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Saarinen, Jani

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Jani Saarinen

DEPARTMENT OF ECONOMIC HISTORY, LUND UNIVERSITY

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Department of Economic History, Lund University
Postal address: P.O. Box 7083, S-220 07 Lund, Sweden
Telephone: +46 46 2227475
Telefax: +46 46 131585

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Innovation Activity in Finnish Industries

- A New Pattern*

Jani Saarinen

1. Introduction

1.1. Background to the study

Studying the economic history of Finland in Sweden may sound like a stupid idea, but it offers a new perspective for the study. All the experiences and comments I got from my C-level paper, which dealt with the industrial renewal in Finland during the last two decades, inspired me to continue my research around this subject. Comments such as "It is impossible to study the industrial renewal in Finland without taking account the success story of Nokia" as well as "Is there any other industry than telecommunications and forest-based industries in Finland" have further nourished my interest to continue studies of the Finnish industry. As I already mentioned in my C-level paper, we cannot forget the role played by the less research and development (R&D) -intensive industries – the low-tech industries – which still maintain an important role in the Finnish industry.[1] Nokia is not the only company in Finland. There are also many other industrial sectors, as this study is going to illustrate.

To study innovation activity in the Finnish industries during the last two decades is an interesting case indeed. All of the great historical events which have taken place outside Finland, for example the fall of the Soviet Union, as well as some developments in Finland, membership of the European Union, have set the Finnish economy in a totally new

* The present study was carried out at the Department of Economic History, Lund University, during the spring 2000. First of all, I wish to express my deepest gratitude to Jonas Ljungberg, Ph.D., who has expertly supervised this study and shared his experience and knowledge with me. I am grateful to Christopher Palmberg, M.A., for his valuable help with the Sfinno database and for making this unique study material available to me. My respectful thanks are due to Maria Kuronen, M.A., for revising the English language of the manuscript. I am also indebted to Erik Dahmén, Emeritus Professor, for devoting me some of his valuable time. Finally, I owe my warmest thanks to my parents, for their encouragement and continual support during my studies here in Sweden.

[1] Saarinen, Jani. 2000. *Industrial Renewal in Finland in 1980s and 1990s.* Bachelor level paper at Department of Economic History, Lund Univerisity. p. 33.

context. Industrial entrepreneurs have also been forced to face the new realities of the surrounding world, not just the situation in the Soviet Union. They have been forced to form a wider picture of Europe, and also of the whole world. This situation has had some major effects on the industrial activity in Finland, and has been one of the main factors behind the innovation activity of Finnish industries.

"Technological change is an extraordinarily complex subject that takes a multiplicity of forms and directions, often requiring different angles of vision for different industries as well as for different periods of history".[2] This statement of Nathan Rosenberg can be seen as starting point for this study. During the last two hundred years, technological change often has been related to economic growth in the form of new types of goods and services. Adam Smith wrote about technical change in the form of new machines as one of the three important causes for increasing incomes.[3] In Ricardo's writings, technological change is mainly associated with mechanisation through investment.[4] Marx argued that the use of machines was a strength of the capitalist system, as it allowed vast increases in productivity.[5] Marx also acknowledged the role of science in the capitalistic production process. According to these classical economists, physical capital investments are the vehicle of technological change in production and in the economy as a whole. This view, called an embodied view on technological change, is illustrated in appendix 1.

Schumpeter departed from the classical economists' view of technological change, when he suggested that innovative activities and their outcomes – innovations – enable the innovator to gain temporary monopolistic power, expiring as soon as the innovation is imitated or replaced.[6] Schumpeter made also a distinction between product innovations – *"the introduction of a new good or a new quality of the good with which consumer on the market are not familiar"* – and process innovations – *"the introduction of a new method of production, that is, one yet tested by experience in the branch of manufacture concerned… [or] a new way of handling a commodity commercially"*.[7] In his later work *Capitalism, Socialism, and Democracy,* Schumpeter switched to emphasising the importance of oligopolistic market structures in promoting innovative activity.[8] The view that Schumpeter

[2] Rosenberg, Nathan. 1994. *Exploring the black box – Technology, economics, and history.* p. 1.
[3] Smith, Adam. 1776. *The Wealth of Nations.*
[4] Ricardo, David. 1817. *Principles of Political Economy and Taxation.*
[5] Marx, Karl. 1867. *Capital.*
[6] Schumpeter, Joseph. 1911. *Theorie der wirtschaftlichen entwicklung.* Duncker & Humblot, Leipzig. English translation: *The theory of economic development.* Harvard 1934.
[7] Schumpeter, Joseph. 1911. (Cited in Archibugi et al. 1994).
[8] Schumpeter, Joseph. 1942. *Capitalism, Socialism, and Democracy.*

introduced is called a disembodied perspective on technological change, and it is illustrated in appendix 1. This perspective has also been used in this study in the analysis of the connection between innovation activity and development of Finnish industries during the last two decades.

1.2. Objective of the study

The objective of this study is to examine and analyse the innovation activity of Finnish industries during 1980-1999 and to find out whether this activity can explain the development of the studied industries. In order to achieve this objective, this study uses the theory of Erik Dahmén, which he introduced in his Doctor's thesis in 1950.[9] In the "Dahménian" approach, different industrial sectors are divided into three different categories: i) advancing industries, ii) stagnating industries, and iii) receding industries.

Industries belonging to these three categories are then further divided into two categories: the more and the less innovative. This categorisation was performed by using the "Sfinno" database. This database consists of some 1700 commercialised innovations from the period 1980-1999 in Finland. A new pattern of innovation activity in Finnish industries based on the combination of the "Dahménian" and "Sfinno" approaches will be introduced. With the help of this new pattern, the connection between innovation activity and development of industries (advancing, stagnating, receding) will be analysed. At this point of the study, answers to the questions like "Did new innovations cause an expansion of the markets?", or "Did there exist a demand in the markets?" considering advancing industries will also be introduced. Considering stagnating and receding industries some explanations for their negative development will be analysed.

1.3. Method and sources

My method has been to go through the statistical facts about the Finnish industry and with the help of some statistical packages to produce figures that would illustrate the condition of the industries as well as possible. The standards used to describe the industries have changed three times during the study period, and this has been the main problem in the collection of statistical material. The first standard SIC 1968/80 (Standard Industrial Classification), dominated during the 1980s, and has been used in this paper until the year 1986. The next one was SIC 1988, which has been used in this study from 1987 to 1991. The third

[9] More about Dahméns approach in chapter "2.1.", p. 11.

one, which is nowadays the most common, is called SIC 1995, and has been used in this paper to cover the period 1992-1999. The problem with these different standards is, that whenever a new classification has been made, some "old" industrial sectors have disappeared, and some "new" ones have been introduced. These changes have been made in order to describe the "real" situation of the industrial activity, which has changed rapidly during the last two decades.

The major part of the statistical data used in this study has been collected from Statistical Yearbooks of Statistics Finland. It would also have been possible to obtain the same information, more precisely classified, in electronic form, but the price to be paid would have been too high. Because of these pure economical difficulties, the following survey concentrates only on a description of the main industrial classes at a two-digit level (20, 21, 22… = SIC Classification). Perhaps in my next study, I will be able to spend more money and study the industrial transformation in Finland more in detail.

This paper will include a short introduction to the economic development during the 20th century. In this part of the study, the book of Riitta Hjerppe on the Finnish Economy in 1860-1985 has been a major source of information. This book consists of a large number of tables and figures on the economic development in Finland. I have also made some own calculations, based on numbers and tables in that specific book, in order to produce the kind of information, which I have considered actual in this study.

1.4. Limitations of the study

As mentioned in "Objective of the study", this paper concentrates on describing the innovation activity of Finnish industries. The Dahménian approach used in this study, contains only of a minor part of the approaches which he introduced in his thesis. Aspects such as the amount of companies and the rate of formation of new companies, as well as financial considerations in the form of profits, taxation, distribution and financing have not been analysed in this study. The reasons for introducing 13 sectors in chapter 5 instead of the 22, which is the number of sectors according to the Dahménian approach, are the following. The number of industrial sectors in Sfinno's division is smaller than the number given in the Statistical Yearbooks of Finland. For instance in textile industries, textiles (17), wearing apparel (18) and leather (19) have their own category in SIC 1995, but in Sfinno all three are grouped together. This "grouping" has been done in order to avoid having large amount of minor industries.

1.5. Criticism of sources

Sources in this study can be divided into five different main categories. Firstly, the work of Erik Dahmén has been the most important source of inspiration. In fact, this study is based on the implementation of the Dahménian classification of industries. Secondly, the statistical yearbooks of Finland have been used in large scale for creating the statistical data. These statistics have been published by Statistics Finland.[10] Their web pages contain also a great amount of statistical data, which have also been used in this study. Thirdly, the Sfinno database has been used to obtain data on innovation. I have already described the reliability of this database in my C-level paper, but will give a short introduction of Sfinno also in this study. However, I can mention already here, that in this paper the Sfinno has been used without any reservations. Fourthly, publications and working papers from different ministries and organisations of Finland have been a valuable source. A great many of these are publications from the Ministry of Trade and Industry and Technology Development Centre of Finland (TEKES). These publications have been used in the final analysis of this study, where the development of different industrial sectors in Finland is being introduced. Finally, home pages of different organisations, federations and companies, as well as articles from newspapers and magazines have been used in combination with other sources. These sources usually contain some interesting small details, which have not been mentioned in ministry publications, but which, when used, give their own specific nature to this study. Because the industrial development in Finland is quite well documented, in my opinion, and because the study period is in "recent history", I see no obstacles for the use of the chosen sources in this study.

1.6. Structure of this study

This introduction is followed by the theoretical section, where the main approaches of this study are discussed, and the theoretical framework is developed. In chapter 3, a historical development of the Finnish economy is introduced, including the main macro-economic indicators of the Finnish economy during the period 1900-1980. After this historical description, a more detailed introduction of the economic development during the last two decades in Finland is given, whereby the reader will get a general understanding of those main events that have characterised the 1980s and 1990s in the Finnish economy. In chapter 4, the results of the Dahmenian and Sfinno approaches are

[10] Statistics Finland is an official statistical data producer in Finland.

described, including also some other results from calculations of industrial output, such as correlation coefficients. This chapter also contains a detailed description of the new industrial pattern. The main analyses of this study can be found in chapter 5, where the developments of the different branches of industry are described, and where analyses of their innovation activity are considered. The concluding chapter 6 provides some key insights from the study, as well as a recapitulation of the main findings and concluding remarks.

2. Towards a Theoretical Framework

2.1. "Dahménian" approach

As mentioned above, the objective of this study is to analyse the innovation activity in Finnish industries by using Dahmén's classification of advancing, stagnating and receding industries. Later on, a description of industrial development in Finland will be provided, and a more exact analysis will be given. However, an introduction to the different concepts included will be given first.

By advancing industries Dahmén means those industrial sectors that have been able to increase their share of markets for their own products in order to satisfy the demand of investors and customers.[11] It is also possible to talk about an advancing industry in cases of an increase of production between two different time periods. These periods should be selected from the same phase of a business cycle. As the chapter on the economic development during the 1980s and 1990s illustrates, Finland had a period of upswing throughout the 1980s and another upswing after that financial and economic crisis of the beginning of 1990s. To enable a comparison between two different periods of upswings, one should to take an average of two or three years from both periods, or even longer period, such as 1983-88 & 1993-98. This has been the methodology of the present study. A more precise introduction of the methods used in the analytical part of this study can be found in the chapter on "Implementation of the Dahménian approach".

Another aspect that needs to be taken into account according to Dahmén is that there has to be a great increase in the production volume before an industry can be defined as an advancing one.[12] In Dahmén's model, an increase of 10% during one specific upswing is not enough

[11] Dahmén, Erik. 1950. *Svensk Industriell Företagarverksamhet – Kausalanalys av den industriella utvecklingen 1919-1939.* p. 89.
[12] Dahmén, Erik. 1950. p. 90.

for an industry to qualify as an advancing industry.[13] Neither does an industry which has had an increase of more than 50% during the first upswing (1983-88), but one of only 15% during the second upswing (1993-98) be called as an advancing one. In such a case, the concept of a stagnating industry is the correct one according to Dahmén. Stagnating industries include all of those industrial sectors in which production has varied by ±10% between the two different upswings. The last group of industries, the receding ones, includes those industries that have not succeeded in competing on the markets and have had a decrease in their production of 10% or more, between the two different upswings.[14]

Another central idea in Dahmén's approach is a distinction between "market filling"[15] and "market creating"[16], which are fairly basic for the characteristics of the process of transformation in different branches of industry and for different periods. An expansion in the level of activity in an industry takes place as a result of either an *external* change (market filling) – a favourable shift in the conditions of demand for the product (without any alternation in the production or price policy of the companies) or an *internal* change (market creating) – the offer of a new commodity, an advertising campaign or a new price policy. It is the latter – internal change – that is engendered by economic innovations.[17]

2.2. Implementation of the Dahménian approach

The Dahménian approach has been implemented in the following way. First the industrial sectors are divided into three different categories: advancing, stagnating and receding ones. The "Dahmenian" approach is used to classify the industries to the categories with the best possible accuracy.

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[13] For instance, if industrial output in Finland has increased less than 10% during the first upswing 1983-1988, this industry can not be called as advancing inductry.

[14] "Upswing" in this chapter means period, when the economic development in general has had a positive development, as was the case in Finland during the 1980s (= first upswing) and after the crisis in 1990s (= second upswing).

[15] Marknadssugning (in Swedish).

[16] Marknadsutvidgning (in Swedish).

[17] Dahmén, Erik. 1950. pp. 49-52.
Look at also:
Lundberg, Erik. 1951. *Entreprenuerial Activity and Industrial Transformation.* In Carlsson, Bo & Henriksson, Rolf G.H. (eds.) 1991. *Development Blocks and Industrial Transformation – The Dahménian Approach to Economic Development.* pp. 92-99.
Thomas, Brinley. 1951. *Swedish Industrial Entrepreneurship.* In Carlsson, Bo & Henriksson, Rolf G.H. (eds.) 1991. pp. 100-102.
Gerschenkron, Alexander. 1957. *A Schumpeterian Analysis of Economic Development.* In Carlsson, Bo & Henriksson, Rolf G.H. (eds.) 1991. pp. 103-113.
& Ljungberg, Jonas. 1990. *Priser och marknadskrafter i Sverige 1885-1969 – En prishistorisk studie.* pp. 72-77.

However, some exceptions to Dahmén's principles were made. In his model, Dahmén used the average of two or three years for his research period. I have used a period of five years both in the 1980s a period before the crisis of the beginning of the 1990s, and a five-year period of after this crisis. The period I have chosen from the 1980s is 1983-1988. During this period, the economic "life" and development was quite stable, as the chapter on the development in Finland during the 1980s and 1990s describes. The second period covers the years from 1993 to 1998. In 1993, the financial crisis which occurred in the beginning of the 1990s was mainly over, and a new upswing in the economy had started. The choice of these two periods could be discussed, but it has been important for me to choose two similar periods, which have not been affected by the crisis that occurred in Finland in the beginning of the 1990s. Secondly, I have made an attempt to compare as long periods as possible, not only two or three-year as Dahmén did, but instead five-year periods, to be able to provide as "real" a description as possible, of the economic life in Finland.

I have divided the different industrial sectors to advancing, stagnating and receding ones on the basis of their industrial production. I have not analysed the number of workers by branch, which was one of Dahmén's aspects, because of all the rationalisation programmes that have been carried out to decrease the amount of employees. Where the increase of employment was one of the qualities of an advancing industrial branch during the inter-war years, an opposite effect can be seen in the development during the 1980s, and especially during the 1990s. Because of this fact, a comparison of the number of employees would have been too misleading in this study.

To enable the comparison of the industrial production, and its value during a period as long as 20 years, I have used the volume index of industrial output in order to measure changes in value added. The volume index has been calculated by using the so-called "Laspeyres index equation". Using this equation, the annual value added of industrial output from the time period covered by my research can be compared with each other. The Laspeyres index equation is as follows:

$$Q_{01} = \frac{\sum_{i=1}^{n} \rho 0i \times \varsigma 1i}{\sum_{i=1}^{n} \rho 0i \times \varsigma 0i} \times 100$$

where

$\rho 0i$ = the price of product in base-year

$\varsigma 0i$ = the amount of product in base-year

$\varsigma 1i$ = the amount of product during the comparison period

Q_{01} = the volume index.

