $S_i^t$ and $S_i^0$ are the hours worked in the sector i in the year t and 0 respectively (Wang & Szirmai, 2008, p. 846).

## 4.2 Limitations of the model

The shift share analysis is a comprehensive and easy to follow method. Its findings are straightforward and therefore, make the interpretation of the two processes of productivity growth, improvements in inner industrial performance structural change, clear. However, this method has also limitations, with the most important being its one-dimensional approach on the drivers of productivity growth.

Capital productivity and total factor productivity, two significant estimations for economic performance are not included in the methodological process. It is as state a "partial measurement" (Wang & Szirmai, 2008 p.846) of productivity that focuses solely on the supply side of productivity since it is only takes into account labour for the growth of productivity. In addition to this, sources of productivity and consequently economic growth like the role of economies of scale and their positive contribution, through technological spillovers in each sector are not taken into account. Moreover, one other limitation is its lack of sensitivity when it comes to the intermediate values of the variables (Wang & Szirmai, 2008). Since it is considering solely the first and last values of the period interested, it fails to depict the progression of productivity levels of labour shares. This is partially resolved by the division of the total period into four time intervals. These eight points of observation for productivity and structural change developments, instead of the first and last observation on the total period, give a more accurate indication of the total productivity growth pattern. Therefore, the same methodological approach is been used for the periods of 1975-1983, 1984-1992, 1993-2001 and 2002-2011. Despites

its restrictions, for the needs of this study that aims at evaluating how productivity changes generates labour mobility under the hypothesis of the ICT pervasiveness with different levels of intensity in the sectors, the shift share model appears to be cohesive tool that is simple and comprehensive character compensates for its limitations.

## 4.3 Classification of the sectors

The study employs a two shift-share approach based on the different classification of the sectors used. Firstly, the three sectors shift share takes place. The total economy is classified under the notion of the three sectors of the economy, the primary, the secondary and the tertiary sector. This classification does not give any insight on the ICT intensity of the industries of the total economy.

The need, therefore, for creating a new classification for the ICT sector economy lies on the center of this research. The 86 industries at two digit disaggregation that comprise the total Finnish economy are being categorized depending on their ICT intensity in the ICT producing, ICT using, less ICT and other industries. Parallel to this the four sectors are sub divided into manufacturing and services.[6] The ICT intensity criteria of the ICT taxonomy is based on ICT capital service flows of the total capital service flow. ICT capital service flows refer to the conversion of capital assets into "standard efficiency units" which accounts for the value of an asset given its depreciation rate, and weighed by the "user cost of capital" for each asset.[7] Given the high rate of depreciation for ICT capital the flows of capital services should be high (van Ark et all, 2003b). The classification of the industries depending on their rate of ICT service flows relative to the total capital service flows, has been adopted by van Ark et all (2003b). The original formation of the sectors under the capital services flows belongs to Stiroh (2001), that conducted the classification for ICT producing, ICT using and other industries for the US industries in 1995.

[6] See the taxonomy of the industries in the corresponding ICT sectors in the Appendix
[7] See van Ark et al (2003) , Stiroh (2001) and OECD Manual-Measurement of Capital Stocks (2001)

### 4.4 Data

To account for changes on productivity, the use of the detailed and more up-to-date (until 2011) dataset on Value Added and Hours Worked at a sectorial (two digits) level from statistics Finland national accounts is used. The Value Added has been deflated with the price index provided by statistics Finland at a 1972 base year. The results that will be derived from the method will portray the current state of productivity growth for Finland's economy. Van Ark et al (2003b) are using the OECD STAN REV3 database for their estimations. The industries that comprise the total economy do not share similar industry names and therefore an attempt was made towards the less deviations from the Van Ark et al. categorization and the STAN database. The reason for not using the same database lies on the fact that STAN REV 3 database, obtains observations until 2009, while the range of the period that this study covers is until 2011.

# 5. Results

## 5.1. Three Sector economy

The evaluation of Finland's industrial productivity patterns begins with the overview of the value added and hours worked progression over the period of 1975 to 2011 in the three sectors of the economy and the individual industries. Furthermore, the productivity trajectories that have been formed in the three sectors of the economy are assessed placing great emphasis on industries with above average productivity levels and productivity growth of the secondary and tertiary sector. Finally, the results of the "three sectors" shift share analysis are presented by examining the impact of structural change and industry level productivity improvements on total productivity growth that constitute its driving forces.

### 5.1.1 Value added and hours worked in the three sectors of the economy

What could be instantly observed from the diagrams is the diminishing role of the primary sector and the increasing importance of services in value added shared.

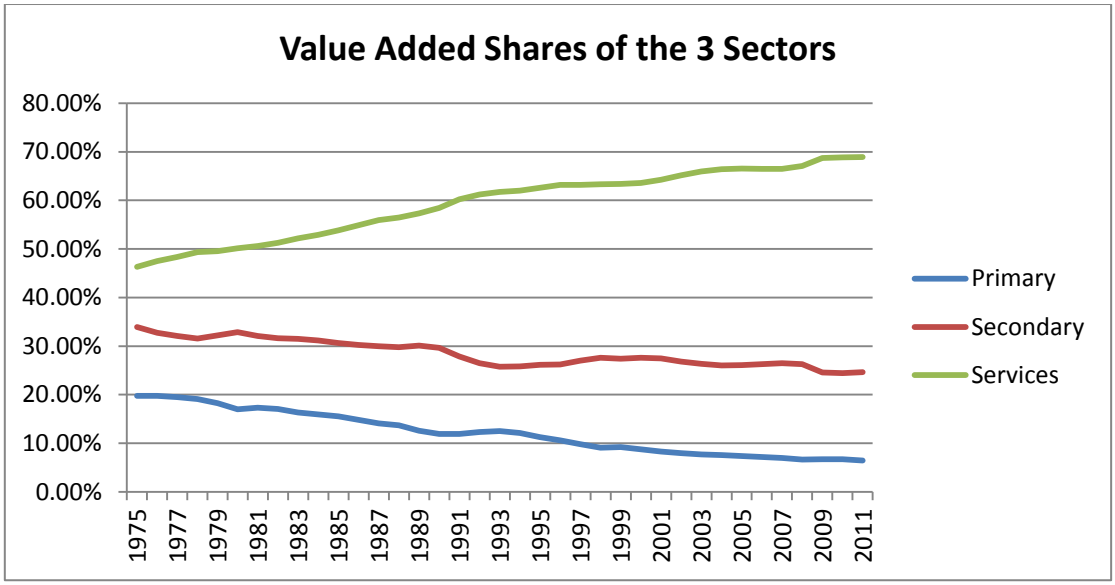


Figure 1. Value Added Shares of the 3 Sectors, Data Statistics Finland, own calculations.

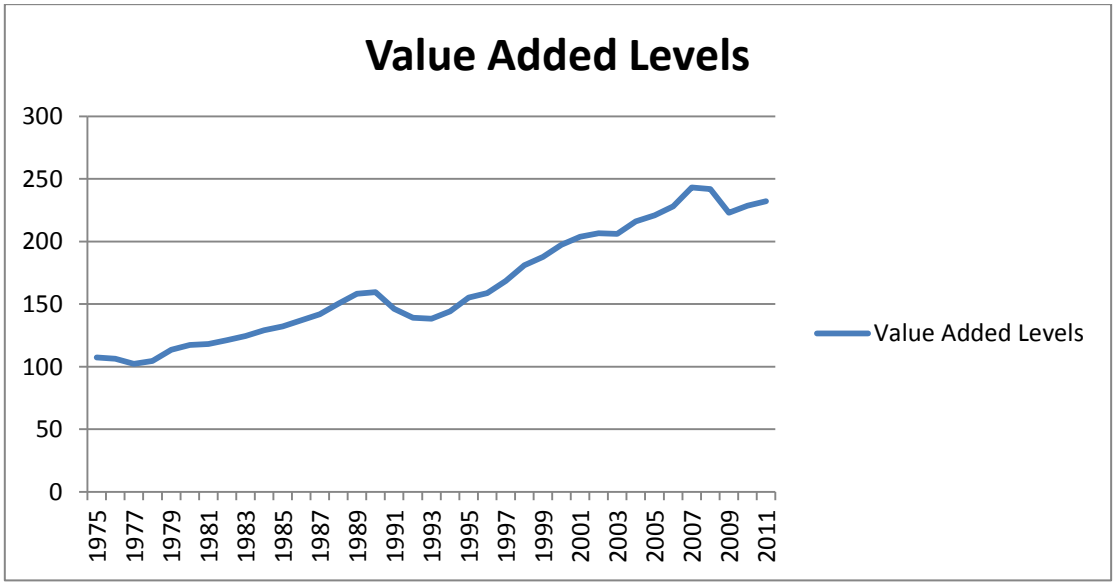


Figure 2. Value Added Levels, Data Statistics Finland, own calculations.

From the start of the period, the tertiary sector was the most contributing in value added terms. The secondary sector has been contracted and by 2011 it had decreased by 11% (Figure 1). A similar progression was observed in the primary sector with a total 14% decline. In the beginning of the period, the primary sector

held approximately 11% of the total value added, highlighting the importance of agriculture in the economy, whereas the secondary accounted for the 39% and the tertiary for the rest half of the total production. By 2011, services have augmented their total value added by 19%, reaching 69% of the total value added produced. At an industry level examination, For the 36 years of the period, the majority of the most contributing[8] to the economic activity industries in value added terms belong to the tertiary sector. The highest in value added industry is the real estate activities followed by construction, public administration, education, wholesale trade, health activities, retail trade, land transport, paper industry, social work activities, and electronics.

As far as the annual value added growth is concern, in 1976 growth decreased by 3,77% but it was quickly overpassed and reached the highest ever since value added growth in 1978.