When the division to advancing, stagnating and receding industries has been made, a more specific description of industrial sectors can be provided. There are 22 industries, which I will analyse and introduce later on in this study. The list of these 22 industries can be found in appendix 2, where the SIC 1995 classification also is introduced. In this same appendix, I attempt to combine in one list these three different standard classifications used in this paper. This "combining" process has been made difficult by the fact that the entire industry has been subject to rapid changes during these last two decades, which means that new industrial sectors have appeared, and some old traditional ones have declined. By using a complete description of these three different standard classifications, I have managed to link these classifications quite well with the SIC 1995, which is the classification used in this paper.

Another difficulty in this combination process was the use of "weight indexes"[18] in order to match volume numbers for each industrial sector with the SIC 1995 classification. In the case of food products and beverages for instance, the original data [19] in the SIC 1968/80 classification was divided into more precise categories (311-313), whereas in the SIC 1995 the same data consisted of only one category (15).[20] In the SIC 1968/80, categories 311 and 312 represent food industries with a weight index of 8.7 and 313 is the classification number for beverages with a weight index 1.4. Calculating these classes together and including only the average of these different volumes would not give the correct results. This is the reason why weight indexes have to be modified in the following way:

$$[(SIC_{311,312} \times 8.7) + (SIC_{313} \times 1.4)] / (8.7 + 1.4)$$

The result from the above equation is equal with the classification number 15 in the SIC 1995. The situation becomes even more difficult when weight indexes vary with time.

[18] Weight index and Group Weight Index (GWI) are two different aspects. Weight indexes have been used in industrial output calculations (appendices 4 and 5), while GWIs have been used in Unit Innovation Number (UIN) calculations (appendix 7).

[19] "Original data" in this case means the Statistical Yearbooks of Finland, where some industrial sectors have got more attention than others in the presentation during the time.

[20] Look at Appendix 2.

In industrial output calculations, the original data consisted of four different base years. The period 1980-1985 had 1980 as the base year, 1985-1990 had 1985, and for 1990-1993, the base year was 1990. The period 1993-1997 was already introduced with 1995 as the base year, which allowed me to use the original data directly. In other cases, I have linked these different periods with each other, as appendix 3 illustrates. The figures for the last two years, 1998 and 1999, I have calculated myself, using the monthly data adjusted per working day. These data can be found on the homepage of Statistics Finland.[21] The results of my calculations are presented in appendix 4.

2.3. The "Sfinno" approach

Finnish Innovations – "Sfinno" – is a project started by the Group for Technology Studies (GTS) in the Technical Research Centre of Finland (VTT) in 1997. The aim of this project is to provide a deeper and more comprehensive understanding of the industrial renewal process in Finland from the point of view of individual innovations.[22] As I have already mentioned in my C-level paper [23], GTS has constructed a database that contains basic data on about 1700 innovations commercialised during the 1980s and 1990s in Finland.[24] Innovations are identified through expert opinion, systematic reviews in technical journals and annual reports of a selected number of large companies. Additional data on innovations are collected by using survey, company registers and patent data. The database contains data on the industrial and technological field of innovations, the year of commercialisation and the company, as well as the origin and diffusion of innovations, R&D collaboration, public support and the commercial significance of the innovations. This data is complemented with more in-depth studies of both quantitative and qualitative nature.[25] The Sfinno database

[21] http://www.stat.fi

[22] Palmberg, Christopher & Toivanen, Hannes. 1999. *Innovations and Technological Change in Finnish Industry – Discussing an Alternative Approach and Some First Results*. p.2.

[23] Saarinen, Jani. 2000.

[24] In Sweden, an interesting study called "One hundred major Swedish technical innovations, from 1945 to 1980" has been made. This study has been focussed on technical innovations of the high technology type. The selection criteria has been quite similar both in this Swedish study and Sfinno, despite the fact, that in the Swedish study, the innovation has to be a successful one, reaching the yearly turnover more than $3.5 million in 1980 prices. To use the Swedish study in order to describe the innovation activity in whole industry might be quite a risky one, because only the cream of the innovation crop has been analysed. For more information, look at: Wallmark J.T. & McQueen D.H. 1991. *One hundred major Swedish technical innovations, from 1945 to 1980.* Research Policy 20 (1991). pp. 325-344.

[25] For more information about the Sfinno, look at:
Palmberg C, Lemola T & Leppälahti A. 1999. *Innovations and industrial renewal in Finland – Back to basics in innovation studies.*

consists basically of only product innovations and, therefore, service sector innovations and organisational innovations are not included in this database.[26]

As I have already discussed the methodology used for including innovations in the Sfinno database in my C-level paper, I am not going to repeat myself. For those who wish to know more about this compilation process, I recommend either reading my C-level paper or more precise description of Sfinno, found on the homepage of the Group for Technology Studies.[27] Due to the fact that Sfinno is so unique and extensive in its own category, I will use this database without any reservations in this study. I can easily agree with the leader of the Sfinno project, and argue that in case of such a small country and economy as Finland is, this database describes the "real" world behind all official statistics, through individual innovations.

2.4. Innovations versus patents

In this study, like in the Sfinno, a product innovation has been defined as an invention that has been commercialised on the market by a business company or equivalent. As a minimum requirement, an innovation has had to pass successfully the development and prototype phase of innovation, involving at least one major market transaction.[28] Reasons for choosing innovations, instead of patent data, were several and they will be described in the following chapters.

Patents are an indicator of an invention and innovation, but they have their pitfalls. Perhaps the most important disadvantage of patents is that not all inventions are patented. Small companies may find patenting too expensive and may try to protect their innovations by other ways, such as by copyright. It can also be said that not all inventions, which are patented, become innovations.[29] In Sfinno, these problems have been solved by identifying innovations through expert opinion, systematic reviews in technical journals and annual reports of a selected number of large companies, as mentioned above in the chapter "The Sfinno approach".[30] Due to the fact that all innovations included in Sfinno must have been commercialised, as the definition above shows, "sleeping-patents" are not included in Sfinno. Another pitfall with patents is that

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& Palmberg C, Leppälahti A, Lemola T & Toivanen H. 1999. *Towards a better understanding of innovation and industrial renewal in Finland – a new perspective.*

[26] Palmberg C, Leppälahti A, Lemola T & Toivanen H. 1999. p.5.

[27] http://www.vtt.fi/ttr

[28] Palmberg C, Leppälahti A, Lemola T & Toivanen H. 1999. p. 38.

[29] The so-called "sleeping patents".

[30] It is not only large companies which have been included in the Sfinno. The whole data contains 952 companies, so that even those small ones have been included.

some companies protect their innovations by alternative methods, notably industrial secrecy.[31] It might also be the case that not all inventions are technically patentable. This can be seen when comparing Sfinno data with patent data in the case of software, which has not been patentable until very recently. In Sfinno the amount of software innovations is about 10 percent,[32] whereas the number of software patents is zero.

Growing interest in the study of innovation and technological change started in the 1980s, as evolutionary and Schumpeterian issues rose higher on the agenda of social and economic research. Since then, there has been an increasing need for the collection of internationally comparable innovation data.[33] During the last two decades, researchers have attempted to develop a new innovation "output" indicator, but unfortunately, an internationally comparable indicator of innovation output does still not exist. However, the various approaches are based on one or more of the following methods: i) identification of major innovations from historical literature; ii) identification of innovations by consulting experts; iii) managers' assessment through postal surveys of numbers of innovations; and iv) counting of innovations by using trade journals.[34] The fourth approach is a recently developed method for measuring innovative activity in a national economy based on new product announcements in trade and technical journals. This "literature-based innovation output indicator" is not meant to capture all aspects of innovation, or to substitute for other indicators, but is seen as a useful addition to the range of indicators available.[35]

2.5. Innovation activity of industrial sectors

To owe the objectives of this study, industries have been divided into more and less innovative ones. The study focuses on innovations, that have been commercialised after 1985. There are several reasons for this choice. Firstly, the total amount of innovations in the Sfinno database

[31] Archibugi, Daniele. 1992. *Patenting as an indicator of technological innovation: a review.* In Science and Public Policy, volume 19, number 6, December 1992. p. 358.
[32] Palmberg C, Niininen P, Toivanen H & Wahlberg T. 2000. *Industrial Innovation in Finland. First Results of the Sfinno-project*. VTT, Group for Technology Studies. Working Papers No. 47/00. p. 14.
[33] Kleinknecht, Alfred & Bain, Donald (eds.) 1993. *New Concepts in Innovation Output Measurement.* pp. 1 & 189.
[34] Kleinknecht, Alfred & Bain, Donald (eds.) 1993. p. 3.
[35] For more information about this literature-based approach, look at:
Coombs R, Naranden P & Richards A. 1996. *A literature-based innovation output indicator*. Research Policy 25 (1996) pp. 403-413.
Santarelli, Enrico & Piergiovanni, Roberta. 1996. *Analyzing literature-based innovation output indicators: the Italian experience.* Research Policy 25 (1996) pp. 689-711.
& Kleinknecht, Alfred & Bain, Donald (eds.) 1993. – This book consists of results from Five-country project, about the use of this new innovation indicator.

before 1985 is 82 of a total of 1292,[36] which is slightly more than 6% of the amount of innovations. This means that the role of these innovations compared with the total number of innovations is less important, but it can also mean that the methodology for identifying innovations had not been consistent during these early years of the 1980s.[37] Secondly, as Dahmén pointed out in his study, it is important to assess whether the expansion of the markets was due to new innovations[38] and what was the reason behind the success of those industrial sectors that managed to grow during the 1990s? In this case, it is important to study the situation right before, during and after the crisis. What the situation was in the beginning of the 1980s is less important in this study.

Table 1 illustrates the distribution of innovations in the Sfinno according to industry divided into three different time periods. In order to make a division into more and less innovative industries, an average value was calculated. The problem, which occurred in this part of study, was that Sfinno consists of the type of industrial sectors that are not included in my calculations on advancing, stagnating and receding industries. Industries, such as software, holding companies etc., cannot be found from the Statistics Finland's list of industrial output. My problem was to decide whether I should use the entire database including software and other sectors, which actually had nothing to do with my study, or could I just select those industrial sectors from Sfinno, that were relevant for this study? I chose to include *only* those industrial sectors that have some relevance in *this* study. Because of this methodology, the total number of industrial sectors in the final phase of the analysis is 13. The list of these sectors is presented above in table 1. The fact that the number of relevant industrial sectors in the Sfinno was 13, and the number of industries after the first division according to the "Dahménian" approach consisted of 22 sectors, posed a problem in this study. The problem was solved by choosing the 13 industrial sectors of Sfinno in the final analysis. Accurate descriptions showing how the 22 industries were matched exactly with the 13 sectors in Sfinno are given

[36] The amount of innovations, which fulfilled the search criteria, was 1292, on 17th December in 1999. At that time, the database was still under construction.
[37] Group for Technology Studies uses also three time periods in their publication about the first results of Sfinno. Look at: Palmberg C, Niininen P, Toivanen H & Wahlberg T. 2000. p. 9.
[38] Dahmén, Erik. 1950. p. 118.

Table 1. Number of innovations according to the Sfinno and their group weight indexes. [39]

SIC 1995	Sfinno 1985-89	GWI 1985-89	Sfinno 1990-94	GWI 1990-94	Sfinno 1995-99	GWI 1995-99
15 & 16	19	11.3	30	11.8	35	7.7
17 - 19	3	4.2	4	2.6	6	2.3
20 & 36	4	6.6	5	6.2	7	7.3
21	11	14.8	21	14.5	14	14.0
22	1	7.0	2	5.9	2	5.9
23 - 25	33	9.4	29	11.1	30	9.8
26	6	4.0	1	2.7	5	2.7
27 & 28	13	8.8	27	9.7	20	10.4
29	50	9.9	58	9.6	83	11.1
30 - 33	46	7.9	68	9.7	86	15.4
34 & 35	4	4.1	10	3.7	7	3.8
C	2	1.4	4	1.2	5	1.1
E	7	10.6	4	11.3	5	8.5
Total	199	100.0	263	100.0	305	100.0

Source: Sfinno 17th December 1999 & Statistical Yearbooks of Finland.

later on in table 5. The previous list shows those sectors, that were included in the final analysis of this study.

A division into more and less innovative industries by using only the number of innovations that each industry has commercialised during the study period, would have been quite an unfair to small industrial sectors, such as non-metallic mineral products. In order to avoid this kind of methodological dishonesty, the so-called "Group weight index" (GWI) has been used to equalise the industrial output. In other words, by using a group weight index, it is possible to calculate exactly what the "real" amount of innovations is per "unit" in each industry. For example, if the

[39] Group weight indexes (GWI) has been calculated by comparing the value added of each industry with the total industry value added during each time period. A choice for three different five year periods has been made, due to the fact, that when I got innovation statistics from Sfinno, the database was still under construction, and more precisely division was not possible. Due to these five year periods, a similar kind of methodology has been used in order to get correct GWI -numbers. I have chosen three base years, 1988, 1993 & 1998, and calculated GWIs for these years. A more precisely method would has been to calculate GWIs for each year, from 1985 to 1999, and take an average of those. However, my decision was to calculate only those three different GWIs, mentioned above. My opinion is, that by using this method, the objective of this study can be achieved.

amount of innovations in transport equipment (SIC 1995 –numbers 34 & 35) is 39, a division by group weight index 3.9 gives the result 10. This means, that each "unit" in transport equipment sector has commercialised 10 innovations. By using this kind of methodology, the differences in industrial output between industries are minimised, and the real innovation activity of each unit has been calculated. By comparing these "Unit Innovation Numbers" (UIN) with each other, a more precise picture of the more and less innovative sectors in the Finnish industry can be given.

When these so-called unit innovation numbers for each industry had been calculated, the next step was to take the average value of these units in order to make a division to those more and less innovative sectors, which is the objective of this study. Industries, which have commercialised more innovations per unit than the average value, belong to the class called "more innovative industries". Industries that have commercialised less innovations than the average value, belong instead to "less innovative industries". Results of these calculations are shown later on in this study in the chapter "The New Industrial Pattern".

3. Economic Development in Finland

3.1. Development before 1980

According to Rostow's terminology, the industrial "take-off" in Finland started somewhere between the 1860s and 1870s, and it was based on the production of wood products.[40] During the next 70 years, the wood industry was the most dominating one in Finnish industry, all the way to the WW II. After the war, the metal product industry took this leading role, in order to pay back the huge war-restitution to the Soviet Union, which Finland was forced to pay. To be able to make these payments, investments in metal industry were made, which led to an increase in this sector and helped the whole economy to achieve a level of "maturity".[41]

3.1.1. Gross domestic product (GDP)

Finland became independent in 1917. During that time the country had a population of 3.134.000 which had increased to 4.788.000 by 1980. Since the day of independence and the end of the WW I, there has been a continuous increase in gross domestic product (GDP) in Finland. GDP

[40] Jutikkala, Eino. 1968. *Suomen Teollistuminen.* In Jutikkala, E. (ed). Suomen talous- ja sosiaalihistorian kehityslinjoja, Helsinki. pp. 207-208.
[41] Lahtinen, Simo. 1977. *Tuotanto, työ ja energia Suomen teollisuudessa vuosina 1900-1975.* Bank of Finland Publications, A:45. p. 17.

per capita calculated at 1985 prices was about FIM 7.300 in 1917 and FIM 61.400 in 1980. As figure 1 illustrates, there was some stagnation in the growth of GDP in the beginning of 1930s, due to major international financial problems, which had an effect on the Finnish economy as well. Also, the decrease during the WW II, as well as the oil crisis in the 1970s have been periods of stagnation or even decrease in GDP. Otherwise, the growth has continued quite steadily, or as the results of Riitta Hjerppe's calculations from the period 1860-1980 show, there has been a slight, but still distinct, acceleration, after the WW II.[42]

Figures 1 and 2 below illustrate the development of the GDP per capita during those eight first decades of the 20th century. As figure 2 shows, there have been some great variations in the annual change of GDP per capita. The unbroken line in figure 2 is an average of five years, and by taking a closer look at this line it can be noticed, that despite the two World Wars, there has been a continuous growth in the GDP per capita. It can also be noticed that this growth has been more even during the period after the WW II, if we compare it with the inter-war years, which was a period of unstable conditions and events around the world.

Figure 1. Gross domestic product/ capita 1900-1980 (1926=100).[43]

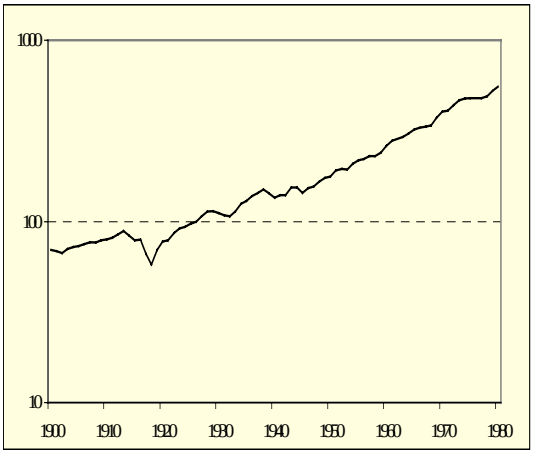
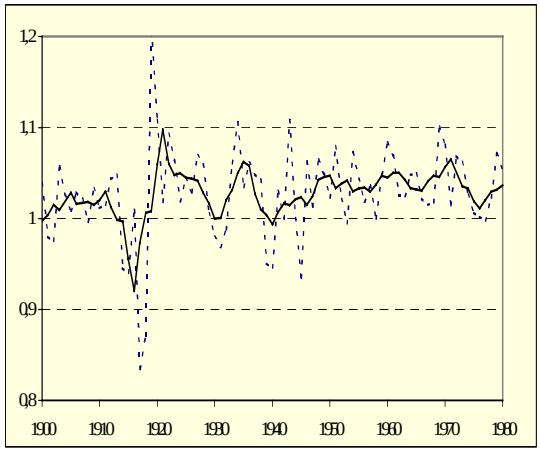


Figure 2. Annual change in gross domestic product /capita 1900-80.



Source in both figures: Hjerppe, Riitta. 1989. pp. 192-194.[44]

[42] Hjerppe, Riitta. 1989. *The Finnish Economy 1860-1985 – Growth and Structural Change.* Bank of Finland's Publications, Studies on Finland's Economic Growth XIII. Government Printing Centre, Helsinki. pp. 42-46 & 58-59.

[43] Index numbers 1926=100.

[44] The numbers in figures 1 and 2 are based on the volume index numbers, where year 1926 has been the base year (100). These numbers can be found from the book of Hjerppe, Riitta 1989 *"The Finnish Economy 1860-1985"*, and from the homepage of Statistics Finland (http://www.stat.fi).

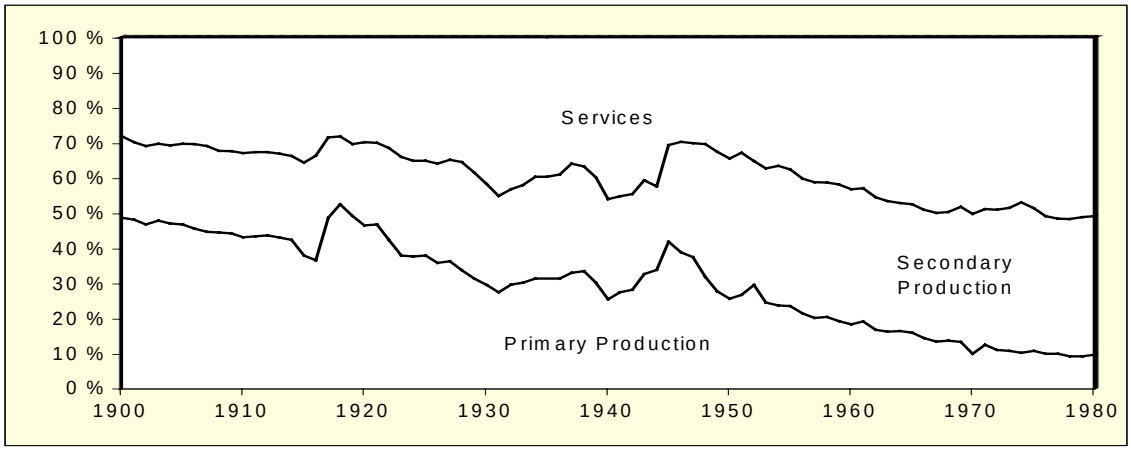
3.1.2. Structural change

The 20th century has been a period of structural change in Finland in many respects. The growth of output and population, changes in the structure of production and the trend towards an increasingly specialised division of labour have been some of the elements of structural change. One of the most rapidly changing areas of change has been the development in the structure of production. Finland has succeeded in increasing the role of secondary production as well as services and has managed to become an industrialised nation. The following figure shows the structural change in the Finnish production.

Figure 3 below shows how the role of primary production has decreased rapidly during the 20th century. Primary production, which includes agriculture, forestry, hunting and fishing, has decreased from 49% of total production in 1900 to 10% in 1980. The figure also shows, how WW I & II as well as the Great Depression during the 1930s, have affected the production of primary goods. During both World Wars, the percentual amount of primary production increased rapidly to guarantee the basic needs for country's inhabitants. After the years of war, primary production has continued to decrease again, quite continuously. It is also worth mentioning that it was as late as in the end of the 1940s, when secondary production overtook primary production, which meant that Finnish economy made the transition to predominantly industrial production.

At the same time, when primary production has decreased, secondary production, which includes all kinds of manufacturing and

Figure 3. Structural change of production 1900-1980.



Source: Hjerppe, Riitta. 1989. pp. 231-236.

construction as well as services, has taken more place in the total production in Finland. Especially the service sector, which includes trade, banking, transport & communication, housing, private and public services, has become the most dominant one in the Finnish economy. Secondary production was the largest sector in the Finnish economy for a fairly short time. In 1956 it was time for services to overtake this position. Eleven years later, in 1967, the role of services was already 50% of the total production in Finland, and it has still continued to increase since then.

Some characteristic qualities of industrialisation are technological development as well as rise in productivity. In Finland, the importance of productivity as a factor in the development of GDP has been increasing continuously during the 20th century.[45] The fastest growth rate has been in manufacturing, where the clarification of production bottlenecks through the gradual adaptation of production technology and the utilisation of production inputs has been of great importance.[46]

3.1.3. Investments

Investments can be viewed in the short run as a demand factor that is indispensable for economic growth.[47] The following figure illustrates the rate of investments in relation to the GDP. I have compared the annual change in investments with the annual change of GDP by using indexes (1926=100). Due to these indexes that are used in the figure below, the percentual amount of investments compared with total GDP cannot be seen. However, this figure illustrates the "real" development of investment activity in Finland during the period 1900-1980. As figure 9 later on will illustrate, investments accounted for almost 39% of the total GDP in 1980. Considering the figure above, both an annual comparison (broken line), and the average comparison of five years (unbroken line) are included.

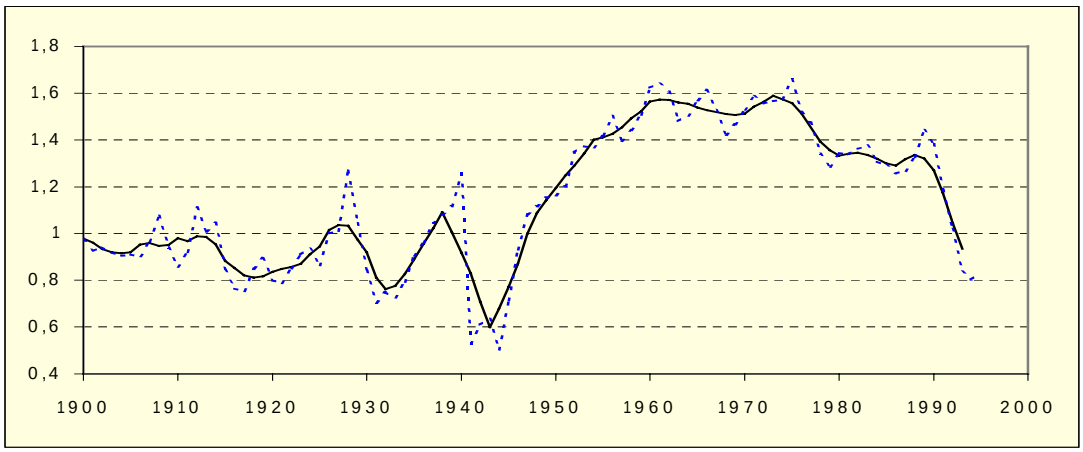
The investment rate in figure 4 shows not only cyclical changes in investments, but also an interest to build up the industry and infrastructure during the 20th century. The figure also shows how investments decreased rapidly during the World Wars and recovered during the years right after. The upswing after the Second World War was especially rapid and long-lasting, reaching its top in as late as 1960. Also worth mentioning is the downswing at the end of twenties, which

[45] Hjerppe, Riitta. 1989. pp. 107-111.
& Ahvenainen, Jorma & Kuusterä, Antti. 1982. *Teollisuus ja rakennustoiminta.* In Suomen Taloushistoria 2. pp. 226-228.
[46] Hjerppe, Riitta. 1989. p. 109.
A more precise description of the development of manufacturing industry can be found in the analyse part of this study, in chapter "Innovation activity in Finnish industries".
[47] Hjerppe, Riitta. 1989. p. 143.

became even worse when the effects of the Great Depression from other side of Europe reached Finland in the beginning of 1930.[48] The downhill, which started in Finland already at the end of 1920s, was caused by the building industry, which had overheated, the money market had become tighter and the agricultural harvest had been poor.[49]

The post-war era was a period of reconstruction in forms of residential construction, construction of the transportation network and industrial plants. According to Hjerppe, the rate of investment would have risen even higher had there not been a shortage of building supplies, raw materials, and foreign exchange for the purchase of machinery.[50] In spite of the lack of these materials, the volume of investments increased more than 10-fold between 1944-1980.[51] A great proportion of investment in machinery and other equipment during these years manifested itself in the rapid growth of productivity, especially in manufacturing between 1960 and 1985.[52] Technological development led to a situation where it was necessary for the companies to invest in new machinery and equipment at shorter intervals in order to maintain a position on the markets. These rapidly increased investments in new technology were one of the factors behind the economic growth during the post-war era in Finland.

Figure 4. Investments in relation to gross domestic product 1900-95 (Index numbers 1926=100).



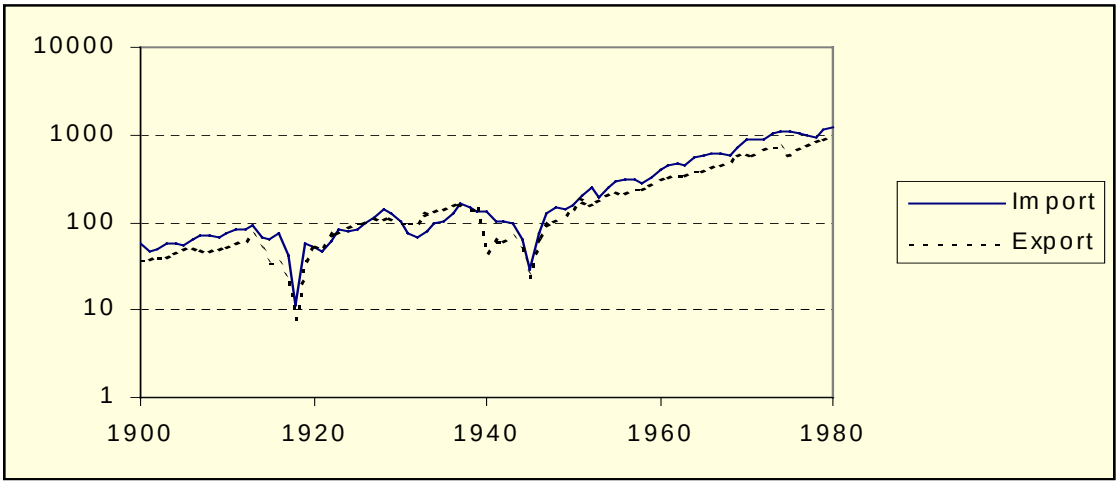
Source: Statistics Finland. (http://www.stat.fi)

[48] For more information of the Great Depression, look at: Dillard, Dudley. 1987. *Västeuropas och Förenta staternas ekonomiska historia.* (Economic Development of the North Atlantic Community – Historical Introduction to Modern Economics) pp. 489-494.
[49] Hjerppe, Riitta. 1989. pp. 48 & 140-142.
& Ahvenainen, Jorma & Kuusterä, Antti. 1982. pp. 222-224.
[50] Hjerppe, Riitta. 1989. p. 142.
[51] Source: Statistics Finland.
[52] Hjerppe, Riitta. 1989. p. 142.

3.1.4. Foreign trade

The foreign trade in Finland during the 20th century can roughly be divided into three different periods. Firstly, the period of free trade during the Russian administration, especially from 1840 to the First World War, was characterised by reduced import tariffs and trade restrictions.[53] It was during this era that foreign trade in Finland expanded quickly.[54] Secondly, the Inter-war period was characterised by protectionism.[55] The volume of trade grew slowly, because of increased tariffs and bilateral trade agreements.[56] Thirdly, the period after the Second World War has been an era of more liberal trading, helped by international trade agreements and multinational companies.[57] During the early years after the WW II, a rapidly increasing international demand for paper and wood helped the recovery of Finnish economy.[58] In figure 5 above, the breaking points of each of these periods mentioned above can be easily seen. I have used the logarithmic scale in

Figure 5. Export and import 1900-1980 (Indexes 1926=100).



Source: Statistics Finland. StatFin 28-03-2000.

[53] Hjerppe, Riitta. 1989. p. 149.
[54] Rasila, Viljo. 1982. *Kauppa ja rahaliike.* In Suomen Taloushistoria 2. p. 96.
[55] Instead of the word protectionism, ”qualified liberalism” was used in the economic policy in Finland during the inter-war period.
Source: Ahvenainen, Jorma & Vartiainen, Henri J. 1982. *Itsenäisen Suomen talouspolitiikka.* In Suomen taloushistoria 2. pp. 178-179.
[56] Pihkala, Erkki. 1982. Kauppa sotien välisellä kaudella. In Suomen Taloushistoria 2. pp. 262-264.
[57] Hjerppe, Riitta. 1989. p. 149.
[58] Pihkala, Erkki. 1982. *Sopeutuminen rauhaan.* In Suomen taloushistoria 2. pp. 346-347.

order to illustrate the relative growth and development of foreign trade in Finland.

Already in the beginning of the 20th century, the role of foreign trade was really important for the Finnish economy. The amount of export was during the first half of the 20th century around 30% of the gross domestic production, while the role of import varied between 20 – 36%.[59] Because of the major role of foreign trade, especially the role of export, fluctuations in economic conditions abroad were transferred to Finland also. Wars and other crises did not make the situation better for Finland, because foreign trade was usually stopped, or dramatically diminished, during the years of war.

3.2. Development during the 1980s and 1990s

3.2.1. Gross domestic product

The economic development in Finland during the 1980s is characterised by a steady and continuous growth as the following figures illustrate. The oil crises in 1973 and 1979 affected Finland less than other West European countries because of the special trading relationship with the Soviet Union, which supplied petroleum in exchange for Finnish industrial goods.[60] This relationship helped Finland to continue its steady growth during the 1970s as well as during the 1980s, and made Finland less susceptible to the crisis of other West European countries. During the whole 1980s, the gross domestic product increased by 4.7% annually.[61]

As the figures 6 and 7 show, the growth of GDP was more rapid at the end of the 1980s, just before the crisis that occurred in the beginning of the 1990s. A negative aspect of growth was that after the opening of international financial and capital markets, the growth in Finland was financed by help of cheap foreign capital and loans, and because of that, the entire economy became sensitive to fluctuations and impacts from abroad.[62] The economy started to show signs of overheating, and the

[59] Tudeer, A. E. 1950. *Suomen ulkomaankaupan rakenteessa tapahtuneita muutoksia.* In Taloudellisia selvityksiä 1950: II. Suomen Pankin taloustieteellisen tutkimuslaitoksen julkaisuja, Sarja A: 11. pp. 5-8.