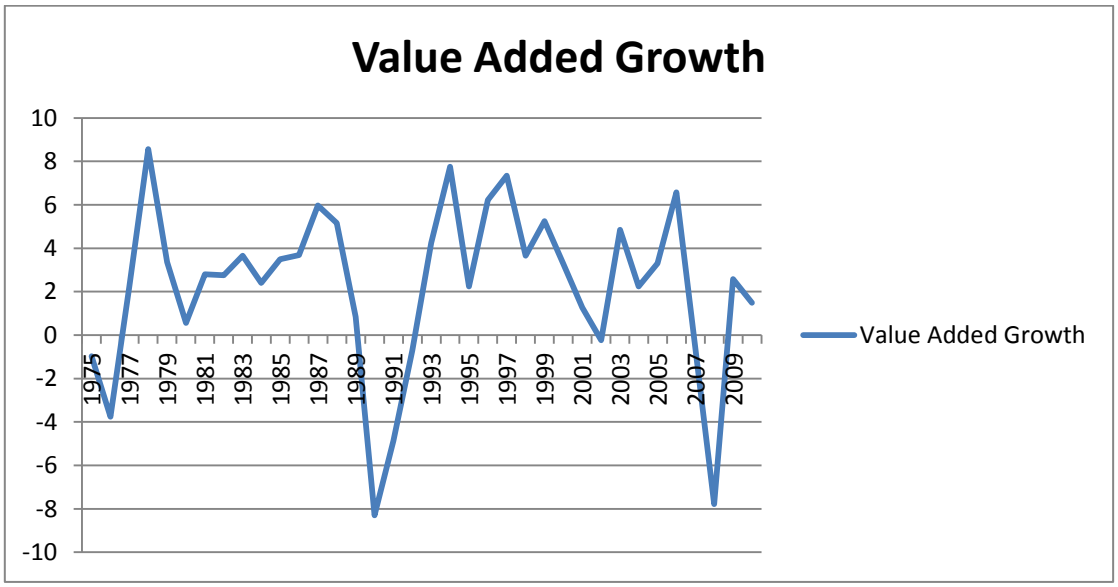


Figure 3. Value Added Growth, Data Statistics Finland, own calculations.

The crisis of the early 1990s hit Finland hard, mirrored by a drop of 8,29% in the growth of output and took 3 years for Finland's economy to bounce back. The year 2009 has also been a significant breaking point in value added growth, that reached -7,78%. After the economic plummeting of 2009, economy returned to positive output growth the following year but the level of value added in absolute terms indicates that the economy until 2011 had not returned to prior to 2009 levels.

[8] The most contributing to economic activity industries are expressed by their average value added levels. See appendix for the total industries ranking.

Contrary to this economic trajectory, there had also been periods of great output increase. The growth of value added in 1979, as mentioned above, was raised to 8,56% and generally throughout the 1980s Finland was portraying positive annual growth. The same goes for the for the period from 1994 to 2006 with the highest rates observed in 1994 (7,75%), 1997 (7,35%), and 2006 (6,58%). After an examination of the fastest growing industries in value added growth terms for the whole period, activities auxiliary to financial and insurance activities, insurance activities, mining of metal ores, management consultancy, legal and accounting activities, and electronics are the industries that displayed the highest value added growth.

Figure 2 depicts the labour input shares measured in hours worked for the three sectors. In absolute terms, the total labour has decreased by 1.959 hours from 1975. The hours worked share of the primary sector has decreased by 13% of the total period.

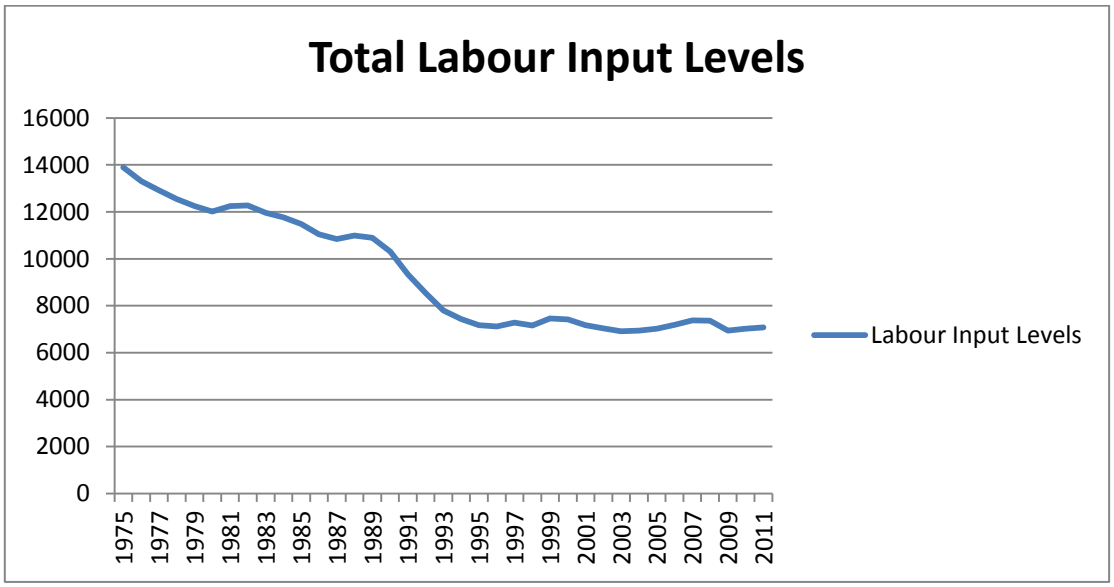


Figure 4. Total Labour Input Levels, Data Statistics Finland, own calculations.

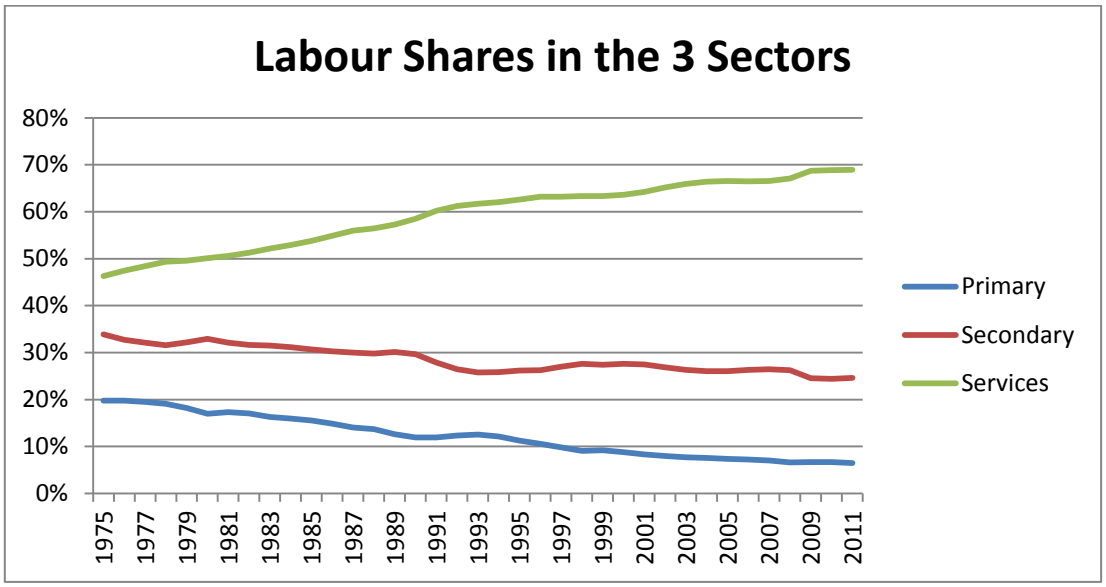


Figure 5. Labour Shares in the 3 Sectors, Data Statistics Finland, own calculations.

Despite the contentious decline of the primary sector in labour shares, it had not reached its lowest point yet, since the decrease was ongoing until 2011, in which point its contribution in labour was at 6%. A similar progression was observed for the secondary sector, which had 9% decrease from 1975 to 2011. The labour shedding from the primary and secondary sectors have attached to the augmenting tertiary sector. Therefore, the tertiary sector's hours worked have increased by 23% from 1975.

What could be drawn upon from the two figures is the significance of the tertiary sector for the economic activity of Finland the past 36 years contributing with more than half of the total value added on 2011. However, defining Finland as a service economy according to Hartwell (Hjerppe, 1989) stage of development categorization, is not validated, since services share in employment is increasing at the expense of both the primary and the secondary. What is more, labour input has decreased from 1975 and at the same time, output has increased in absolute terms. This fact puts great emphasis on the role of productivity growth in the economy.

### 5.1.2 Productivity Patterns

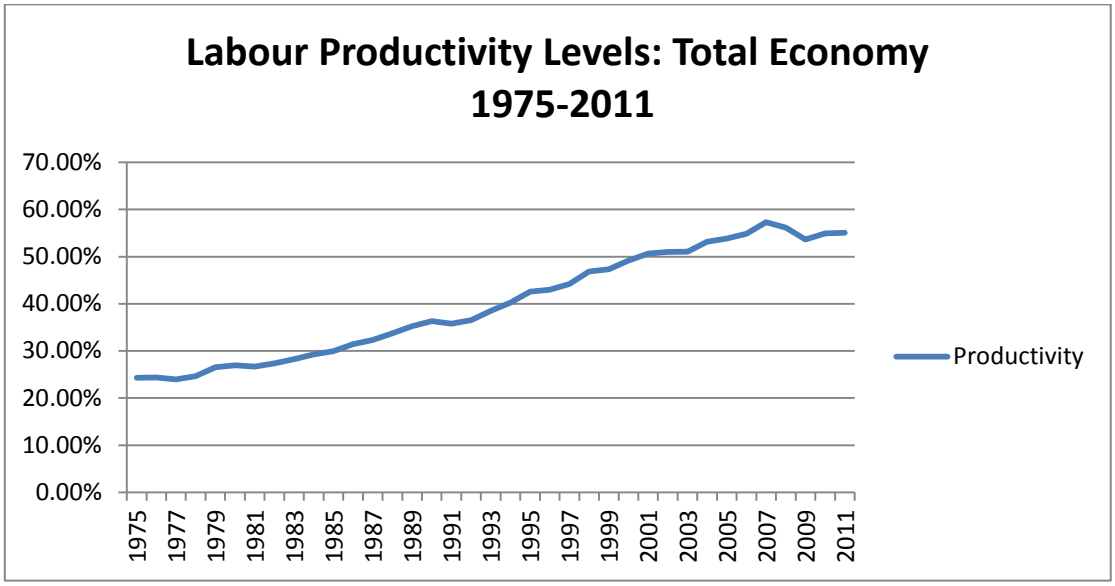


Figure 6. Labour Productivity Levels: Total Economy 1975-2011, Data Statistics Finland, own calculations.

Productivity has shown a significant increase from 1975 to 2007, as observed from Figure 6. For the next years of the period, it decreases and reaches a lowest in 2009. By 2009, productivity has increased but not in pre-2007 levels (figure 7). By using the HP-Filter(1997), the depiction of productivity's long term pattern is clearly depicted. The general trend of productivity is a deceleration of the growth pace that begins to radically decline after the 1990s. Looking at the raw data, There were two periods where productivity growth turned negative, in 1990s and 2008 (figure 3). Both related to crisis periods.

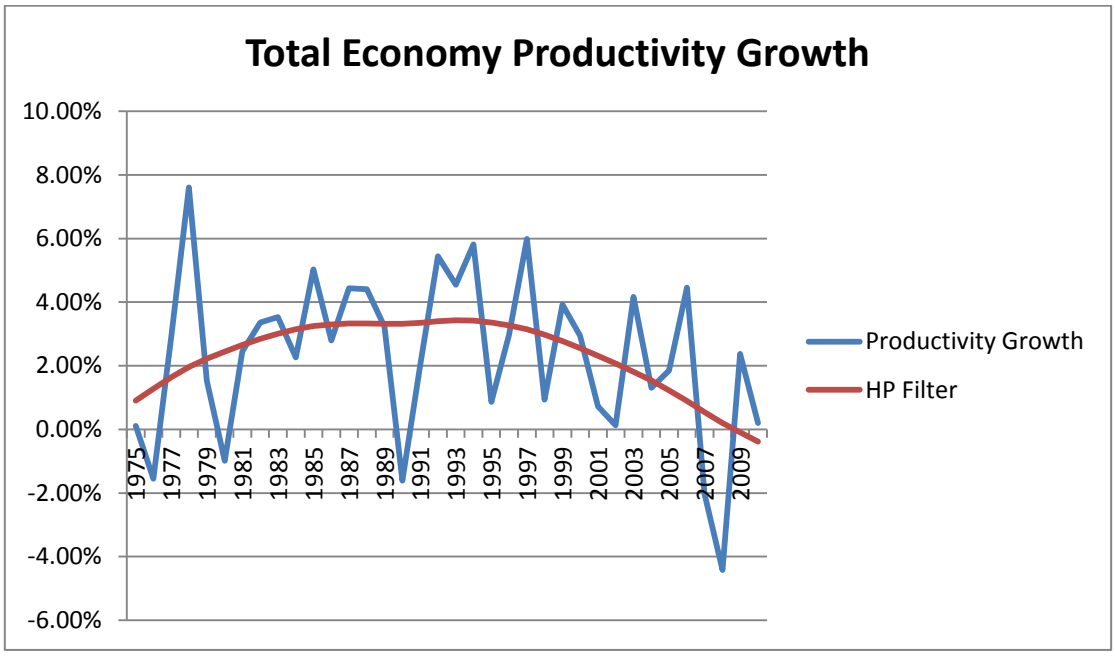


Figure 7. Total Economy Productivity Growth, Data Statistics Finland, own calculations.

Under a sectoral level examination, what could be observed is that productivity in the primary sector shows a moderate productivity progression compared to the other two sectors, increasing by 11,38% from 1975, apparently due to its excess labour shedding process. Both services and manufacturing are displaying higher productivity than the total productivity. When it comes to the tertiary sector, during the 36 years of the period, productivity in absolute numbers has grown 34%. The decrease of productivity growth rates starts at 1987 and continuous throughout the rest of the period. The secondary sector is also displaying a significant productivity progression. Especially, after the crisis of the early 1990s, the secondary sector's productivity level is augmenting remarkably and by 2007, it reaches its highest level. In growth terms, after 1995 productivity acceleration of the secondary sector starts to decline. The average productivity growth of the post 1995 period is 1,5% contrary to the pre 1994 that reaches 3,12%. The same figures for the tertiary are 2,36% and 1,77% respectably for the periods. Productivity growth has increased in agriculture for the same periods by 1,23%.

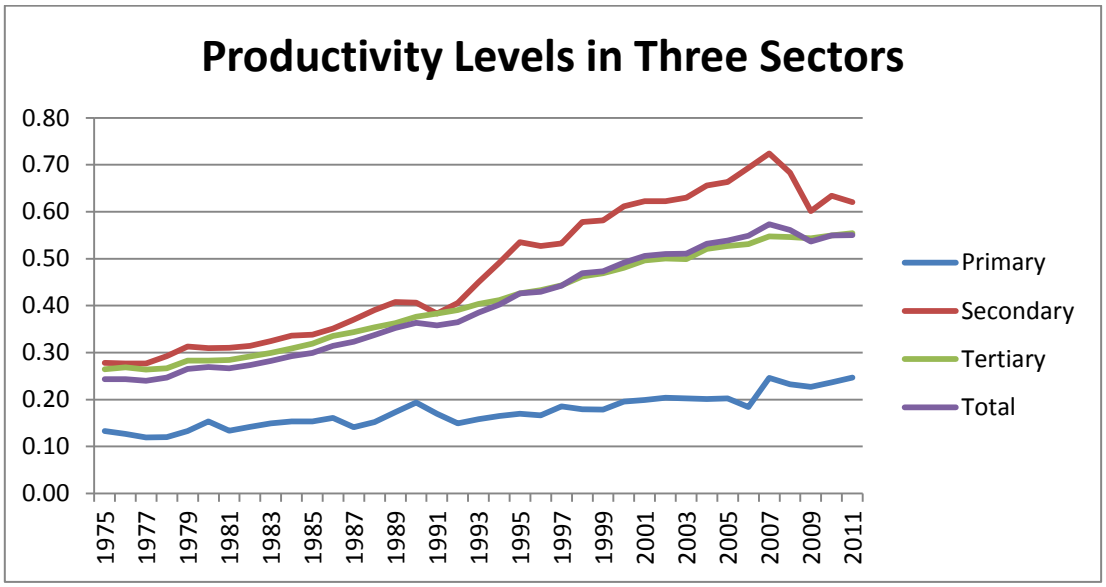


Figure 8. Productivity Levels in Three Sectors, Data Statistics Finland, own calculations.

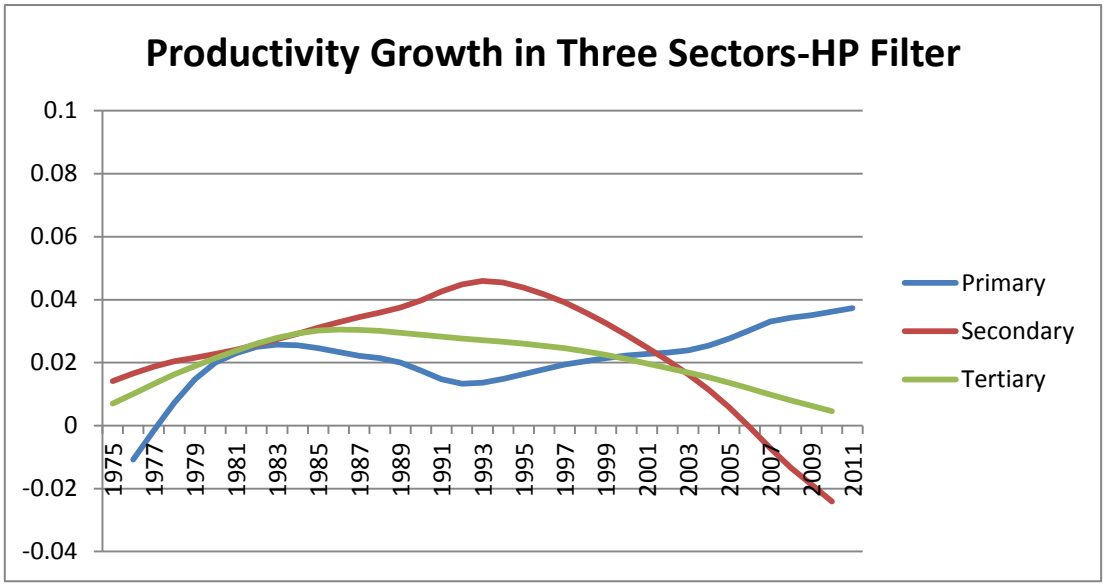


Figure 9. Productivity Growth in Three Sectors-HP Filter, Data Statistics Finland, own calculations.

In a more detailed examination of the productivity progression of the manufacturing sector, the productivity levels and growth rates of the secondary sector industries are presented (figure 4). For agriculture, the industry with higher average productivity growth and level is fishing. Industries that are engaged with the extraction, production, and refinement of ores and chemical products appear to feature in the top of the average productivity-level industries taxation. In addition to this, paper industry, electronics, and industries dealing with the manufacturing of beverages are also exhibiting above average productivity. Furthermore, the electricity, gas, steam and air conditioning supply, water supply and waste

management and construction sectors are as well highly productive.[9] The least productive sectors are the wearing apparel production and mining support service activities.

When it comes to speeding up productivity pace, similar to the average productivity levels, mining related industries with mining of metal ores, manufacturing of coke and refined petroleum products and chemical related industries with pharmaceuticals are performing the highest productivity growth rates. Moreover, forest related industries like paper and woodworking industries have also undergone significant productivity growth. The electronics industry has also delivered higher than average productivity growth, as also did the electricity, gas, steam, and air conditioning supply sector. On the contrary, mining support service activities and manufacture of tobacco products are show the least productivity growth.