[60] Kauppila, Jari. 1999. *Bruttokansantuotteen kasvu.* In Suomen Vuosisata, pp. 170-172.

[61] The average increase in GDP:
GDP in 1980: 430,063 Mmk; GDP in 1989: 583,768 Mmk
→ GDP increased by 73,7% during this period, which means, that annual increase was 4,7%
Source: StatFin & own calculations.

[62] Valtiovarainministeriö. 1999. *Conference Paper for Unofficial Meeting of Ecof*. p. 1.

situation became too difficult for the Finnish economical institutions to handle. The deep period of depression that Finland faced in the beginning of the 1990s was in fact a result of the outbreak of this bubble. The situation was made worse on the financial stagnation in the rest of Europe and the collapse of foreign trade with the Soviet Union.

As we can notice from the figure 6, the Finnish economy started its recovery in 1993, and reached the pre-crisis level in 1996. The difference between the growth in the 1980s and 1990s was that after the crisis, the economy was more solid. The most important goal for the economic policy in 1991 was stabilisation of the economy.[63] Another goal was to cut government finance in order to stop international loaning. A stabilisation of prices became one of the new goals of the financial policy for controlling inflation.[64] Afterwards it can be discussed whether these political goals that were set up in the beginning of 1990s have been successful.[65] The Finnish economy grows continuously, as figure 6 illustrates, and the foundations of the economy are "healthier" and "stronger" than during the growth in the 1980s.

Figure 6. Gross domestic product at 1995 prices 1980-1999. FIM million.

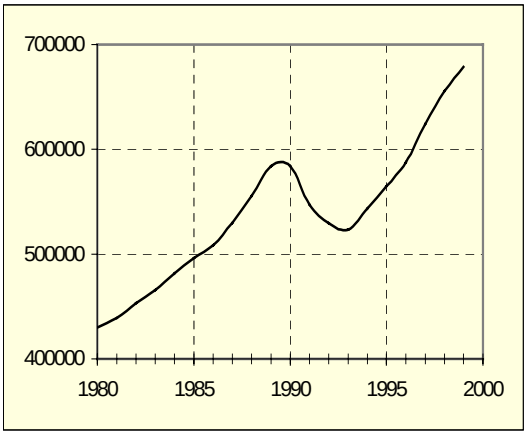
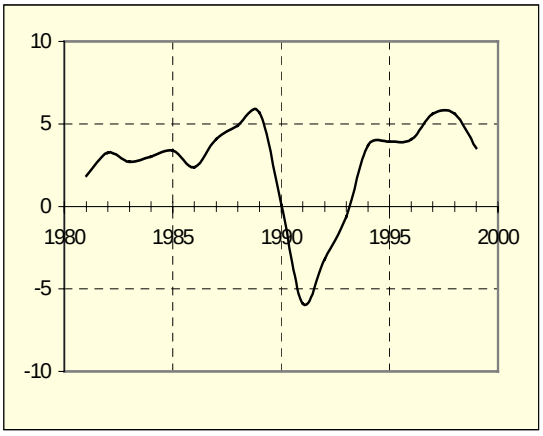


Figure 7. Annual percentual change in gross domestic product 1980-1999.



Sources in figures 6 & 7: Statistical Yearbook of Finland 1999, p. 280.
& Suomen Vuosisata CD-ROM (The Finnish Century CD-ROM).

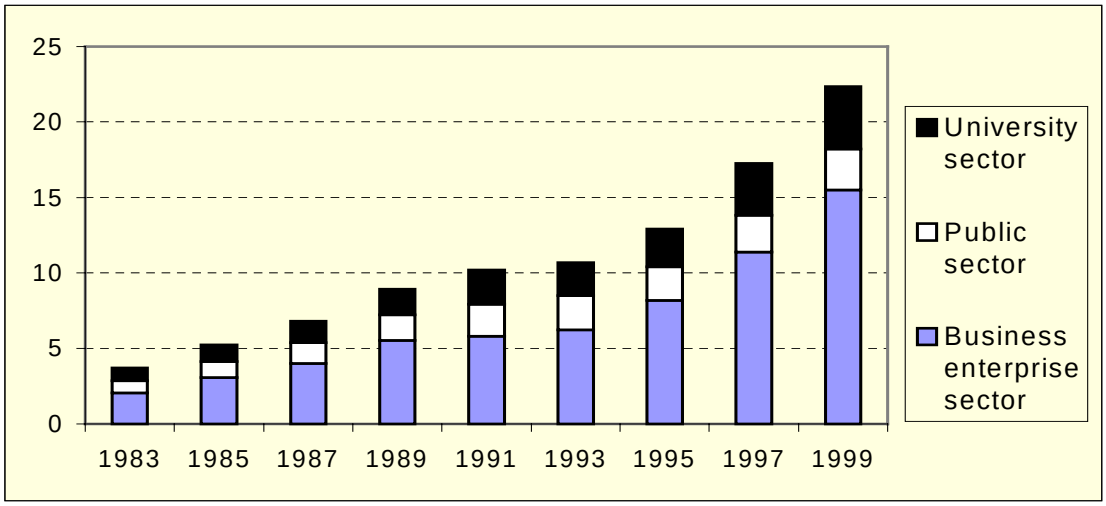
[63] Valtiovarainministeriö. 1999. p. 1.
[64] Valtiovarainministeriö. 1999. p. 2.
[65] According to Financial Times, the strong and sustained recovery during the 1990s is partly explained by the depth of the preceding slump, by a competitive exchange rate and partly by a phenomenal contribution from the electronics sector, led by telecoms giant Nokia.
Look at: Brown-Humes, Christopher. 1999. *Heady cure for depression.* Country Brief, Financial Times Survey, July 1999. (http://www.ft.com).

3.2.2. Research and development (R&D)

In the beginning of the 1980s, the industrial sector made an initiative in order to improve the level of research and development in Finland. The reason for this initiative was that Finnish products were not competitive enough in the international markets.[66] Since then, investments in R&D have increased steadily as figure 8 shows. It is worth mentioning that despite an economic depression in the beginning of 1990s, investments in R&D have continued to increase.

The main factor behind the increase in R&D investments has been the activity of the companies. It has been shown that the production of R&D intensive goods is positively correlated to high productivity and

Figure 8. Research and development expenditure in Finland 1983-1999. FIM billion, at current prices.



Source: Statistical Yearbook of Finland 1999. p. 472.
& Teollisuustieto 2/2000. p. 5.

[66] Pohjola, Hannele. 1999. *Julkisen panostuksen vähentämiselle ei perusteita – Teollisuuden t&k-investoinnit kasvavat.* In Teollisuustieto 17/1999. p. 9.

high productivity growth.[67] As can be noticed from the figure above, the role of business enterprise sector was some 70% (FIM 15.5 billion) of the total amount (FIM 22.3 billion) of intestments in 1999. It can also be seen that total development of R&D expenditure is mainly based on the growth of the companies' R&D investments. R&D expenditures have also become global.[68] Prospects for future indicate that investments of industry will concentrate more and more in R&D, instead of material goods.[69]

3.2.3. Structural change

During the 1990s, the structure of Finnish industry has changed dramatically. Especially the role of electrical and electronics industry has doubled during that decade,[70] and it has become the third basic pillar in the Finnish economy, along the traditional forest-based and metal industries. One of the keys to this success has been increased investments into R&D, which started in the end of 1970s, and which have since then increased continuously. This has in its turn resulted in another change in the industrial structure, the growing role of high technology products. High-tech industries have been the most rapidly growing field during the 1990s, which can be seen in appendices 4 and 5, but also in export figures. Exports of these products exceeded imports in 1995 and are continuing to grow rapidly. By 1999 Finland was exporting well over FIM 45 billion in high-tech products – almost one-fifth of all exports – with imports running at about FIM 32 billion.[71] The major high-tech product group in 1998 was telecommunications equipment, accounting for 73% of all high technology exports.[72]

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[67] This has been shown in Edquist & McKelvey 1992, Edquist 1993 and Tyson 1992. Learning curves are also steeper for R&D intensive goods, and their development and production are often associated with positive externalities. This means that a country with a relatively large production of R&D intensive goods can be expected to experience a higher productivity growth (and a higher economic growth) than other countries.
For more information, look at:
Edquist, Charles & McKelvey, Maureen. 1992. *The Diffusion of New Product Technologies and Productivity Growth in Swedish Industry.* Consortium on Competitiveness & Co-operation (CCC) Working Paper, No. 91-15.
Edquist, Charles. 1993. *Technological Unemployment and Innovation Policy in a Small Open Economy.*
Tyson, Laura (D'Andrea). 1992. *Who's Bashing Whom? Trade Conflict in High-Technology Industries.*

[68] Räsänen, Ville. 1998. *Internationalization of R&D in Finnish Multinational Companies 1993-1998.* pp. 4 & 62-63.

[69] Pohjola, Hannele. 1999. p. 9.
& Heiäng, Paula & Ourila, Anne. 1998. *Teknologia ja tulevaisuus.* TEKES. pp. 8-9.

[70] Tsupari, Pekka. 1999. *Koko teollisuuden tuottavuusluvut antavat liian optimistisen kuvan.* In Teollisuustieto 14/1999. p. 4.
& White, Joe. 2000. *The techno way to export more.* In Views on Finnish Technology 2000. pp. 4-5.

[71] White, Joe. 2000. pp. 4-5.

[72] Palmberg C, Leppälahti A, Lemola T & Toivanen H. 1999. p. 3.

3.2.4. Investments

Economic growth is mainly based on the innovations and implementation of new technology. In order to get this new technology into use, one has to invest in new machines, buildings as well as infrastructure. Investments in industry play a major role in growth of industrial output. In figure 9, investments of the entire economy are compared with gross domestic product. This figure shows how investments remained at the level of about 30% of GDP during the 1980s, but after the crisis have only managed to reach a level of 20% of GDP. This figure gives perhaps a more realistic picture of investing activity in the whole economy, because it does not show only the increase in the value of investments, but compares the common development of the whole economy. This figure shows clearly how the level of investments in the whole economy have been much lower after the crisis compared with the pre-crisis level.

Figure 9. Investments / gross domestic product 1980-2000.

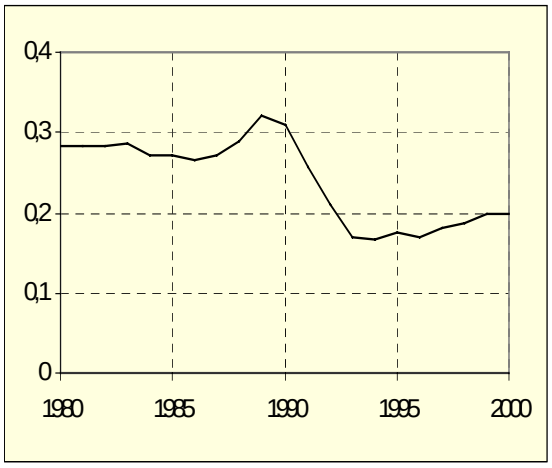
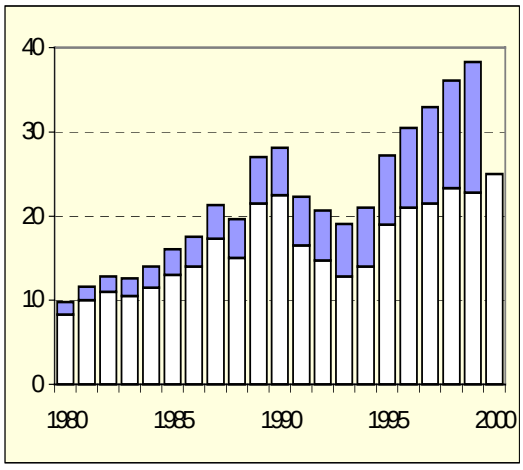


Figure 10. Investments in industry [73] 1980-2000. FIM billion, at current prices.



Sources in figure 9: Suomen Vuosisata CD-ROM (The Finnish Century CD-ROM) & Valtionvarainministeriö. 2000. *Taloudellinen katsaus – helmikuu 2000.* pp. 30-32.

Sources in figure 10: Teollisuustieto 18/1999, pp. 4-5 ; Teollisuustieto 7/1999, pp. 3-4 ; Teollisuustieto 2/2000, p. 5 & Statistical Yearbook of Finland 1999. p. 472.
Comments: White pillar = material investments ; Dark pillar = R&D expenditures.

[73] Investments in industry include material investments (white pillars) and R&D expenditure (dark pillars).The amount of investments in 2000 is a prediction about the outcome of industrial surveys, made by Teollisuutieto in 1999. (http://www.tt.fi).

Figure 10 shows the development of investments in industry. During the 1980s, investments in industry more than doubled, reaching their pre-crisis peak in 1990. During the crisis, the amount of investments fell rapidly, but started to recover again in 1994. Three different trends have been observed during the 1990s in industrial investments in Finland. Firstly, the amount of investments has doubled during the "after crisis" period 1993-1999.[74] A slight downswing in material investments in 1999 was caused by the decrease in foreign demand, as can be noticed in figure 11 in the next chapter.[75] Secondly, there is a structural change in investments. Companies have increased rapidly their investments in R&D in order to improve the competence level of the personnel as well as the level of high technology.[76] Thirdly, investments have become global. In 1999, almost half of all material investments went abroad, mainly to other European Union (EU) countries. Among industrial sectors that invested most were forest, metal, electronics and chemical industries. Small domestic markets that do not give any possibilities for growth have been the reason for these investments. Companies also secure their positions at international markets, as well as create and strengthen opportunities for export from Finland.[77]

3.2.5. Foreign trade

Throughout the 1980s, exports and imports were almost equal, as figure 11 illustrates. The most important reason for this development was the trade with the Soviet Union, which dominated Finnish foreign trade and developed quite steadily. But during the 1990s, the growth of export has been clearly larger than the growth of import. During the period 1990-1998, the annual growth of exports was 7.4%, while imports increased only 2.4% annually.[78]

The metal industry in general, and the electronics industry in particular, have been the industrial sectors that have stood for most of the growth of exports. Another branch inside the metal industry, the shipbuilding industry, has also been successful during the 1990s. Demand for so-called luxury cruisers has been constant and has been an important export product for metal industry. In case of imports, the metal industrial products represented in 1998 about 55% of the total

[74] Amount of investments in 1993: FIM 19.0 billion ; in 1999: FIM 38.3 billion.
[75] Tsupari, Pekka. 1999. *Teollisuus kansainvälistyy vauhdilla – Investoinnit nousuun ensi vuonna.* In Teollisuustieto 18/1999. pp. 4-5.
[76] Pohjola, Hannele. 1999. p. 9.
[77] Ylä-Anttila, Pekka. 1996. *Beyond Cluster Studies – Internationalization of Business and National Policies.* In Kuusi, Osmo (ed.) 1996. *Innovation Systems and Competitiveness.* pp. 94-97.
& Tsupari, Pekka. 1999. pp. 4-5.
[78] Tuomainen, Jorma. 1999. *Ulkomaankauppa.* In Suomen Vuosisata. pp. 156-157.

amount of imports. At the export side, metal products overtook the traditional forest-based products in the beginning of 1990s. In 1998, the amount of metal industry products was already more than 50% of the total exports.[79]

The expansion of markets has characterised the development of foreign trade during the last decades. EU countries have become the most important trading partners in the nineties, representing in 1998 60% of imports, and 56% of exports. Trade with Soviet Union practically finished in 1990, but has recovered again. In 1998 Russia was the fifth largest trade partner of Finland. Also, the trade with Asian countries has increased due to the success of electronics industry of Finland. Finnish electronics companies have become more dependent on the import of components and other similar products from these Asian countries in order to maintain their large scale of exports.

Figure 11. Foreign trade 1980-99. FIM billion, at current prices.

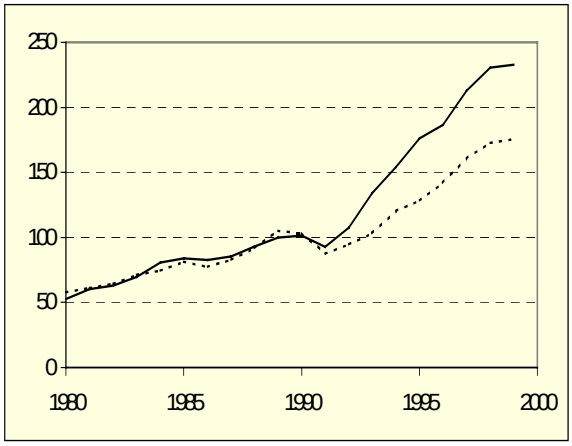
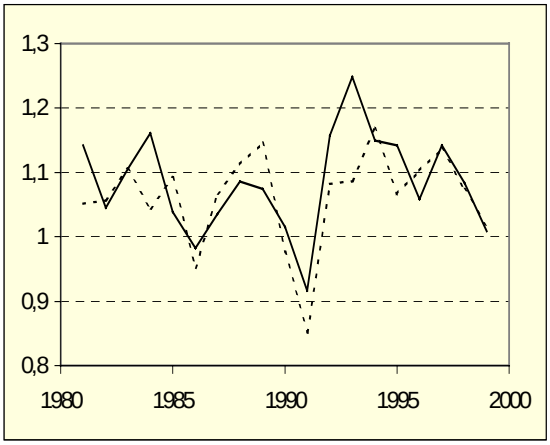


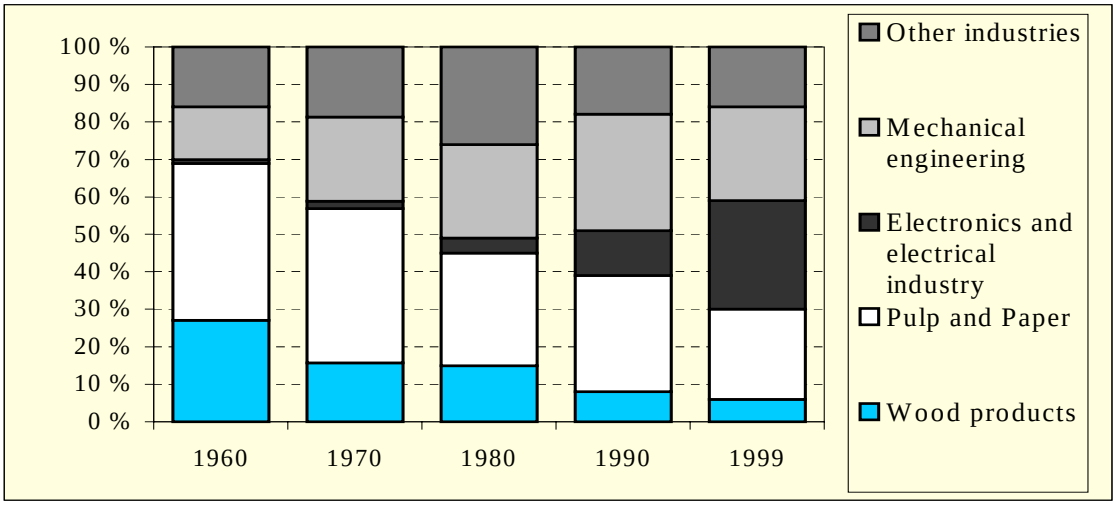
Figure 12. Annual change in foreign trade 1980-1999.



Source in both figures: Statistics Finland.
Comments: Broken line = Import ; Unbroken line = Export.

[79] Statistical Yearbook of Finland 1999. pp. 217-237.
& Tuomainen, Jorma. 1999. pp. 156-157.

Figure 13. Exports of the Finnish industry by industrial sector 1960-1999.

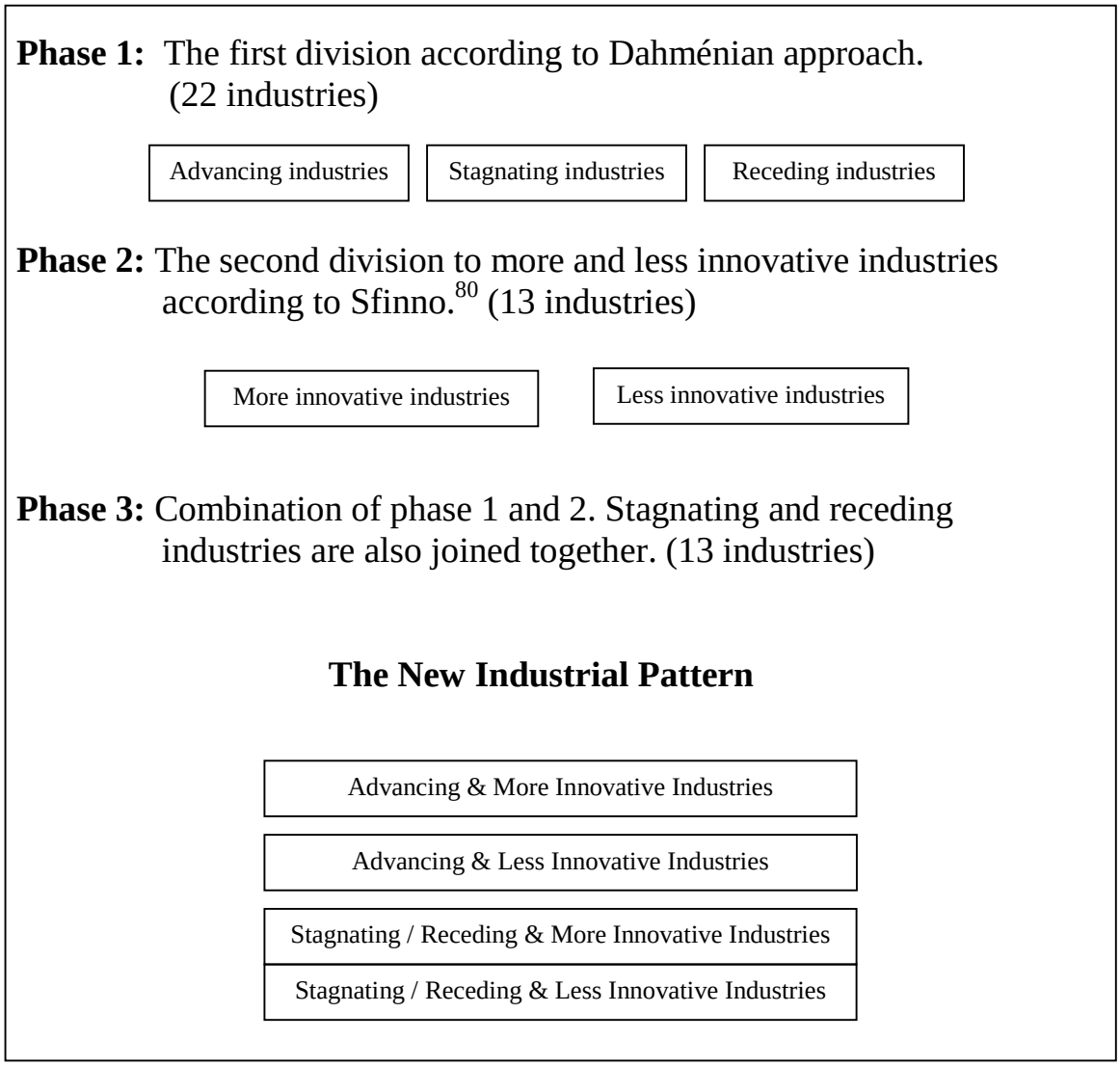


Source: National Board of Customs & Federation of Finnish Electrical and Electronics Industry.

4. Towards a New Industrial Pattern

In this chapter, the main analysis of this study is introduced. Firstly, the results of the Dahménian approach are introduced, showing the division into advancing, stagnating and receding industries. Secondly, the results of Sfinno are described with a division to more and less innovative industries. Finally, the results of the Dahménian approach as well as the results from Sfinno will be combined and a new division into four main categories will be presented. In the figure below a short clarification of this progress is given.

Figure 14. Progress of the New Industrial Pattern.



4.1. Results of the Dahménian approach

In this chapter, results of my calculations are presented. The methodology I have used is already described in chapter 2.1. I will start with advancing industries by introducing and commenting some figures. It is important to remember that in this part of the study the amount of

[80] In this phase, the amount of innovations from Sfinno has been divided with the "Group Weight Index" (GWI), which describes the amount of sectoral industry output compared with the total industrial output in Finland. The more specific results from these calculations can be found the appendix 7. The indicator, which describes the innovation activity of industry, has been named to "Unit Innovation Number" (UIN).

industrial sectors is 22 (Sectors 15-36 in SIC 1995). I have also taken into account mining and quarrying (C); energy, gas and water supply (D) as well as other manufacturing and recycling (Other D) in my calculations. As can be seen in table 1, I have already combined some individual industrial sectors with each other, this is the case with sectors (30-32) as (34-35). The reason for this has been the lack of availability of original data. As mentioned earlier, there have been changes in the classification methodology during the study period, and new industrial sectors have appeared in the economy.

The original data have been collected from the Statistical Yearbooks of Finland, where a division to industrial sectors according to the three different SIC classifications has been made. In appendix 2, a list of these industrial sectors is introduced, and the appendix also shows the results obtained by combining the different classifications.

4.1.1. Advancing industries

As mentioned earlier, an advancing industry has succeeded in increasing its industrial output by a certain amount between the two different periods of economic upswing. In this case, an advancing industry has managed to increase its output with at least 10% during the period 1993-1998 compared to the period 1983-1988. The following table contains those industrial sectors that have managed to be advancing in Finland according to the principle mentioned above.

Not surprisingly, manufacture of electrical and electronics machinery has been the most advancing industrial sector in Finland in this comparison. These electrical machines include for instance office machinery and computers, as well as radios, televisions and communication equipment. What is surprising, however, is that the increase in this sector has been as rapid as the numbers shows us. If we look at the figure illustrating an increase of this sector in appendix 5, we can observe that the growth has actually been exponential, instead of linear one, as the case has been among other sectors. The same figure also shows how the crisis in the beginning of the 1990s did not significantly affect the growth of this sector. However, the development already during, but most of after the crisis, has been amazing.

Table 2. List of advancing industries.[81]

SIC 1995 –number and name of industry		Change in output 1993/98 over 1983/88
15	Manufacture of food products, beverages	17.6 %
20	Manufacture of wood and wood products	17.0 %
21	Manufacture of pulp, paper and paper products	40.8 %
23	Manuf. of coke, refined petroleum products and nuclear fuel	46.7 %
24	Manuf. of chemicals and chemical products	35.6 %
25	Manufacture of rubber and plastic products	31.3 %
27	Manufacture of basic metals	57.4 %
28	Manufacture of fabricated metal products	29.0 %
29	Manufacture of machinery and equipment	23.4 %
30-32	Manuf. of electrical and electronics machinery	372.5 %
33	Manuf. of medical, precision & optical instruments, watches and clocks	77.7 %
C	Mining and quarrying	10.2 %
Other D	Other manufacturing, recycling	15.3 %
E	Electricity, gas and water supply	33.1 %

The manufacture of medical, precision and optical instruments, including watches and clocks, comes on the second place with quite a good marginal to the other sectors. As we can notice from appendix 5, there was a downswing in this sector during the crisis, but a comparison with other sectors also shows that this downswing was not as deep in the instrument sector as in many other sectors. The basic metals sector was also not affected by the crisis. Of course, there was a short period of downswing in this sector as well, but the industry succeeded in recovering quickly, and continued its growth, even more rapidly than before the crisis.

The next and last group which I am going to analyse at this point of study, is chemistry- related sectors, including the manufacture of coke, refined petroleum products and nuclear fuel (23), chemicals and chemical products (24), as well as rubber and plastic products (25). These sectors have also increased their industrial output by more than 30% and, despite of the crisis, have succeeded to increase their output quite steadily.

[81] Results of calculations can be seen in appendix 4. In appendix 5, a graphical illustration is also introduced.

4.1.2. Stagnating Industries

This group of industrial sectors is characterised by great downswings in the beginning of the last decade. A graphical illustration in appendix 5 shows that none of these industries have managed to reach the pre-crisis level in their industrial output. During the crisis, the industrial output of other non-metallic mineral products and furniture went down to a level that was lower than the level in the beginning of the 1980s. A look at the development of these two industries during the 1980s shows also the steadiness of growth during this decade. Compared with these two sectors, the publishing and printing industry continued its steady growth during the 1980s followed by a less rapid fall in the beginning of the 1990s. The publishing and printing sector managed to recover from the crisis with smaller damages, and had almost reached the pre-crisis level of industrial output by 1998. The following table presents those industrial sectors, belonging to this category.

An interesting aspect in all of these three industries is, that despite the stagnating mature of these sectors, the growth has actually been more rapid during the period after the crisis. This can be seen in appendix 5, where numbers below the figures describe the growth in production during the periods 1983-1988 and 1993-1998, respectively. This indicates that these industries have managed to recover well after the crisis, but still have not reached the pre-crisis level of industrial output.

Table 3. List of stagnating industries.

SIC 1995 -number and name of industry		**Change in output**
		1993/98 over 1983/88
22	Publishing, printing etc.	1.8 %
26	Manuf. of other non-metallic mineral products	-6.6 %
36	Manufacture of furniture	-8.9 %

4.1.3. Receding industries

Not all industrial sectors have succeeded in increasing their production during these two decades. Perhaps the most dramatic development has taken place in the textiles sector, including manufacture of textiles, wearing apparel and dressing of leather (numbers 17-19 in table 4). These industries were characterised by deep downswings during the 1980s. As we can see in appendix 5, the manufacture of textiles has decreased steadily throughout the decade, but started to show some signs of recovery in the beginning of the 1990s when the crisis had already begun. After a period of stagnation in the beginning of the 1980s, the other two sectors, wearing apparel and dressing of leather, fell rapidly in the end of that decade, and continued to fall even during the 1990s. In the case of tobacco manufacturing, the development during the 1990s has decreased continuously, perhaps because of the public opinion. Manufacture of tobacco products has in fact become so small in Finland during the last years that it has been included to the foodstuffs industry in my final analysis of this study. The share of tobacco products in the case of industrial output of the entire industry is about 0.1%.

The last sector in this comparison, the manufacture of transport equipment, has developed quite unevenly during these two decades. A bottom level was reached in 1993, after which the growth has been a really rapid. Despite this positive development after the crisis, the transport industry has not managed to reach the pre-crisis volumes of industrial output. However, a comparison with the other receding industries shows that the transport sector has the most positive signs of recovery, as the "growth in production in 1993-1998" figure in appendix 4 illustrates.

Table 4. List of receding industries.