For the tertiary sector, the most productive industry of the period is real estate, whose volume of productivity is influenced by the large employment share in the sector. Air transport and telecommunications together with rental and leasing activities are also amongst the industries with above average productivity. The financial and insurance activities demonstrate a significant productivity progression followed by the audio-visual activities. Household activities and food and restaurant activities are holding the last places of the productivity levels. Fast growing industries in productivity terms are insurance, with productivity growth 6 fold higher than the above average productivity growth service industries, auxiliary activities to financial and insurance activities, telecommunications and management consultancy. Financial, legal and accounting and social work activities also featuring in the higher than mean service activities. Successively, wholesale trade, travel agencies security and investigation and postal and courier, publishing rental and leasing and household activities are too above average productivity acceleration rates. At the bottom ranks of productivity, growth features the membership organizations and office administration activities.

After having examined the productivity patterns of the Finnish economy in terms of productivity levels and productivity growth, the mechanisms responsible for

[9] A further disaggregation to industrial level of the electricity, gas ,steam and air conditioning supply, water supply and waste management and construction sectors was impossible due to lack of two digit value added and hours worked data therefore they are assessed as whole.

these productivity trajectories, i.e. improvements of productivity in the industries' production and reallocation of resources from less productive sectors to sectors that are more productive, are evaluated. To distinguish the degree of their involvement to the total productivity growth, the shift share analysis is used.

## 5.2. Shift Share analysis

One solid result from the three sectors shift share analysis of the whole period 1975-2011 is that productivity gains are vastly delivered from productivity improvements within the sectors. As far as the structural change effect on total productivity, it is far less significant.

Total productivity growth that occurred during the period under examination reaches 125,81%. 111,61% of the total growth is attributed to within sector productivity change. An interpretation of this progression could be that the technological advancements and efficiency improvements that took place in the production mechanisms of industries are responsible for the productivity growth of the sectors and consequently of the total economy. It also highlights the relative employment share as an influential factor for the growth of the effect. More specifically, the sector with the highest within productivity improvements is the tertiary followed by the secondary and the primary. Their contribution to the within productivity change is 54,81%, 47,55% and 9,25% responsively.

However, as seen from the Figure 9 the tertiary does not portray higher productivity levels than the secondary. In addition to this, the data suggest that the productivity growth over the period for the secondary is higher than the tertiary. They do, nevertheless, suggest a remarkable decrease in terms of employment shares for the secondary, whose decline stands for -9 % from 1975 to 2011. For the tertiary, the increase of employment share between the first and last year of the period is 23%. When considering the 1975 employment shares, clearly, the tertiary is advancing compared to the other two sectors, with 46,32% of the total employment share. The interpretation, therefore, for the result is that the 111,07% contribution of the total 125,81% productivity growth from the within productivity change is attributed to all three sectors but the most contributing sector of the economy to productivity growth is the tertiary due to its vast size in employment shares.

Structural change, as a process of productivity growth is contributing 14,20% to the total productivity growth. This means that 14,20% of total productivity growth is attributed to the reallocation of resources to more productive sectors. When examining the interaction and static effect it appears that reallocations are largely oriented to the tertiary sector. More specifically, 7,50% of the total productivity growth is due to the reallocation of resources from industries with relatively lower productivity growth to industries with faster productivity growth. given the negative impact of both the primary and the tertiary to the interaction effect, labour is channeled to the faster growing tertiary sectors industries. The 6,70% contribution of the static effect refers to redistributions of labour inputs to the more productive industries of the tertiary from the less productive primary and secondary industries.

At this point it should be mentioned that reallocation of resources do not occur solely towards the tertiary industries, as it could be mistakenly thought. Since the shift share is dealing with aggregated sectors, the productivity and labour inputs progressions of single industries are not apparent. What the model suggests is that the sectorial total employment shares and total productivity growth are showing the general trend that is attained after the summation of the industry level changes of productivity and labour. For the tertiary, the portion of the decline of the labour input in industries is smaller than augmenting of others

**Table 1. Data Statistics Finland, own calculations.**

| 1975-2011 | Within | Static | Interaction |
|---|---|---|---|
| Primary | 9,25% | -7,29% | -6,23% |
| Secondary | 47,55% | -10,61% | -13,02% |
| Tertiary | 54,81% | 24,60% | 26,74% |
| Total | 111,61% | 6,70% | 7,50% |

| Total Productivity | Structural Change |
|---|---|
| 125,81% | 14,20% |

The total period shift share analysis as mentioned in the previous section, does not leave room for a view of the process of structural change between the years and significant developments, could remain "hidden". Therefore, the period is divided

into successive sub-periods of 10 and 11 years and form the 1975-1983, 1984-1992, 1993-2001 and 2002-2011 periods.

### 5.2.1 Four Period Shift Share for the 3 sectors

The findings of the first period (1975-1983) shift share analysis indicate that productivity growth over this period is 16,19%. The within industry productivity improvements are reaching 14,30% with structural change holding the rest 1,89% of the total productivity growth. The secondary and the tertiary are displaying equal within productivity growth effect of 6,50% while, the primary's contribution to the effect is 1,29%.

Table 2. Data Statistics Finland, own calculations.

| 1975-1983 | Within | Static | Interaction |
|---|---|---|---|
| Primary | 1,29% | -1,90% | -0,23% |
| Secondary | 6,49% | -2,72% | -0,46% |
| Tertiary | 6,51% | 6,37% | 0,82% |
| Total | 14,30% | 1,75% | 0,14% |
| | | | |
| Total Productivity | | Structural Change | |
| 16,19% | | 1,89% | |

Structural change adds a 1,89% on the total productivity growth and resources are oriented mainly towards the more productive tertiary sector since the static effect is 1,61% higher than the interaction effect. If the contribution of the within productivity change effect did not occurred, solely reallocation of resources to sectors with higher productivity growth (static effect), the total productivity growth would have stand 1,75%.

For the 1984-1992 period, total productivity is growing by 24,77%. Again, the productivity changes are largely coming from within industries' productivity improvements. The primary sector had negative productivity differential between the

last and first year of the period that is depicted to the negative sign of the within productivity effect.

Table 3. Data Statistics Finland, own calculations.

| 1984-1992 | Within | Static | Interaction |
|---|---|---|---|
| Primary | -0,22% | -1,90% | 0,05% |
| Secondary | 7,43% | -5,39% | -1,12% |
| Tertiary | 14,81% | 8,77% | 2,33% |
| Total | 22,02% | 1,48% | 1,26% |
| | | | |
| Total Productivity | | Structural Change | |
| 24,77% | | 2,74% | |

The influence of the structural change process is 2,74% with the static effect and interactive effect having almost similar impact on structural change. The secondary sector appears to have losses in labour share during this period with a parallel higher productivity level in the end of the period. The crisis of the 1990s have affected to a great extend the productivity pattern in the secondary sector. As the data suggest, the productivity growth for 1990 to 1991 dropped on average by 3%. However, the rest of the period's productivity growth is fast. The next year it bounced back to higher than 1984 growth rates. The use of 1992 as the last year of the period was selected to limit the crisis effect. The primary is losing both labour and productivity while the tertiary is augmenting in both aspects. Both structural change effects signify the reallocation of labour to the higher and faster growing productivity tertiary industries.

The third period has had the fastest total productivity growth relative to the other periods. In the same sense, structural change process is also reaching its highest contribution to growth.

Table 4. Data Statistics Finland, own calculations.

| 1993-2001 | Within | Static | Interaction |
|---|---|---|---|
| Primary | 1,33% | -1,73% | -0,45% |
| Secondary | 11,58% | 1,99% | 0,77% |
| Tertiary | 14,80% | 2,63% | 0,60% |
| Total | 27,71% | 2,89% | 0,92% |
| | | | |
| Total Productivity | | Structural Change | |
| 31,52% | | 3,81% | |

The 31,52% total productivity growth that is by 27,71% attained by within productivity growth and 3,81% by structural change. What could be drawn upon from the 3rd period shift share analysis is that, both the secondary and the tertiary are displaying strong within productivity improvements and resources are absorbed by them both, to their more productive industries.

The final period (2002-2011) displays a significant slowdown on productivity progression, when compared to the previous period. Total productivity growth has decreased its growth pace relatively to the previous period, at 7,76% growth rate.

Table 5. Data Statistics Finland, own calculations.

| 2002-2011 | Within | Static | Interaction |
|---|---|---|---|
| Primary | 0,67% | -0,60% | 0,31% |
| Secondary | -0,19% | -2,72% | 0,00% |
| Tertiary | 6,63% | 3,65% | 0,00% |
| Total | 7,11% | 0,34% | 0,31% |
| | | | |
| Total Productivity | | Structural Change | |
| 7,76% | | 0,65% | |

The driving force of productivity growth is within productivity change effect, and structural change is at its lowest point with 0,65% contribution to the total productivity acceleration. The secondary sector has negative within productivity growth underlying the significant decrease of productivity that occurred in the last years of this 10 years period. The employment leakage of the secondary is also large and it had decreased by -2% between 2002 and 2011, a progression that is depicted in the negative static effect. It, therefore, implies that labour is shifting away from the less productive secondary sector's industries to the more productive tertiary's. Both the tertiary's with 6,36% and the primary's with 0,67% within productivity change effect states that productivity had augmented for them in the 4$^{th}$ period. However, different reasons structure this progression. For the tertiary, productivity grew on the basis of an increase of labour share, while for the primary due to labour sheading as implied by the interaction effect. Labour inputs are shifted from the less productive primary and secondary sectors. The interactive effect in this period is rather small and therefore its contribution limited. However, it implies that labour inputs are directed away from low productivity growth agriculture and into the productivity accelerating industries of the tertiary sector.

After having examined the productivity trends of the total period and sub periods under the three sector hypothesis, the ICT intensity sectors productivity patterns are being evaluated starting with the value added and labour input developments for the ICT sectors.

## 5.3 ICT Intensity Sectors

The value added shares illustrate the augmenting of the less ICT services sector. By 2011 it account for 44% of the total value added produced. An increasing contribution to the total value added over the period is displayed by the ICT using services. For all the manufacturing industries, apart from the ICT Producing Manufacturing, the value added share is declining in favor of the services industries.