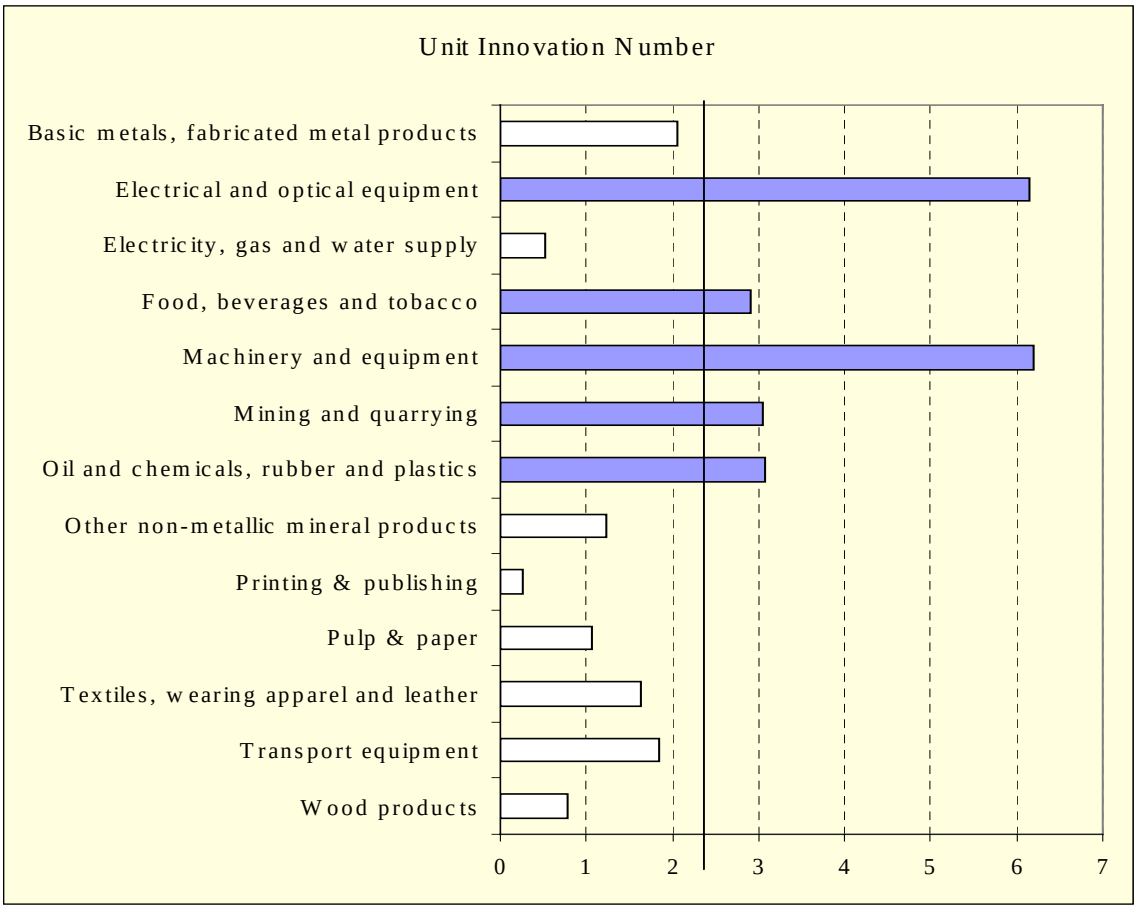
SIC 1995 –number and name of industry		**Change in output**
		1993/98 over 1983/88
16	Manufacture of tobacco products	-22.0 %
17	Manufacture of textiles	-23.5 %
18	Manufacture of wearing apparel etc.	-71.1 %
19	Dressing of leather etc.	-50.7 %
34-35	Manufacture of transport equipment	-11.4 %

4.2. Results of the Sfinno approach

The results of the Sfinno approach are presented in this chapter. The number of industrial sectors analysed is 13, as shown by the following figure. The methodology, which has been used to separate the industries to more and less innovative ones has been the following. First, the number of commercialised innovations has been calculated in 5-year periods beginning from 1985. These results can be seen in appendix 6. Second, the number of innovations has been divided by the group weight indexes, which can be found in table 1. These calculations have been made for every industrial sector. Result from these calculations is called the "Unit Innovation Number" (UIN), and can be seen in figure 15 below. Those industrial sectors that have been more innovative compared with the average value of the entire database, are marked by dark poles. White poles mark industries that have been less innovative. The average value in this case is 2.4 innovations per one industrial unit.

Group weight indexes, which have been used in following figure in order to calculate the UIN, are taken from the Statistical Yearbooks of Finland. As mentioned before, these indexes have varied during the investigated period (look at table 1). The methodology, used at this point of study, has been to divide the investigated period into three different 5-year periods (1985-89 , 1990-94 & 1995-99), and by the help of innovation statistics from each of these periods and that of three different GWIs (1988, 1993 & 1998), the UIN values for each of these three periods have been calculated. The final UIN index is an average of these three different values and is presented in the figure above. A more precise illustration of the computing process is presented in appendix 7.

Figure 15. Unit Innovation Number (UIN).



Source: Sfinno 17th December 1999 & Statistical Yearbooks of Finland.

4.3. The New Industrial Pattern

Before introducing the industrial sectors, the results from the combination of these two approaches, the Dahménian and the Sfinno, are given. As mentioned earlier in this study, stagnating and receding industries are combined at this phase of the study. The following table summarises all the main results of this study and introduces the classification of industries according to the New Industrial Pattern. The following chapters describe the development of these sectors in detail.

Table 5. Classification of industries according to the New Industrial Pattern.[82]

		Change in Industrial Output	Correlation with Total Industry	Number of Innovations (Sfinno)	UIN	Ranking in UIN List
	Advancing & More Innovative Industries					
15&16	Foodstuffs and tobacco	16.2 %	0.9389	84	**2.9**	**5.**
23 – 25	Oil & chemicals, rubber & plastics	35.6 %	0.9725	92	**3.1**	**3.**
29	Machinery and equipment	23.4 %	0.9053	191	**6.2**	**1.**
30 – 33	Electrical, electronics and optical equipment	284.6 %	0.9694	200	**6.1**	**2.**
C	Mining and quarrying	10.2 %	0.7581	11	**3.1**	**4.**
	Advancing & Less Innovative Industries					
21	Pulp and paper	40.8 %	0.9720	46	**1.1**	**10.**
27&28	Manuf. of basic and fabricated metal products	43.1 %	0.9877	60	**2.1**	**6.**
E	Electricity, gas and water supply	33.1 %	0.9471	19	**0.5**	**12.**
	Stagnating/Receding & More Innovative Ind.					
	-					
	Stagnating/Receding & Less Innovative Ind.					
17 – 19	Textiles, wearing apparel and leather	-57.0 %	-0.7772	13	**1.6**	**8.**
20&36	Wood products & furniture	7.6 %	0.7792	16	**0.8**	**11.**
22	Printing and publishing	1.8 %	0.6558	5	**0.3**	**13.**
26	Manuf. of other non-metallic mineral products	-6.6 %	0.3330	12	**1.2**	**9.**
34&35	Transport equipment	-11.4 %	0.0200	21	**1.9**	**7.**
	AVERAGE			**59**	**2.4**	

[82] Correlation numbers have been calculated in order to illustrate the relationship between a specific industrial sector and the total industry during the period 1980-1999. This correlation allows me to analyse, whether a specific industry has followed the total industrial development or not, in case of development of annual production between the period 1980-1999.

5. Innovation Activity in Finnish Industries

"Everything that can be invented,
has been invented."

Charles H. Duell, Commissioner,
U.S. Office of Patents, 1899.

The following chapters will describe the innovation activity in Finnish industries, according to the new industrial pattern shown in figure 14 above. A sector-specific analysis of advancing and more innovative industries is given first, with the objective of trying to find out what events have affected the development and innovation activity of these 13 described industries. Secondly, an introduction of advancing but less innovative industries is given concentrating those characteristics that could explain the advancing nature of these industries despite their low innovation activity. Because industries that are stagnating / receding and innovative at the same time do not exist, the last group consists of five stagnating / receding and less innovative industries. Finally, in chapter 6, some conclusions are drawn from these case studies, which, hopefully, give new insight into the innovation activity of Finnish industries.

5.1. Advancing and more innovative industries

5.1.1. Manufacture of foodstuffs and tobacco [83]

In 1997, food industry was the fourth largest branch of industry in Finland, after metal and engineering, forest and chemical industries. The gross value of production was FIM 49 billion and value added FIM 11 billion. Food industry employed 40.000 wage and salary earners, and the market share of Finnish food products in Finland was 85%. The value of food exports was FIM 6 billion and the value of food imports FIM 11 billion. 85% of the raw material used by the Finnish food industry was domestic.[84]

As we can see in appendix 5, the development of food industry has been stable during the whole period under study. The domestic demand

[83] Because of the minor role of the tobacco industry in the Finnish economy, this industry has been joined together with the whole foodstuffs industry. In some older statistical yearbooks, the tobacco industry was automatically one part of the foodstuffs industry, but recently, it has got its own two digit classification number (16). But as mentioned earlier, tobacco industry represents only some 0.1 % of the total value of industrial production, and because of this, it has been joined together with foodstuffs industry in this part of the study. Further on this analyse, concentration is focused only to describe developments on the foodstuffs industry.

[84] Sources in this section: Statistical Yearbook of Finland 1999 & Elintarviketeollisuusliitto ry.

for products has been stable, and the importance of export has been relatively small. Export to Russia, which started in the 1970s, was in 1997 more than one third of total exports.[85] Because of this, the developments in Russia have affected directly the entire food industry in Finland.

Food industry has been traditionally characterised by its domestic nature, but the 1980s some major changes occurred. Internationalisation, as well as globalisation, have proceeded fast, and have set the food industry to face several new challenges, such us cheap import products. Other changes occurring in the 1980s include rationalisation programmes, when companies, in order to increase their competitiveness, started to concentrate their production to fewer utilities. Together with computer-controlled manufacturing processes, these changes led to an increase in unemployment.[86] An important development was also mergers of companies, which started to increase in the last half of the 1980s, and gradually spread across the borders.

In the beginning of the 1990s, the food industry was facing a new situation. The integration with Europe started to intensify, reaching its "high-phase" in 1995, when Finland became a member of the European Union. This membership and new – more open – food markets have increased the significance of international markets for Finland at least by two ways. Firstly, the development of prices in the domestic markets now depends on the level of import prices and their development. Secondly, changes on export markets affect more directly the result of those companies that are dependent on exports. [87]

To keep their market position in Finland, food industry has during many years successfully followed their basic-idea, the so-called "high-quality strategy". This idea has also spread to the international markets, where competitiveness of Finnish food industry is based on high-quality, technology and special skills. In order to maintain these quality aspects, investments in R&D have had the key role. In 1998 the amount of R&D investments in 1998 was FIM 400 million, which is some 3.5% of value added of the entire food industry. In this case, Finnish food industry does well also in international comparison, and because of this extensive investments into R&D, Finnish food industry can be defined as a medium high-tech industry.[88] The food industry is also one of the most R&D intensive industrial branches in Finland.[89]

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[85] Virtanen E, Hiltunen M & Peltola M. 2000. *Elintarviketeollisuus 2000 –työryhmän mietintö.* Kauppa- ja teollisuusministeriön työryhmä- ja toimikuntaraportteja 2/2000, Elinkeino-osasto. p. 13.
[86] Virtanen E, Hiltunen M & Peltola M. 2000. pp. 13-15.
[87] Virtanen E, Hiltunen M & Peltola M. 2000. p. 13.
[88] According to the newest taxonomy of R&D intensity, industries, by which R&D intensity is 3-5% of value added, are called as medium high-tech industries. In this taxonomy, foodstuffs industries in

Because of the efforts that have been made to guarantee the survival of the food industry in Finland, domestic food products have managed to maintain their position in the Finnish markets despite the new openness in Europe. The marketing share in stores is almost 90%. Despite the relatively small size of Finnish food companies, in comparison with some European ones, investments in R&D have increased, and the high level of quality has been achieved. Food industry has also commercialised a great number of innovations during the last 15 years, and this is why the food industry places fifth on my UIN ranking list.[90] This relatively high ranking can be explained by the great investments in R&D during the last two decades, which have in turn resulted in new innovations or products.

The consumption of food products follows fairly well the size of the population. It is impossible to suddenly people to start eating more food, which means that an increase in the markets cannot be expected. What can be expected in this case is that consumers will start to demand products of higher quality, which is already happening. This means, that qualities, such as freshness, healthiness and also reliability, have become some of the criteria in the choice of food products. As the previous chapters describe, food product industry in Finland has become internationalised during the last 20 years. New markets for Finnish food products have been opened, mainly in the member countries of EU.

Rationalisation programmes, which were already implemented in the mid-1980s included some new process innovations in computer-controlled manufacturing. Also, the high number of innovations and the high UIN index, 84 and 2.9, respectively, give us an understanding of an innovative industrial sector. From the point of view of Dahmén's methodology, changes in consumption, in forms of an increased demand for products of higher quality and healthiness, have caused a market pull for food producers. Because of this, the domestic food product companies have increased their investments into R&D, in order to face these new demands. Investments have in turn resulted in high number of

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general are classified as low-technology intensive industries. However, R&D intensity varies in different countries during different periods of time. For more information, look at:
Hatzichronoglou, Thomas. 1997. *Revision of the High-Technology Sector and Product Classification.* STI Working Papers 1997/2. OECD.

[89] Sources in the last three sections have been some notices from the home page of Finnish Food and Drink Industries Federation (http://www.etl.fi). These notices include:
Heiskanen, Seppo. 05.11.1998. *Elintarviketeollisuus panostaa laatuun.*
Hämäläinen, Pekka. 03.08.1999. *Elintarviketeollisuus kavahtaa monopoliväitteitä.*
Lastikka, Lea. 11.10.1997. *Elintarviketeollisuus panostaa vientiin.*
As well as articles:
Pihlaja, Eila. 1999. *Elintarviketeollisuus selvisi Eun alkutahdeista hyvin.* In magazine *Ruokasuomi 99-01*.

[90] Look at table 5.

new products and innovations. How large a role these individual innovations have played in this process is difficult to measure, but nevertheless their role cannot be ignored.

5.1.2. Oil and chemicals, rubber and plastics

In the chemicals industry, technological development has played a major role throughout the history. This industry has also been characterised by its high-tech nature, due to the large investments in R&D over the years. To describe shortly the developments in this sector, the model of Achilladelis et al. is presented.[91] This model of the dynamics of the chemicals industry consists of four following stages. In the first stage (1930-50) the industry was characterised by a few highly important innovations, low patenting activity and low demand. The second stage (1950 to mid-1960s) is one of a rapid growth of innovations, patents and sales as companies rushed to take advantage of a proven technology. The third stage is one of maturity, when innovations, patents, and sales curves flattened out (mid-1960s to early 1970s), companies cut back on risky research and limited experimentation. The fourth stage is characterised by a falling rate of innovation, flat sales and intense competition as surplus capacity and new entrants eroded profit margins. At this stage, large companies started to buy products and services from small new companies, each of which concentrated on its own area of core competence. This networking and external linking between different companies has been one of the factors behind the success of chemicals industry.[92]

During the period 1945-1970 in Finland, the production volume in the chemicals sector, besides rubber, increased rapidly, much more than the total industrial output.[93] New products were created, which meant more personnel, which in turn resulted in an increase of production. Until the 1970s the chemicals industry grew by producing oil products and fertilisers for the Finnish markets. The 1970s was an era of rapid growth of exports and development of new products, including

[91] Achilladelis, B.G., Schwarzkopf, A. & Lines, M. 1990. *The dynamics of technological innovation: the case of the chemical industry.* Research Policy, vol. 19, no. 1, pp. 1-35.
Also: Achilladelis, B.G., Schwarzkopf, A. & Lines, M. 1987. *A study of innovation in the pesticide industry.* Research policy, vol. 16, no.2, pp. 175-212.

[92] Other sources in this section:
Sharp, Margaret. 1994. *Innovation in the Chemicals Industry.* In Dodgson, Mark & Rothwell Roy (eds.) 1994. *The Handbook of Industrial Innovation.* pp. 169-181.
Landau, Ralph & Rosenberg, Nathan. 1994. *Innovation in the chemical processing industries.* In Rosenberg, Nathan. 1994. pp. 190-191.
& Freeman, Chris & Perez, Luc. 1997. *The Economics of Industrial Innovation.* Third Edition. pp. 106-108.

[93] Not even motorising was enough to keep rubber industry at the same level with the other chemical industries. In the seventies, rubber industries stagnated and started to lose their markets to plastics industries.

biotechnology products in their modern form,[94] followed by a period of internationalisation in the 1980s. The foundations of chemical industry in Finland lay in the domestic demand from other industries, agriculture, energy and transportation.[95]

During the last two decades, the industrial output of the chemicals industry increased by 36% between those two investigated periods of this study. The crisis in the beginning of the 1990s had only a minor effect on the development of the industry, and a strong correlation with the total industry indicates that chemicals industry managed to keep up well with the common development of Finnish industry. Chemicals industry has also commercialised 92 innovations, which is much more than the average number of all industries. With a UIN index of 3.1, the chemicals sector has been the third most innovative industry in Finland during the last two decades.

Some two-thirds of the chemical production in the world can be characterised as being some kind of bulk commodity. In Finland, this situation is even more evident, because the share of commodities is remarkable. However, the chemical industry has counter-balanced this situation, by concentrating on its core competencies, and by developing new networks. Co-operation with other companies or universities has become more important, and the traditional characteristics of hostile competition and secrecy have been laid aside. The major goal in chemicals industry is to achieve a high level of knowledge in order to be competitive at the international markets. Investments in R&D play a central role in this strategy. Companies are also buying research results and services from other companies, domestic and foreign, to increase their productivity and the quality of their products.[96] This has been the

[94] Eliasson & Eliasson argue in their article, that after information technology, biotech is the next hope for a science based society. Characteristic for the biotechnology is, that it differs fundamentally from other industrial technologies in the origin of its competence base and in its diffusion. In development process, the laboratory, academic or industrial, is the core issue. When a new product is completed, clinically tested and authorised, the actual manufacturing cost of a drug is relatively insignificant.
Look at: Eliasson, Gunnar & Eliasson, Åsa. 1997. *The Pharmaceutical and biotechnological competence bloc and the development of Losec.* In Carlsson, Bo (ed.) 1997. *Technological Systems and Industrial Dynamics.* pp. 139-168.

[95] Sources in this section:
Hjerppe, Riitta. 1982. *Teollisuus.* In Ahvenainen J, Pihkala E & Rasila V (eds.) *Suomen Taloushistoria 2 – Teollistuva Suomi.* pp. 427-428.
& Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. *Advantage Finland – The Future of Finnish Industries.* The Research Institute of the Finnish Economy (ETLA). p. 127.

[96] Considering the patenting activity of Finnish chemical companies, patenting applications are dominated by few large companies. This strengthens the fact, that especially large companies are buying research results and services from those so-called research laboratories. For more information about the patenting activity of Finnish chemical companies, look at:
Valkonen, Pekka. 1998. *Mitä suomalaisten yritysten patentointi kertoo kemian teknologian tasosta? (Patenting as an indicator of technological competence: The case of the Finnish Chemical Industry).* ETLA Discussion Papers No. 630. (Finnish text, English summary).

reason behind the increase in small research laboratories in Finland, which each having its own specific area of research activities.[97]

The importance of the chemicals industry for the Finnish economy has increased continuously during the last two decades.[98] Markets, both domestic and foreign, for Finnish chemicals products have expanded, while new products have become more specialised and customer-oriented. International co-operation has opened up new possibilities abroad, while domestic networks make it possible to use the best available results of many specialised chemicals sectors. In my opinion these are some of the factors behind a more innovative chemicals industry.

5.1.3. Manufacture of machinery and equipment

Machinery industry has after WW II been an important industrial sector in Finland. The machinery industry started to grow as a result of the payment of war indemnities to the Soviet Union after the WW II. After the payment of war indemnities, trade with the Soviet Union continued as before. Due to this trade, manufacture industry had a continuous demand for their products, especially for paper-machines, which were also exported to some other countries because of their high quality. The amount of personnel increased during the period 1948-1977 from 26.000 to 61.000.[99]

During the period 1948-1977, investment and intermediate goods accounted for a major part of the production. Recently, some major changes have occurred in machinery industry. Sustainable development, customer-orientation and service have become more important goals in the production processes. Flexible manufacturing techniques of small production utilities make it possible to respond to changes in the markets as well and to maintain competitiveness. During the 1990s, investments in R&D increased annually by 10-20%, production output grew, and exports advanced.[100]

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[97] Sources in this section:
Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 138-140.
Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 83-87.
Teppola, K. 21.01.2000. *Kemianteollisuus tarvitsee huippuosaajia.* An article in Helsingin Sanomat.
Homepages of Pharmaceutical companies, including:
Fortum (http://www.fortum.fi); Orion Group (http://www.orion.fi); Farmos (http://www.farmos.fi); Leiras (http://www.leiras.fi); & Kemira (http://www.kemira.com).

[98] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. p. 87.

[99] Hjerppe, Riitta. 1982. pp. 421-422.

[100] Sources in this section:
Mäenpää I, Viitanen M & Juutinen A. 1996. *Metalliteollisuus Suomen taloudessa.* Kauppa- ja teollisuusministeriön tutkimuksia ja raportteja 14/1996, Teollisuusosasto. pp. 86-87 & 108-111.
Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 125-127 & 132.
Hjerppe, Riitta. 1982. p. 422.
Homepage of Metalliteollisuuden Keskusliitto (http://www.met.fi) .

The growth of machinery and equipment industries has almost equalled the development of all industry during the investigated period as the strong correlation (0.9053) indicates. Between the period 1983-88, annual growth was about 5%. During the crisis in the beginning of the 1990s, production decreased rapidly, but stagnated fast. Comparison with other industrial sectors affected by depression shows that for machinery and equipment the period of downswing was shorter and deeper than for other industries. After the crisis, annual growth was 10% in 1993-98, which was the second best compared with all industrial sectors. This sector has commercialised 191 innovations, which gives a value of 6.2 at my UIN scale. What is most surprising is that manufacture of machinery and equipment takes the first place in UIN ranking list. This means that not even electrical and optical equipment industry has been as innovative as machinery and equipment industry.[101]

Obviously, one factor behind the advancing nature of this industry has been the large number of innovations. An amazing fact is that investments in R&D have increased only from FIM 0.9 billion in 1985 to FIM 1.5 billion in 1998, while the same numbers in electrical and optical sector have been 0.6 and 6.8, respectively.[102] This means, that machinery and equipment industry has managed to find out some other means than investments in R&D in order to become an advancing and more innovative industrial sector. An increase in exports, helped by new market areas, is also one factor behind the success of this sector, but does not explain the high UIN index. What then are the reasons behind the innovative nature of this industry?

Firstly, there have been changes in the production philosophy. In order to be competitive at the markets, the industry has concentrated more on quality, price, service and utility of products. This has ensured that not only products but also production processes have been developed. Companies have adopted the approach that manufacturing is not a production plant, it is an integrated combination of different activities; sales, financial calculation systems, quality systems, design engineering, purchasing, manufacturing, delivery and after-sales activities. Secondly, companies have concentrated on their core competence. This means, that co-operation and networking with other companies or universities have increased. International co-operation, for instance participation in international technology projects, has increased continuously during the last two decades. Also, knowledge management as well as ability to organise processes globally have become more

[101] Some reasons for this have been introduced in chapter 5.1.4.

[102] Source: Metalliteollisuuden Keskusliitto. 1999. *T&K menojen kehitys metalli- ja elektroniikka-teollisuudessa.* (http://www.met.fi).

important, not only for large, but also for small and medium size enterprises (SMEs). Thirdly, the business environment has been favourable to growth. There is no great respect for tradition in Finland, but rather a hunger for the new. If a better way of doing something comes up and works, it is usually adopted quickly, without fuss and bother. Finally, the investments into education have become more common, not only into the schools and universities, but also inside the companies. These are some of the factors behind an innovative machinery and equipment industry.[103]

According to Dahménian approach, the application of innovations and the launching of new products have caused a market expansion. The course of events had the character of market expansion in part because there were a whole lot of new consumer capital goods, and partly because "young" goods,[104] which were unknown to many potential consumers at the beginning of the 1980s, continued to widen their markets.

5.1.4. Electrical, electronics and optical equipment

The history of this industry is not as long as that of other industrial sectors in Finland, but it has been all the more successful. The growth of electrical industry started in the late 1960s, and almost doubled during the period 1970-75. The main factor behind the increase in the 1970s was the breakthrough of electronics industry, which resulted in a rapid technological change in electrical industry. Electrical machinery, cables and telecommunication products represented major part of this industry. These products dominated also during the 1980s, as electrical industry kept on growing continuously more than doubling its total output, as illustrated in appendix 4. However, the 1980s was a decade when companies and politicians started to pay more attention to investments in R&D.[105] The annual growth rate of the R&D volume was

[103] Sources in this chapter:
McArthur, Rick. 1996. *Industry-driven development to manage change.* In *Views on Finnish Technology 1996.* p. 25.
Ourila, Anne (ed.). 1996. *Teknologia 2000 – Osaamisella tulevaisuuteen.* TEKES. p. 58.
Homepages of Engineering and machinery companies, including:
Metra (http://www.metra.fi); & Fiskars (http://www.fiskars.fi).
Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 125-127.
Arnold, John. 1997. *Traditions for the future.* In *Views on Finnish Technology 1997.* p. 9.
Poje, Terence. 1998. *Manufacturing Technology Guilds a Faster Future.* In *Views on Finnish Technology 1998.* p. 8.
Forström, B, Kautonen, M & Toivonen, J. 1997. *Innovatiivisten pk-verkostojen menestystekijät.* Teknologiakatsaus 55/97. TEKES. pp. 3-7.
Lemola, Tarmo & LaPointe, Kirsi. 1995. *Suomi Eurekassa – Eureka Suomessa.* VTT julkaisuja 807. pp. 18-21.
[104] Compare to Dahmén, Erik. 1950. p. 132.
[105] In some cases, large investments in R&D became not as successful as was assumed. This was a case in fiber optic communications industry, where research interest and activity were started

approximately 10% on average during the decade, which was the highest rate of all OECD countries. While *productivity* was the key point of emphasise in the 1970s, a new concept called *quality* became more important in the production processes and competitiveness of the companies.[106]

Throughout the 1990s the development of electronics and electrical industry has been rapid. As appendix 5 illustrates, the growth has been exponential during that decade. Today, electronics and electrical industry accounts for almost one-third of Finland's total exports. This sector is now the third pillar of Finnish industry next to mechanical engineering and forest industries. The growth of electronics and electrical sector has mainly been driven by expertise, innovation, and competitiveness. Companies and research institutes have invested heavily in R&D, and the state has also seen the importance of R&D as a driving force for further growth. Other industrial sectors have also contributed to the development of electronics and electrical sector by adopting more and more functions in their own products and production processes.[107]

The advancing nature of electronics, electrical and optical industry is explained by the fact that industrial output has almost tripled between the investigated periods. While annual growth rate during 1983-88 was 13%, the rate for period 1994-98 was 25%. This development can also be seen in appendix 5, where the growth rate of this specific industry differs greatly from that of other industries. It can also be stated that the crisis in the beginning of the 1990s was a starting point for an exponential development. The number of commercialised innovations is the highest compared with all other industries. However, when GWI is taken into account the ranking in my UIN list is *only* second. This is due to the fact, that a large part of innovations introduced in this sector, have

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seriously already in the middle of 1970s. The research work included optical fiber measurements and accomplishment of fiber fabrication facilities in laboratory. The research was much driven by technology. This activity slackened down in the 1980s, because there existed not enough business possibilities. At the same time, in late eighties, concentration was focused on fiber cables, and the manufacturing of them started to increase. The huge change in information technology in late 1990s, made optics the focus of technology again.
Source: Sjöholm H, Juvonen R, Leppihalme M, Törmälä S & Piironen P. 1999. *Optical Communications – The Solution for 21st Century's Broadband Communications.* Technology Review 75/99. TEKES. pp. 2-3 & 41-44.

[106] Sources in this section:
Hjerppe, Riitta. 1982. p. 422.
Palmberg C, Leppälahti A, Lemola T & Toivanen H. 1999. p. 2.
& Hirvonen, Esko. 1990. *Innovation Management ja yritysten uudistuminen.* In *Innovaation onnistuminen.* Sähkö- ja elektroniikkateollisuusliitto, Utilise-projekti. pp. 32-33.

[107] Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 51-55.
Federation of Finnish Electrical and Electronics Industry (SET). 1999. *The Finnish Electronics and Eletrical Industry Stands Global.* pp. 2-3.
& Homepage of Instrumentarium (http://www.instrumentarium.fi) – a medical equipment company.

been classified as software innovations.[108] In the following chapters some reasons for the advancing and innovative nature of this industry will be presented.

Firstly, as already mentioned before, the basis for success lies in heavy investments into R&D. Innovation is the key when change never stops; there are new technologies to be applied, new demands from the end-user and higher standards of environment-friendliness to be met. Secondly, flexible specialisation in meeting customers will guarantee long-term relationships. Companies have started to concentrate more and more on their area of core know-how at every stage of their operations. This is why supportive know-how and services can be acquired from other companies in the co-operation network. Thirdly, global networking, not only in the form of exports, but also by means of foreign investments increases production resources. Large companies are not the only ones that have succeeded in these investments, but also SMEs have functioned as links in a strong value chain. Fourthly, skills of the personnel, when know-how means skill at one's work and the ability to use it to meet customer's needs, have improved. Updated technical skills, teamwork, communication and language skills have all become important in an international environment. Investments into education in this field cannot be forgotten either. Finally, the customers of a very demanding domestic market and with their ability to quickly adopt new technologies have also contributed. Some good examples of this are the penetration level for mobile terminals and the number of Internet connections, which are among the highest [109] in the world on a per capita basis. From my point of view, these factors have played an important role in the development of electronics, electric and optical sector in Finland during the last decade.[110]

5.1.5. Mining and quarrying

The mining and quarrying industry has been an important part of the development of the Finnish economy since the end of the WW II.

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[108] Palmberg C, Niininen P, Toivanen H & Wahlberg T. 2000. p. 18.
(Mobile phones, for example, contain a great amount of software related innovations).

[109] Considering the number of Internet connections, a distinction between different sources occurred. In Finnish and OECD's sources, Finland was on the first place, while in Swedish sources, the ranking was second or third. Due to these differences, the word "among" has been used.

[110] Sources in this section:
Federation of Finnish Electrical and Electronics Industry (SET). 1999. *The Finnish Electronics and Eletrical Industry Stands Global.* pp. 4-5.
Hawkins, Eddy. 1999. *Competition and cooperation.* In *Views on Finnish Technology 1999.* pp.8-9.
TEKES & SET. 2000. *Visioista osaamistarpeisiin – Huippuosaamisella menestykseen. Osaamislinjaus 2004.* pp. 28-34.
Homepage of Labsystems (http://www.labsystems.fi) – a medical equipment company.
Homepage of Nokia (http://www.nokia.com) – a telecommunications company.
& Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 58-60.

Despite the small size of the mining branch, products that were mined were processed further in the basic metal branch, and were sold abroad. A large number of these "final" products were transported to the Soviet Union as war indemnities. The growth of the basic metal industry was fully dependent on the mining industry, and together their share of the total industrial production during the years 1950-80 increased from 25% to 33%.[111]

Mines are usually opened in sparsely populated places. This has resulted in some positive development possibilities for those regions, in form of new jobs and other new industries, which have been opened around the mine. Because of this, the regional political aspect of new mines is important. New possibilities have been created in places where nothing existed before. However, this is only the bright side of the development. When a mining operation is finished, it affects the whole region. This has been the case with a number of mines in Finland during the last 20 years.

Because of this common development of the mining branch in Finland, new methods have been adopted to keep this branch alive. At the same time while the "real" domestic mining industry has continued to decrease slightly, raw materials have been imported in large scale from abroad. Mining companies have now started to process further these raw materials and have concentrated on their best areas of knowledge, such as iron, copper and nickel, and their processing, as well as on the organising of raw material services. These arrangements have resulted in a strong competitive position on international markets.

The bedrock in Finland is still quite a mystery, and this has been one reason for increased investments into R&D. In this case, the situation in Finland is quite unique, because the government is responsible for the research of bedrock and new raw materials, and for their possible development. When a new occurrence has been found it will be sold in auction. With this arrangement the mining companies save their resources and can continue to concentrate on the implementation of new raw materials and technologies.