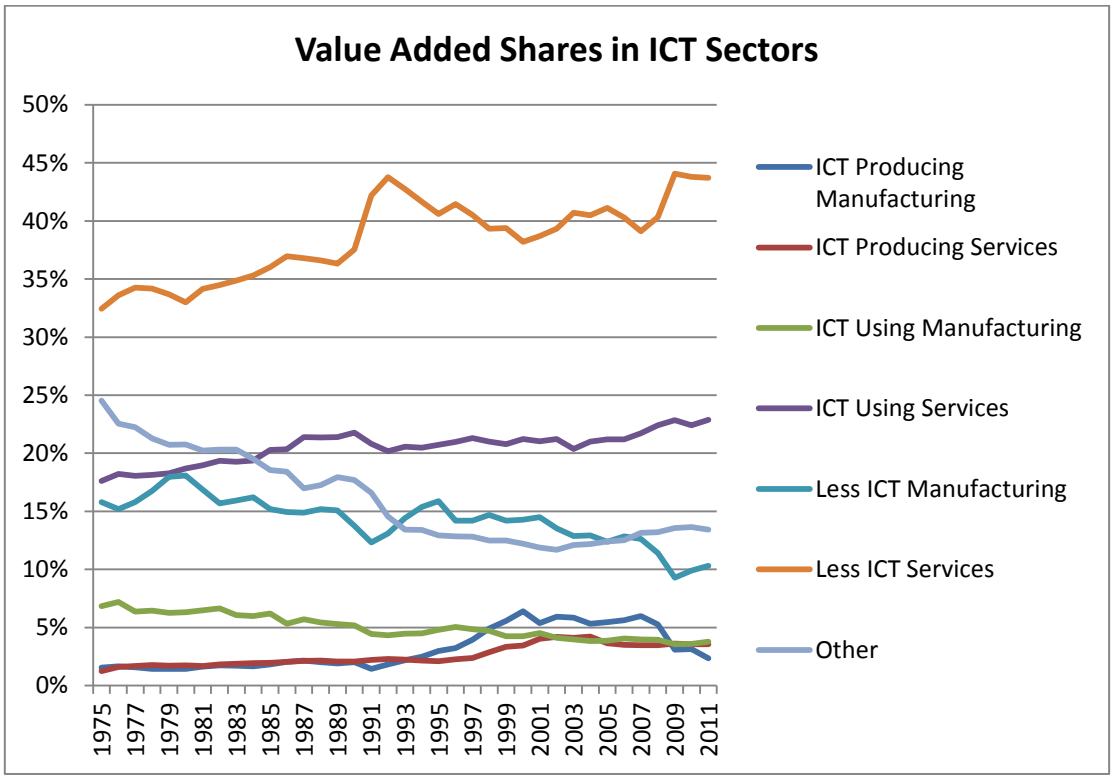


Figure 10. Value Added Shares in ICT Sectors, Data Statistics Finland, own calculations.

The labour shares of the ICT sectors are presented in Figure 11. The less ICT sector has the most significant increase from 1975 to 2011 followed by the ICT using services. Also, with a smaller labour share that in 1975 barely reached 1,52% and 0,78% respectably, the ICT producing manufacturing and ICT producing services are increasing their labour share on the total economy. In 2011 they account for 2,02% and 2,04%. The highest share for the ICT producing sector was in 2000 with 2,61% of contribution to the total labour shares. The ICT using manufacturing is following a downturn trend, while the ICT using services are augmenting by 5,50% from the start of the period. The fall of the other industries sector has been rather significant with 15% decrease.

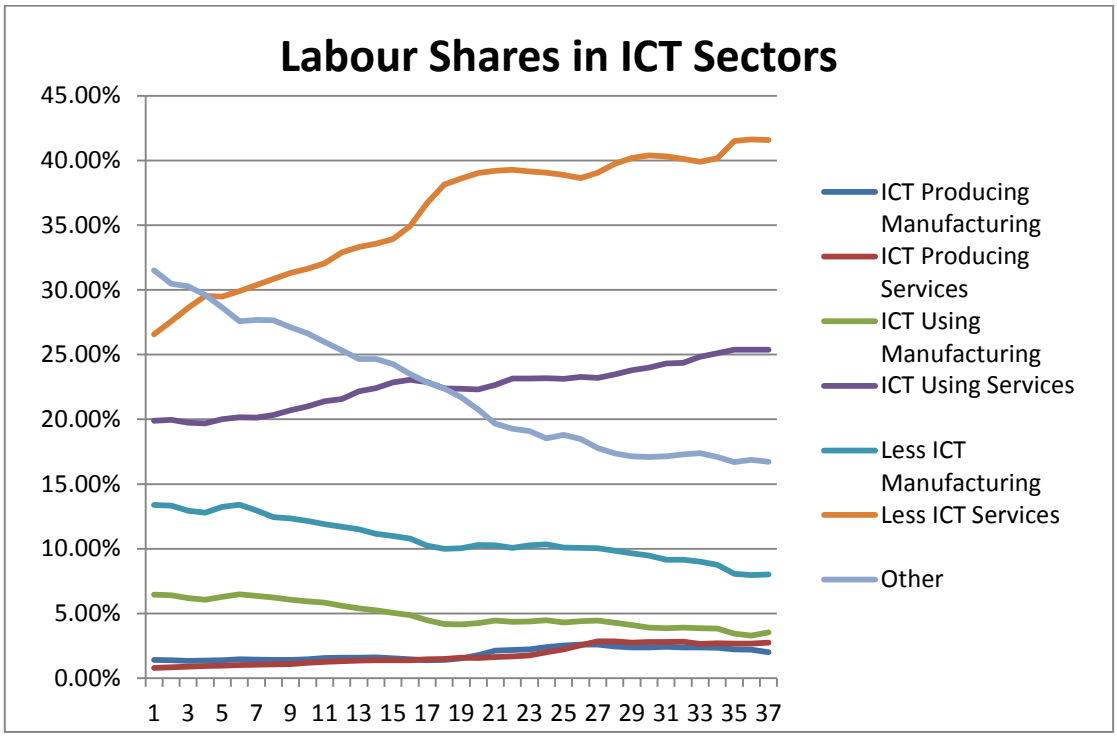


Figure 11. Value Added Shares in ICT Sectors, Data Statistics Finland, own calculations.

The productivity growth trend for the ICT sectors is being revealed through the HP filter smoothening out of the business cycles effects. The ICT producing Manufacturing is demonstrating a distinctive pattern of productivity growth relatively to the rest of the sectors. Its increase in the 1990s has been noteworthy as was its rapid decline in the late 2000s. In 1997, its annual growth had been 27%, the largest growth in the period. However, the decline of the sector in the 1990-1991 due to the crisis has given a relative good starting point for productivity growth since it has been lower than normal. The average annual productivity growth has been 3,51%. All sectors have shown an upward trend during the same period but none comparable to the ICT producing manufacturing. The general decline trend of the late 2000s is followed by all sectors.

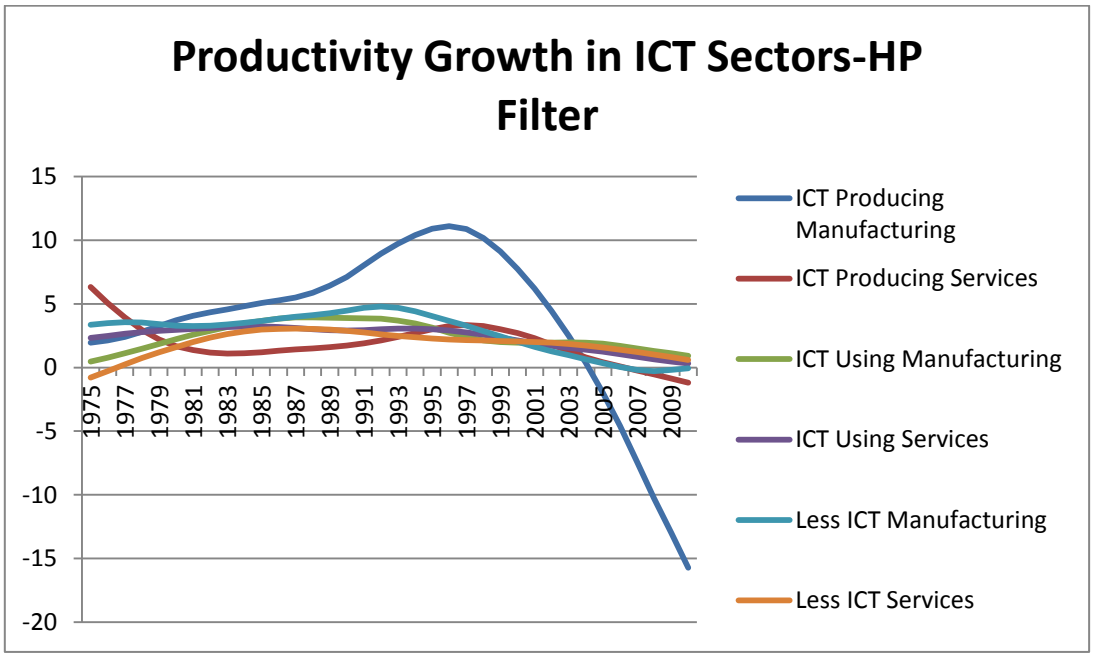


Figure 12. Productivity Growth in ICT Sectors-HP Filter, Data Statistics Finland, own calculations.

### 5.3.1 ICT Shift Share Analysis

The results from the three sectors shift share analysis of the 3rd period, illustrate a rather significant productivity trajectory. The productivity growth that occurred during the second part of the 1990s coincides with the emerging of the ICT era and ICT cluster for Finland. This fact, gives a special role to the ICT diffusion as a mechanism that triggers productivity growth. Therefore, the reallocations of resources towards more productive sectors will coincide with the reallocation of labour to the sectors with the higher ICT intensity, which will be the most productive ones, as suggested by the theory, since ICTs fulfill the GPTs criteria. If not, and, hence, structural change is negative, the industries that are under the sectors have not fulfilled their ICT diffusion potential under the ICT intensity taxonomy of the industries.

In order to examine the progression of structural change under the notion of the ICT intensity mechanism of growth, an ICT shift share is conducted. As in the three sectors shift share, measurements for the whole 1975 to 2011 period and for the four sub periods are taking place.

The results from the ICT shift-share analysis stress the contribution of the within productivity change for the total productivity growth for Finland in the 1975 to 2011 period. Total productivity growth stands for 125,81% from which, 121,03% is derived from within industries improvements of productivity. The rest 4,78% is coming from structural change.

In an examination of the two shift-share approaches shows a significant difference between the portions of structural change amongst them. This could be linked with the fact that under the ICT shift-share analysis, the effects that drive the mechanisms of structural change, the static and the interaction effect differentiate from the one approach to the other. The 9,42% difference in the two structural change effects is mainly due to the difference in the interaction effect, which in the three sector shift-share was 7,50% and in the ICT shift share -1,26%.

Given that the interaction effect is referring to the interaction between the within effect and the static effect, therefore changes in productivity and changes in employment, the ICT taxonomy "uncovered" the differences in the dynamics of the interaction effect ,by loosen the aggregation of the 3 sectors hypothesis. The Interaction effect is influenced by two forces. The within productivity change and the static effect. Therefore it is influenced by changes in the composition of productivity and changes in the composition labour share. Sectors with simultaneous, towards the same direction, changes in productivity and employment will have positive interaction effect, when sectors with opposite direction of productivity and employment shares will have negative effect. The ICT producing manufacturing and services, the ICT using services and the less ICT services show positive productivity and employment differentials for the period. Therefore, their interaction effect is positive. On the contrary, the ICT using manufacturing, less ICT manufacturing and the other industries sector display opposite directions of employment and productivity. Consequently, their productivity differential in the last year of the period to the first has been positive, whilst the employment share differentials, negative. In the total period ICT shift share analysis, the contribution of the "opposite direction" of productivity and employment is overpassing the "same direction" sectors. Hence, the overall result is that the sectors gaining in productivity do not augment the share of the total economy, and labour is allocated to the slow productivity growth ICT producing manufacturing and services, the ICT using

services and the less ICT services sectors. Given the change of the interaction effect, the within productivity change effect also had a 1,45% difference between the two approaches. The static effects are more or less similar for the two approaches. For all changes, the level of aggregation of the sectors is responsible for the mismatch of the effects.

Table 6. Data Statistics Finland, own calculations.

| ICT Shift-Share Analysis 1975-2011 | | | |
|---|---|---|---|
| 1975-2011 | Within | Static | Interaction |
| **«ICT Producing»** | | | |
| Manufacture | 2,19% | 0,64% | 0,92% |
| Services | 1,05% | 3,11% | 2,63% |
| **ICT Using** | | | |
| Manufacture | 8,77% | -3,10% | -3,97% |
| Services | 22,86% | 4,87% | 6,32% |
| **Less ICT** | | | |
| Manufacture | 23,05% | -6,33% | -9,24% |
| Services | 30,63% | 18,34% | 17,32% |
| **Other** | 32,48% | -11,50% | -15,23% |
| **Total** | 121,03% | 6,03% | -1,26% |

| Total Productivity | Structural Change |
|---|---|
| 125,81% | 4,78% |

To continue on, all sectors display positive within productivity change, a fact that implies that for all sectors productivity levels had increased relative to 1975 levels. More specifically, the sector with the highest productivity developments within its industries for the whole period is the other industries sector, with contribution to the within effect of 32,48%. The productivity differential from 1975 to 2011, however, is not the highest among the sectors, which implies that other sectors have relatively higher changes in their productivity levels. Therefore, it could be assumed that for being the most contributing sector in terms of within productivity

changes, the relative employment share of the sector, which is the higher amongst the sectors, is influencing the effect. A strong influence on within productivity growth is depicted in the "less ICT sector" and the ICT using services. The effect seems to be neutral for the within productivity changes of the ICT producing sector. This occurs due to the relatively small in terms of employment share size of the sector. A characteristic of the ICT producing manufacturing sector is that its labour share has had the smallest growth amongst the sectors. On the contrary, this does not apply for the ICT producing services that experienced 250% growth.

The static effect signifies that labour inputs are oriented from sectors with lower productivity levels, to sectors with higher. Employment is shifting away from the other industries, less ICT manufacturing and ICT using manufacturing towards the less ICT and ICT using services sectors. The negative sign of the interaction effect states that productivity and employment follow opposite directions. It could be linked therefore with the reallocation of labour to sectors with slower productivity growth. That is confirmed for the other industries, the ICT using manufacturing»» and less ICT using manufacturing. These sectors have decreasing labour share within the period and increasing productivity levels. However, they are not as productive, and labour is absorbed by the ICT producing sector, the ICT using services and the less ICT services.

Having examined the productivity patterns of the ICT sector, it could be said that the results from the ICT shift share for the total period disregards the productivity progressions that have taken place in different time intervals. Therefore, as done in the previous section, the shift share analysis will be conducted for the four sub-periods.

For the first period, productivity is augmenting with a 16,19% growth rate. Structural change contributes 1,75% to the total growth. The 14,44% of the total productivity growth is due to inner-sectoral productivity changes.

Table 7. Data Statistics Finland, own calculations.

| 1975-1983 | Within | Static | Interaction |
|---|---|---|---|
| **«ICT Producing»** | | | |
| Manufacture | 0,48% | -0,01% | 0,00% |
| Services | 0,30% | 0,50% | 0,12% |
| **ICT Using** | | | |
| Manufacture | 0,66% | -0,44% | -0,04% |
| Services | 3,89% | 0,72% | 0,16% |
| **Less ICT** | | | |
| Manufacture | 4,28% | -1,24% | -0,34% |
| Services | 1,93% | 5,79% | 0,35% |
| **Other** | 2,89% | -3,43% | -0,40% |
| **Total** | 14,44% | 1,90% | -0,16% |
| | | | |
| Total Productivity | | Structural Change | |
| 16,19% | | 1,74% | |

The less ICT manufacture sector is delivering most of the growth of the effect. Industries that outperform in productivity for this sector are related to the heavy, traditional industries like chemicals, paper and woodwork, and mining process industries that have been Finland's leading industries before the ICT revolution. Another significant sector for the productivity growth contribution is the ICT using services as is the other industries sector.

As for the structural change effect, it is highly affected by the reallocation of resources from the less productive other industries, less ICT manufacture and ICT using-manufacture sectors. Its positive sign suggests that labour is channeled to the more productive sectors, the less ICT services, ICT using services, and ICT producing services. The ICT producing manufacturing remained unaffected by the static effect. The reallocation effect towards higher productivity growth sector that is captured by the interaction effect, is rather small but it implies that labour is oriented to lower productivity pace sectors.

In the second period, the productivity and structural have evolved. In terms of the increased total productivity growth relative to the first period by 24,77%, the less ICT services is the most important sector of the Finnish economy with a remarkable change in the productivity from the within effect.

Table 8. Data Statistics Finland, own calculations.

| 1984-1992 | Within | Static | Interaction |
|---|---|---|---|
| **«ICT Producing»** | | | |
| Manufacture | 0,7% | 0,0% | 0,0% |
| Services | 0,3% | 0,5% | 0,1% |
| **ICT Using** | | | |
| Manufacture | 1,7% | -1,8% | -0,5% |
| Services | 4,2% | 1,3% | 0,3% |
| **Less ICT** | | | |
| Manufacture | 3,7% | -2,9% | -0,7% |
| Services | 10,0% | 7,2% | 2,1% |
| **Other** | 2,1% | -3,1% | -0,3% |
| **Total** | 22,6% | 1,2% | 0,9% |
| | | | |
| Total Productivity | | Structural Change | |
| 24,77% | | 2,15% | |

The ICT using services also increased their productivity growth contribution to the effect. The first signs of the upcoming ICT producing manufacturing have also started to emerge. The others industries sector has the same growth in within productivity changes, as did in the first period.

The structural change effect has augmented with 2,15% growth pace indicating that the labour has oriented to more productive sectors. More specifically, as the static effect indicates, the labour share of the “other industries” is still decreasing as does the labour share of the less ICT manufacturing and ICT using manufacturing. The effect is driven by both static, and interaction effect signifying

that resources are channeled to sectors with higher productivity growth and higher productivity levels.

The third period displays the highest productivity growth for all periods. It is the period after the 1990s crisis where growth rates start to accelerate due to its relative previous decreasing economic position. In addition to this, the emergence of the ICT producing sector is vastly affecting productivity growth acceleration. The total productivity growth grows with 31,52% pace and the within productivity effect contributes with 27,75% to the total effect.

Table 9. Data Statistics Finland, own calculations.

| 1993-2001 | Within | Static | Interaction |
|---|---|---|---|
| **«ICT Producing»** | | | |
| Manufacture | 2,04% | 1,47% | 1,37% |
| Services | 0,70% | 1,79% | 0,56% |
| **ICT Using** | | | |
| Manufacture | 1,09% | 0,31% | 0,08% |
| Services | 6,09% | 0,77% | 0,23% |
| **Less ICT** | | | |
| Manufacture | 4,64% | 0,01% | 0,00% |
| Services | 7,55% | 0,51% | 0,09% |
| **Other** | 5,64% | -2,42% | -1,02% |
| **Total** | 27,75% | 2,44% | 1,32% |
| | | | |
| Total Productivity | | Structural Change | |
| 31,52% | | 3,76% | |

All sectors are exhibiting growing productivity developments, with the less ICT services contributing the most followed by the ICT using services and the less ICT sector. The acceleration of growth of the «ICT Producing» sector and its contribution to the within productivity change compared to the other periods is significant.

Labour is still shifting away from the other industries sector and is reallocated to the rest sectors since they are all contributing positively to the static effect that accounts for 2,44% to the total growth. The ICT producing sectors are drivers of the effect absorbing the distributed labour inputs. If structural change was the only effect influencing productivity growth, the total productivity would be3,26% coming solely from the ICT producing manufacturing and ICT producing services. In addition to this, the interaction between the within productivity change and static effects is positive. Therefore, labour inputs and productivity have the same orientation for the ICT producing, ICT using services sectors. The employment that the other industries sector is releasing is channeled to the industries of the sectors with accelerated productivity growth.

The last period shift share analysis results reflect the productivity downturn of the Finnish economy. Total productivity is plummeting at 7,72% and the process of structural change has turned negative.

Table 10. Data Statistics Finland, own calculations.

| 2002-2011 | Within | Static | Interaction |
|---|---|---|---|
| **«ICT Producing»** | | | |
| Manufacture | -2,88% | -1,03% | 0,50% |
| Services | -0,23% | -0,14% | 0,01% |
| **ICT Using** | | | |
| Manufacture | 0,83% | -0,71% | -0,14% |
| Services | 1,56% | 1,72% | 0,13% |
| **Less ICT** | | | |
| Manufacture | 0,11% | -2,52% | -0,02% |
| Services | 5,69% | 1,81% | 0,26% |
| **Other** | 3,32% | -0,43% | -0,12% |
| **Total** | 8,40% | -1,30% | 0,61% |
| | | | |
| Total Productivity | | Structural Change | |
| 7,72% | | -0,68% | |

Productivity growth is largely occurring from the less ICT service sectors and the other industries sector. Apart from the ICT using services, the most ICT intensive sectors, the ICT producing and the ICT using manufacturing, have decreasing within effect. Therefore, the static effect implies that labour is oriented to the less productive lower intensity ICT sector. Structural change is strongly influenced by the static effect since the interaction accounts solely for 0,67% of productivity growth.

# 6. Discussion

By evaluating the results of the two-approach shift- share analysis, the main conclusion drawn is that the contribution of structural change to total productivity growth has been limited. The total period shift share analysis, in both approaches of the sectors' classifications, shows that the dominance of the within productivity change effect has casted away the reallocation of labour from less productive, to more productive sector, as a largely influential process for furthering the total productivity growth potential. Despite its moderate impact on total productivity growth, the process of structural change did occur and its contribution has been positive. Consequently, to the question *"Is structural change the driving force of productivity growth for Finland?"* the answer is that it has not. It appears that its impact has been positive to the total productivity growth, but nevertheless, insignificant when it is compared to the within productivity change effect, which has been Finland's driving force of total productivity growth. The effect of structural change has been limited to all periods and in both shift share approaches. Its highest contribution was demonstrated in the 3$^{rd}$ period, between the years of 1993 to 2001 connecting the period of high productivity with higher reallocation process, while its lowest contribution was observed in the fourth, 2002-2011.

The limited structural change effect on productivity growth goes in line with several previous research attempts analyzed before in this study. This progression, however, is depicted in more recent times, after the exhaustion of the primary sector's labour shares and the overwhelmingly increasing of the tertiary sector. As for the ICT intensity structural change effect, it appears to be even less significant, due to the vast differentials in productivity growth and labour shares between the service industries that influence largely the interaction effect.

Regarding the reallocation of labour towards the higher productivity ICT intensive sectors (ICT producing and ICT using), the structural change effect to the moderate extent that it was conductive to productivity growth, the results from the total period ICT intensity shift share roughly suggest that labour was mainly reallocated to the less ICT service sector. Hence, the hypothesis concerning the reallocation of labour to the ICT intensive sectors due to higher productivity growth does not appear to be widely confirmed.

Nevertheless, under a detailed examination of the analysis, it is implied that the sectors where labour was oriented apart from the less ICT services, were the ICT using services, the ICT producing services, and lastly the ICT producing manufacturing sectors, with the smaller impact on the total structural change contribution to total productivity growth. For the ICT producing sector both manufacture and services had positive static and interaction effects. As a total sector the ICT producing had the second highest contribution to structural change. The ICT using sector had a moderate performance when it comes to structural change that is driven solely by the ICT using services. The remaining other industries sector was displaying negative structural change effect. Therefore, it could be indicated that for the question *"Is labour oriented towards the intensive ICT sectors?"* labour has been channeled to both ICT intensive and less intensive sectors. The role of services under the ICT intensity classification as a "labour magnet" is verified, as it had also observed in the 3sector shift share.

One interesting perspective observed was the moderate performance of the ICT producing sector in the within effect and the structural change effect. As suggested by the theory, it was be expected that ICT producing sector's impact to the structural change effect was expected to be significant, given that it is the highest ICT intensive sector. However, this was not illustrated to the results. For the total period, its within effect accounted for 2,19% of the total productivity growth while the structural effect has been 1,56%. The corresponding figures for the most contributing to productivity growth less ICT services sector was 30,63% and 35,66% respectably.

The reason why the ICT producing sector, was not the most contributing sector to the structural change effect, lies on its relative small labour share. Viewed in productivity growth terms, the ICT producing sector has been the fastest growing sector for Finland the period of 1975 to 2011. Hence, it is its relatively small sector

size that could not contribute to the structural change effect as much as the large labour share of the less ICT service sector despite that the productivity growth of the less ICT services was smaller.

Taking into account the previous research on the topic of structural change, Fageberg (2000), offers a possible explanation for this development. Currently, the economic structure that the new technological mode of the ICT has established, made the traditionally strong connection of output-labour-productivity significantly less lucid (Fagerberg, 2000). Such a progression implies that the simultaneous increase of output through labour increases and therefore, productivity growth for the generation of the most productive sectors pattern of growth, has not been as conductive factor to productivity growth for the ICT highly intensive sectors. The augmented volume of the ICT capital to the ICT producing manufacturing sector could possibly give an insight to the issue.

Consequently, for the question *"Is the ICT Producing sector the most contributing sector to productivity growth"?* the best suited interpretation of the results suggest that the ICT producing manufacturing sector is not as contributing to the structural change effect as the less ICT services, but its role is highlighted, since its moderate impact on structural change is derived due to its small sector side and not due to lower productivity growth which had had the higher growth than any other sector.

# 7. Conclusion

The main goal of this thesis has been the investigation of the conductive forces to productivity growth for the Finnish economy over the ICT era. Given The significant transformation of its economic structure, from a natural resource depended economy to one of the most technologically advanced information society, accounting for the impact the factors that had delivered the significant productivity increases over the past 4 decades, appears to be crucial for understanding the mechanisms of economic growth.

Under the notion that productivity growth is not generated solely by productivity improvements on the production sphere, but also through the reallocation of resources out of less productive economic activities and into more

productive i.e. structural change process, the productivity growth pattern of Finland had been evaluated.

Special attention was placed towards creating a theoretical framework that could generate a platform in order to link theories of GPTs, with Schumpeter's "creative destruction", Perez's "techno-economic paradigms", and the process of structural change as a conductive factor to productivity growth, from 1975 to 2011. By employing these conceptual tools, the hypotheses that the relatively more ICT intensive sectors will display higher productivity growth than the less ICT intensive sectors and that labour reallocation will be channeled towards the ICT intensive sectors since they are more productive than the less intensive, were formed. To test for the validity of the hypotheses, three research questions emerged concerning the effect of structural change and if it had been the driving force to productivity growth, if labour is oriented to the ICT intensive sectors and lastly if the most ICT intensive sector has been contributing the most to total productivity growth. To account for research questions, a two approach shift share analysis was conducted. For the first approach, the total economy was decomposed under the three sectors categorization. The second approach was disaggregating the economy on the basis of the sectors' ICT intensity.

The outcome from the methodological approaches stresses strongly the impact of the service industries augmenting labour share. Even though The ICT intensity shift share illustrated in more detail the progressions of the ICT intensive manufacturing industries and services, it still was not able to show in more detail the progressions on the big less ICT intensity sector due to the dense aggregation the outnumbered industries. However the density of the less ICT sector in both manufacturing and services and their moderate productivity growth increases signify that it is the less, influenced by the ICT mode industries that labour is channeled to.

The results that were obtained suggest that the process of structural change had not been as contributing to productivity growth as the within productivity change effect. Therefore, although labour reallocation had been responsible for moderate productivity growth progressions, it was not the driver of its growth. In addition to this, it was observed that resources were channeled to both less intensive ICT sectors and ICT intensive sectors. However, the impact of the ICT intensive sectors have been smaller. Concerning the role of the "ICT producing manufacturing" sector and

its contribution to the total productivity growth and structural change effect, it appears that given its relatively small labour share is not able to vastly influence the effects. Nevertheless, it has been the most productive sector in both growth rates and in absolute numbers.

Lastly, the importance of structural change has been highlighted by the academic literature as a factor that is able to augment productivity growth. The recent pattern of economic structure that the ICTs have imposed to the economy has altered the way that aggregate productivity was accumulated. Nevertheless, that progression does not imply that the process of structural change is in significant. It suggests that further research should aim at the disaggregated economic activities so the dynamics of the process of structural change will be clearly revealed. As far as the productivity improvements within the sectors are concerned, it has been the decisive factor of the augmentation of productivity growth. The improvements from the ICT technologies in the production sphere through efficiency gains have been vast. Both processes had their role for Finland's emergence from a back ward Agrarian society into the advanced technologically nation.

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Appendix

| Average Productivity Levels of Secondary Sector Industries | |
|---|---|
| Industry | Level |
| 19 Manufacture of coke and refined petroleum products | 1,49% |
| D Electricity, gas, steam and air conditioning supply | 1,32% |
| 17 Paper industry | 0,84% |
| E Water supply and waste management | 0,83% |
| 20 Manufacture of chemicals and chemical products | 0,80% |
| 26 Electronics industry | 0,75% |
| 21 Pharmaceutical industry | 0,73% |
| 11 Manufacture of beverages | 0,70% |
| 07 Mining of metal ores | 0,67% |
| F Construction | 0,65% |
| 24 Manufacture of basic metals | 0,64% |
| 08 Other mining and quarrying | 0,52% |
| 28 Manufacture of machinery and equipment n.e.c. | 0,49% |
| 12 Manufacture of tobacco products | 0,47% |
| 27 Manufacture of electrical equipment | 0,47% |
| 23 Manufacture of other non-metallic mineral products | 0,47% |
| 22 Manufacture of rubber and plastic products | 0,46% |
| 18 Printing | 0,46% |
| 10 Manufacture of food products | 0,44% |
| 29 Manufacture of motor vehicles, etc. | 0,41% |
| 25 Manufacture of fabricated metal products | 0,39% |
| 30 Manufacture of other transport equipment | 0,39% |
| 33 Repair and installation of machinery and equipment | 0,37% |
| 32 Other manufacturing | 0,37% |
| 16 Woodworking industry | 0,36% |
| 13 Manufacture of textiles | 0,34% |
| 31 Manufacture of furniture | 0,32% |
| 15 Manufacture of leather and related products | 0,26% |
| 14 Manufacture of wearing apparel | 0,23% |
| 09 Mining support service activities | 0,06% |
| 05_06 Mining of coal and extraction of crude petroleum and natural gas | |
| Average Productivity Level | 0,56% |

Table 1a. Data statistics Finland

| Productivity Growth of Secondary Sector Industries | |
|---|---|
| Industries | Growth% |
| 07 Mining of metal ores | 18,73 |
| 19 Manufacture of coke and refined petroleum products | 8,89 |
| 21 Pharmaceutical industry | 5,04 |
| 24 Manufacture of basic metals | 4,97 |
| 17 Paper industry | 4,88 |
| 26 Electronics industry | 4,73 |
| D Electricity, gas, steam and air conditioning supply | 4,08 |
| 16 Woodworking industry | 4,02 |
| 11 Manufacture of beverages | 3,26 |
| 20 Manufacture of chemicals and chemical products | 2,93 |
| 29 Manufacture of motor vehicles, etc. | 2,90 |
| 33 Repair and installation of machinery and equipment | 2,85 |
| 27 Manufacture of electrical equipment | 2,82 |
| 28 Manufacture of machinery and equipment n.e.c. | 2,78 |
| 08 Other mining and quarrying | 2,65 |
| 22 Manufacture of rubber and plastic products | 2,49 |
| 10 Manufacture of food products | 2,35 |
| 23 Manufacture of other non-metallic mineral products | 2,31 |
| 15 Manufacture of leather and related products | 2,15 |
| 25 Manufacture of fabricated metal products | 1,87 |
| 14 Manufacture of wearing apparel | 1,87 |
| 18 Printing | 1,75 |
| F Construction | 1,66 |
| 32 Other manufacturing | 1,53 |
| 31 Manufacture of furniture | 1,31 |
| 13 Manufacture of textiles | 1,26 |
| E Water supply and waste management | 1,21 |
| 30 Manufacture of other transport equipment | 1,07 |
| 09 Mining support service activities | 0,21 |
| 12 Manufacture of tobacco products | 0,02 |
| 05_06 Mining of coal and extraction of crude petroleum and natural gas | |
| Average Productivity Growth | 3,29 |

Sectoral Classification in the tree sectors of the economy: Primary, Secondary, and Tertiary Sectors of the Finnish economy.

| Primary Sector | Secondary Sector | Tertiary Sector |
|---|---|---|
| **A Agriculture, forestry and fishing**<br>01 Agriculture and hunting<br>02 Forestry<br>03 Fishing | **B Mining and quarrying**<br>05_06 Mining of coal and extraction of crude petroleum and natural gas<br>07 Mining of metal ores<br>08 Other mining and quarrying<br>09 Mining support service activities<br>**C Manufacturing**<br>10 Manufacture of food products<br>11 Manufacture of beverages<br>12 Manufacture of tobacco products<br>13 Manufacture of textiles<br>14 Manufacture of wearing apparel<br>15 Manufacture of leather and related products<br>16 Woodworking industry<br>17 Paper industry<br>18 Printing<br>19 Manufacture of coke and refined petroleum products<br>20 Manufacture of chemicals and chemical products<br>21 Pharmaceutical industry<br>22 Manufacture of rubber and plastic products<br>23 Manufacture of other non-metallic mineral products<br>24 Manufacture of basic metals<br>25 Manufacture of fabricated metal products<br>26 Electronics industry<br>27 Manufacture of electrical equipment<br>28 Manufacture of machinery and equipment n.e.c.<br>29 Manufacture of motor vehicles, etc.<br>30 Manufacture of other transport equipment<br>31 Manufacture of furniture<br>32 Other manufacturing<br>33 Repair and installation of machinery and equipment<br>**D Electricity, gas, steam and air conditioning supply**<br>**E Water supply and waste management**<br>36 Water collection, treatment and supply<br>37 Sewerage<br>38 Waste collection, etc. activities; materials recovery<br>39 Remediation activities and other waste management services<br>**F Construction**<br>41 Building construction, etc.<br>42 Civil engineering, etc. | **G Trade**<br>45 Trade and repair of motor vehicles, etc.<br>46 Wholesale trade<br>47 Retail trade<br>**H Transportation and storage**<br>49 Land transport<br>50 Water transport<br>51 Air transport<br>52 Warehousing and support activities for transportation<br>53 Postal and courier activities<br>**I Accommodation and food service activities**<br>55 Accommodation<br>56 Food and beverage service activities<br>**J Information and communication**<br>58 Publishing activities<br>59_60 Audio-visual activities<br>61 Telecommunications<br>62_63 Computer and information service activities<br>**K Financial and insurance activities**<br>64 Financial activities<br>65 Insurance activities<br>66 Activities auxiliary to financial and insurance activities<br>**L Real estate activities**<br>**M Professional, scientific and technical activities**<br>69 Legal and accounting activities<br>70 Activities of head offices; management consultancy<br>71 Architectural and engineering activities, etc.<br>72 Scientific research and development<br>73 Advertising and market research<br>74 Other professional, scientific and technical activities<br>75 Veterinary activities<br>**N Administrative and support service activities**<br>77 Rental and leasing activities<br>78 Employment activities<br>79 Travel agencies, etc.<br>80 Security and investigation activities<br>81 Services to buildings and landscape activities<br>82 Office administrative and other business support activities<br>**O Public administration and social security**<br>841_842 Public administration<br>843 Compulsory social security activities |

| | | |
|---|---|---|
| | | 844 Defense equipment and conscripts<br>845 Maintaining of railways<br>846 Maintaining of roads and streets<br>85 Education<br>**Q Human health and social work activities**<br>86 Human health activities<br>87_88 Social work activities<br>R Arts, entertainment and recreation<br>90_92 Cultural activities and gambling<br>93 Sport, amusement and recreation activities<br>**S Other service activities**<br>94 Activities of membership organizations<br>95 Repair of household goods<br>96 Other personal service activities<br>**T Household service activities** |

Source: statistics Finland, own classification process based on theory.

Industrial classification according to ICT intensity

| **ICT PRODUCING** | | **ICT USING** | | **LESS ICT** | | **OTHER INDUSTRIES** |
|---|---|---|---|---|---|---|
| **Manufacturing** | Services | Manufacturing | Services | Manufacturing | Services | |
| **26 Electronics industry** | 61 Telecommunications | 14 Manufacture of wearing apparel | 45 Trade and repair of motor vehicles, etc. | 10 Manufacture of food products | 33 Repair and installation of machinery and equipment | 01 Agriculture and hunting |
| **27 Manufacture of electrical equipment** | 62_63 Computer and information service activities | 18 Printing | 46 Wholesale trade (excl. motor vehicles, etc.) | 11 Manufacture of beverages | 49 Land transport | 02 Forestry |
| | | 28 Manufacture of machinery and equipment n.e.c. | 47 Retail trade (excl. motor vehicles, etc.) | 12 Manufacture of tobacco products | 50 Water transport | 03 Fishing |
| | | 30 Manufacture of other transport equipment | 53 Postal and courier activities | 13 Manufacture of textiles | 51 Air transport | 05_06 Mining of coal and extraction of crude petroleum and natural gas |
| | | 31 Manufacture of furniture | 58 Publishing activities | 15 Manufacture of leather and related products | 52 Warehousing and support activities for transportation | 07 Mining of metal ores |
| | | 32 Other manufacturing | 59_60 Audio-visual activities | 16 Woodworking industry | 55 Accommodation | 08 Other mining and quarrying |
| | | | 64 Financial activities | 17 Paper industry | 56 Food and beverage service activities | 09 Mining support service activities |
| | | | 65 Insurance activities | 19 Manufacture of coke and refined petroleum products | 68201 Letting of dwellings | D Electricity, gas, steam and air conditioning supply |

| | | | | |
|---|---|---|---|---|
| | 66 Activities auxiliary to financial and insurance activities | 20 Manufacture of chemicals and chemical products | 68202 Operation of dwellings | 36 Water collection, treatment and supply |
| | 69 Legal and accounting activities | 21 Pharmaceutical industry | 681+68209 +683 Other real estate activities | 37 Sewerage |
| | 70 Activities of head offices; management consultancy | 22 Manufacture of rubber and plastic products | 75 Veterinary activities | 38 Waste collection, etc. activities; materials recovery |
| | 71 Architectural and engineering activities, etc. | 23 Manufacture of other non-metallic mineral products | 841_842 Public administration | 39 Remediation activities and other waste management services |
| | 72 Scientific research and development | 24 Manufacture of basic metals | 843 Compulsory social security activities | 41+432_439 Building construction, etc. |
| | 73 Advertising and market research | 25 Manufacture of fabricated metal products | 844 Defence equipment and conscripts | 42+431 Civil engineering, etc. |
| | 74 Other professional, scientific and technical activities | 29 Manufacture of motor vehicles, etc. | 845 Maintaining of railways | |
| | 77 Rental and leasing activities | | 846 Maintaining of roads and streets | |
| | 78 Employment activities | | 85 Education | |
| | 79 Travel agencies, etc. | | 86 Human health activities | |
| | 80 Security and investigation activities | | 87_88 Social work activities | |

| | | |
|---|---|---|
| | 82 Office administrative and other business support activities | 92 Gambling and betting activities |
| | | 93 Sport, amusement and recreation activities |
| | | 94 Activities of membership organisations |
| | | 95 Repair of household goods |
| | | 96 Other personal service activities |
| | | T Household service activities |

Source: statistics Finland, own classifications based on van Ark et. al.2002)