The number of commercialised innovations in the mining branch is low, only 11, but because of the low GWI this industry can be defined as "a more innovative industry". Innovations have mainly been associated with large mining machines and are usually developed and introduced by mining companies. Due to the size and complexity of these machines, process innovations are more common than product innovations in this industrial sector. A similar phenomenon can be seen also in other sectors, especially in energy and paper industries, as

[111] Hjerppe, Riitta. 1982. p. 421.

discussed later on. Despite a small number of commercialised innovations in the mining industry, it reaches a honourable fourth place in the UIN ranking list.[112]

5.2. Advancing and less innovative industries

5.2.1. Pulp and paper

The pulp and paper industry has a long tradition in Finland and has, together with other forest-based industries, always been one of the main industries.[113] Since the day of independent, Western European countries have been the most important export destinations of pulp and paper products, and have replaced export to the Soviet Union. An important aspect for Finland in this development was that Western Europe has been a large consumer of pulp and paper products during the whole post-war period. In the 1950s, Finland assumed an economic policy which included, among others, investments into export industries. This policy resulted in a two-fold increase in pulp and paper production during 1955-1967, and due to increasing demand from abroad, export of pulp and paper increased continuously.[114]

During the last two decades, the output of pulp and paper industry has increased by 41%, and its development has been correlated strongly with all industries as illustrated table 5. Export of paper products has more than doubled during these decades, while pulp export has stagnated, despite an increase in production. Different types of high-quality papers top the list of most important export products. About 80%

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[112] Sources in "Mining and quarrying" sections:
Official notice from Ministry of Domestic Affairs (http://www.intermin.fi):
Korhonen, Martti. 02.12.1999. Speach in *"Fennoskandian malminetsintä- ja kaivannaisteollisuus-konferenssi"* in Rovaniemi.
Official notice from Suomen Luonnonsuojeluliitto (http://www.sll.fi):
Tunkkari, Heikki. 1999. *Kalotin kaivostoiminta – Malminetsijät hakevat aarretta mutta löysivätkö he sen aivan liian aikaisin?*.
An article in Helsingin Sanomat (http://www.helsinginsanomat.fi):
Oksanen, Annukka. 05.02.2000. *Outokumpu kelluu kohti aallonharjaa.*
& Homepage of Outokumpu (http://www.outokumpu.com) – a metal products company.

[113] *"In 1865, engineer Fredrik Idestam established a wood-pulp mill by a riverbank in southern Finland and started manufacturing paper. The company, which he named Nokia, soon became successful as the consumption of paper and cardboard rapidly increased during European industrialisation. Idestam established an international network of salesmen, and Nokia's products were exported to Russia and then to the UK and France. In the 1930s, China also became an important trading partner. A large workforce was attracted to the Nokia factory, and a town of the same name grew up around it. Although the company no longer has a presence there, a lively community called Nokia still exists on the banks of the beautiful river Emäkoski…."*
Source: (http://www.nokia.com) .

[114] Sources in this section:
Sevola, Yrjö. 1999. *Puun käyttö.* In Suomen Vuosisata. pp. 117-118.
Hjerppe, Riitta. 1982. pp. 413-421.
Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 42-43.
& Metsäteollisuuden tilastot vuodelta 1998. pp. 15-21.

of exports go to other European countries. Despite their high-quality products, the pulp and paper industry has only commercialised 46 innovations, which gives a value of 1.1 at my UIN scale and a 10th place on UIN ranking list. The result is quite surprising considering the development of this industry and its role in Finnish economy. It can be said, that new products, innovations, have not contributed to the growth of this sector.[115]

The most important trends in the recent years have been the industry's consolidation and its international expansion. In addition to mergers and strategic alliances with foreign companies, the industry has invested in production plants abroad and is seeking a global commercial and manufacturing presence in its markets. Another reason for acquiring plants abroad has been the increase in paper recycling. Since about 90% of the output of Finnish paper and paperboard industry is exported, attention has been paid to make paper recycling more efficient abroad, especially in the main market region – Central Europe. The consumption of paper and paperboard in Europe is expected to increase at an average annual rate of 2% up to the year 2010, while paper recycling becomes more efficient and increases steadily. The latest developments in the Finnish pulp and paper industry emphasise the triple goals of enhanced efficiency, ever increasing environmental awareness [116] and high-quality products. In order to carry out these improvements and changes, investments into R&D have increased continuously. This strategy has been successful, which can be seen from increased production and productivity, decreased pollution and high-quality intensive products. By using the Dahménian approach, it can be stated that there exist market pull caused by a complementary between computerisation and paper consumption. These factors, however, do not explain the low UIN. [117]

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[115] Sources in this section:
Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 42-45.
Sevola, Yrjö. 1999. pp. 118-119.
Metsäteollisuuden tilastot vuodelta 1998. pp. 16-21.
& Lähepelto, Jaakko. 1999. *Sustainable Paper. Research Programme – Final Report 1993-1998.* TEKES. pp. 9-10.

[116] A good example in case of environmetal awareness is the first totally chlorine-free greenfield pulp mill, which was opened in 1996.

[117] Sources in this section:
Finnish Forest Idustries Federation. 1998. *Key to the Finnish Forest Industry.* pp. 4-5, 11 & 36-37.
Ourila, Anne (ed). 1996. pp. 99-100.
Morgan, Nina. 1996. *Finland's pulp and paper industry: Production up – pollution down.* In *Views on Finnish Technology 1996.* pp. 14-15.
Morgan, Nina. 1997. *The paper chain.* In *Views on Finnish Technology 1997.* pp. 14-15.
Koskenlinna, Markus & Saarnivaara, Veli-Pekka. 1996. *The forest – a renewable resource.* In *Views on Finnish Technology 1996.* p. 9.
Homepages of pulp & paper machinery companies, including:
Ahlström (http://www.ahlstrom.fi); & Valmet (http://www.valmet.fi).

Pulp and paper manufacturing is a long and complex process. The machines are used in this process are large, extremely expensive and contain a great deal of high technology. These machines and plants can easily be compared with plants used in the energy sector – once built, it is used for decades.[118] These facts explain why innovations in this sector, especially in machines that already are in use, are incremental, not radically new. This means that only one part is usually replaced machines therefore usually contain components from a long period of time. It is also worth mentioning that there are only two alternatives in running a paper machine: either the machine works with 100% capacity or it is stopped. This means that every minute the machine is not in use costs a lot of money. To build up a whole new machine requires about 100 engineers and takes approximately one year to build.[119] I suppose that these facts explain the less innovative nature of pulp and paper industry.

5.2.2. Manufacture of basic and fabricated metal products

As already mentioned earlier, the development of basic metal industry was highly dependent on the production of the mining industry during the period 1950-80. During the WW II imported mining equipment was in short supply, and domestic manufacturing started. After the war, investments were made to create sufficient production capacity, which in turn resulted in an increase of variety of products.[120] Because of reconstruction and war reparations, metals were in high demand,[121] which is why, the manufacture of basic metals was one of the most rapidly increasing sectors of the Finnish industry in the 1960s.[122] Another reason for this success was the expansion of the steel industry

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& Lähepelto, Jaakko. 1999. pp. 9-11.

[118] For more information, look at:

Laestadius, Staffan. 1996. *Technology level, knowledge, formation, and industrial competence within paper manufacturing. Working Paper.* Department of Industrial Economics and Management, Kungliga Tekniska Högskolan, Stockholm.

& Laestadius, Staffan. 1997. *The relevance of scinece & technology indicators: The case of pulp & paper. Working Paper.* Department of Industrial Economics and Management, Kungliga Tekniska Högskolan, Stockholm.

In these working papers, Laestadius discusses the high-tech nature of pulp and paper industries. He describes the manufacturing process of paper, what kind of machines there are used, and by what way new innovations are taken place in these machines. Laestadius discusses mostly about the situation in Sweden and Finland, which are the most advanced countries at this sector.

[119] Sources in this section:

Laestadius, Staffan. 1996. pp. 20-23.

Laestadius, Staffan. 1997. pp. 10-13.

& Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. p. 42.

[120] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 57-59.

[121] Dahmén, Erik. 1966. *Ekonomisk utveckling och ekonomisk politik i Finland. En undersökning av åren 1949-1962 samt några framtidsperspektiv* Andra uppl. Bank of Finland Publications, Series C 4. p. 21.

[122] Hjerppe, Riitta. 1982. pp. 421.

during that same decade. In the 1970s Finnish companies started to produce so-called semi-finished products, and in the 1980s, it was time for internationalisation.[123]

During the period 1950-80 the production of metal goods focused mainly on the manufacture of heavy metal products including, for instance heavy machinery and ships. But also low-technology products, the so-called volume products in this case, such as those used in construction, cutlery, tools and metal tanks, faced an increasing demand in the domestic markets.[124] Efforts were also made to increase the export of metal products, resulting in a continuous rise in export,[125] despite the weak development of price level in the international markets. The growth of exports signified a flow of foreign capital into the country that helped the economic expansion inside the country.[126]

The development in the manufacture of basic metals has been quite amazing during the last two decades. As table 1 above illustrates, the change in industrial output has been 57.4%. This means that basic metal branch has been the third fastest growing industrial sector in Finland in this comparison. One reason behind this success has been the fact that more than half of its manufacturing inputs comes from the domestic metal industry. Only 26% of inputs are imported, and an other 19% come from other industrial sectors.[127] This indicates well-functioning logistics and a domestic processing chain. The shipbuilding industry has been an important partner for the basic metal branch with a stable demand during the 1990s. However, the role of other metal industries, such as fabricated metal products, manufacture of machinery and electrical products, cannot be forgotten.

In metal products industry, the development has faced many new challenges especially in the 1990s. Products have become more complex and advanced, as new materials have appeared. During the 1990s the key goals in this branch have been flexibility, customer-oriented production as well as reliability and quality of products.[128] In Finland, these goals have been achieved by manufacturing small volumes in relatively small processing units. In addition to customer-specific products, this strategy has translated into significant shortening of the total manufacturing time of the products.[129]

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[123] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 57-58.
[124] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 59
& Hjerppe, Riitta. 1982. pp. 421-422.
[125] Hjerppe, Riitta. 1982. p. 422.
[126] Dahmén, Erik. 1966. p. 40.
[127] Mäenpää I, Viitanen M & Juutinen A. 1996. pp. 24-25.
[128] Ourila, Anne (ed). 1996. pp. 55 -59.
Look at also: Annual Reviews of TEKES 1995-1999.
[129] Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 132-133.

What is needed for this branch to be able to follow up the above-mentioned strategy, is investment into research and development. In the metal products branch, as also in basic metal industry, R&D is concentrated on the development and renewing of the basic processes, further processing, and the manufacture of customer-specific products. New materials are also studied to find out the best possible materials for each individual product.[130] One improvement that has contributed to this branch, is the so-called "Virtual Factory", where the production of a factory, its processing units and production stream are simulated with the help of computer technology. By chancing different components efforts can be made to find out an optimal solution that would improve the productivity and profitability of the factory by using the already existing machines.[131] Finally, the SIMSON programme has to be mentioned, which started in 1991 with the primary objective of improving the performance and competitiveness of the industry. This program improved the co-operation between companies in Finland and also lead in some new possibilities with international development co-operation. The programme also created about 20 innovations. Half of these were already on the markets before the end of the programme in 1995, and the other half was in their commercialisation phase at that point of time.[132]

As the appendices 4 and 5 illustrate, the basic and fabricated metal products industries have been advancing during the last two decades. These industries have also commercialised 60 innovations, which is more than the average in this comparison. But although this branch is so large, it has not succeeded in being an innovative branch when assessed by the methods used in this study. With a UIN of 2.1 it ranks as sixth on the UIN list.

5.2.3. Electricity, gas and water supply

The close relationship of high productivity and energy-intensity is a clear empirical regularity of long-running economic growth.[133] [134] In

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Look at also Homepage of Outokumpu (http://www.outokumpu.com) – a metal products company.

[130] Ourila, Anne (ed). 1996. pp. 58-59.
& Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 132-133.
Also: Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. p. 63.

[131] TEKES Annual Review 1995.

[132] Ourila, Anne (ed). 1996. pp. 60-61.
& TEKES Annual Review 1995.
For more information of SIMSON, look at: *SIMSOM – Technology, Organisation and People – Towards World Class Manufacturing.* Federation of Finnish Metal, Engineering and Electrotechnical Industries – FIMET, 1995. F. G. Lönnberg, Helsinki 1995.

[133] Rosenberg, Nathan. 1994. p. 161.

[134] MacKerron describes in his article *Innovation in Energy Supply"* the processes and directions of innovation within the energy sector. He states, that advances in energy technology have been at the heart of industrial innovation throughout the twentieth century, and introduced the most important

Finland, the energy consumption per capita is and has been high, due to the arctic climate, long distances and low population density. Also, the main industrial sectors in Finland, forest and metal, are very energy-intensive. These factors, together with the fact, that Finland does not have domestic fossil fuel deposits, has made the country dependent on imported sources.[135] Unlike in some other countries, the demand for electric light and other electrical appliances was not the main driving force behind the technological development of power supply. It was the main industries, forest [136] and metal, that set the requirements which power companies struggled to fulfil. Together with rapid urbanisation in the post-war period, energy technology was forced to some major developments in order to satisfy an increasing domestic demand.[137]

During the last twenty years, many of the fundamental principles in the area of energy policy changed. After the Chernobyl nuclear plant disaster in 1986, plans to build a fifth nuclear plant in Finland were postponed, and in the same year oil prices dropped to levels not seen since the start of the second oil crisis. In the 1990s, Finnish trade with the Soviet Union, until then dominated by energy products, had been transformed. Moreover, combating climatic change had become the main environmental concern.[138]

The energy sector has followed well the development of the total industry, as the high correlation number in table 5 illustrates, but in product innovation activity this sector comes in the 12th place. However, the structure of Finnish exports has changed in recent years, and as a result, energy technology accounted for almost 10% of total Finnish export of goods in 1998. Finnish energy technology manufacturers have also become more competitive in international markets during the

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development and innovations which have taken place in the energy sector. He takes also up a discussion about increased investments in R&D, which have characterised this sector during the last twenty years. For more information, look at:
MacKerron, Gordon. 1994. *Innovation in Energy Supply: The Case of Electricity.* In Dodgson, Mark & Rothwell Roy (eds.) 1994. *The Handbook of Industrial Innovation.* pp. 182-190.

[135] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. p. 69.
Lahtinen, Simo. 1977. pp. 40-41.
& Hjerppe, Riitta. 1982. pp. 428-429.

[136] The Finnish pulp industry has a long tradition in energy production. Especially in the 1950s, as energy demand grew, this industry tried to maintain its self-sufficiency by help of their own hydro-electronic plants, and also by starting to use waste and excess warmth for district heating. By producing much of its own energy, the industry has been able to put pressure on the domestic power companies to keep energy prices competitive. Source: Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. p. 71.

[137] Arnold, John. 1997. *Energy and a sense of history.* In *Views on Finnish Technology 1997.* p. 22.
& Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. p. 69.
& Timonen, Leena. 1999. *Energian käyttö.* In Suomen Vuosisata. pp. 307-308.

[138] TEKES. 1998. *Energy Technology Programmes 1993-1998. Final Report.* Technology Programme Report 9/98. pp. 3-5.
& Sirkeinen, U. 1999. *Energiapolitiikan eväitä ensi vuosituhannelle.* In Teollisuustieto 18/99. p. 16.

1990s.[139] How is it possible, that a less innovative industry has succeeded to be so advancing during the 1990s? Some reasons for this success are given in the next paragraph.

Firstly, the product cycles in energy technology are slow compared to, for instance, electronics. Once built, a plant is used for decades; the basic structures of a distribution network even longer. Innovations that are introduced are mostly incremental (process innovations), not radically new. This explains partly the low number of product innovations. Secondly, Finns account for one-third of the world's population living above 60° latitude north, where the climate is cold with great variations. Together with long distances and generally energy-intensive forest, metal and chemical industries, energy needs in Finland are high. This means that Finland has to utilise a wide variety of power sources, technologies and know-how. Thirdly, Finnish expertise in energy has been influenced by especially favourable organisational and institutional conditions. These include the mechanisms for competition in the domestic marketplace and strong networking both in Finland and abroad. Despite high energy needs in Finland, the home market is relatively small for companies. However, the small home market has also been a stimulus for exports. Finally, the branch has invested heavily into R&D. Market liberalisation, national competitiveness and the issue of climate change are some of the most potent factors driving the R&D of Finnish energy technology. Complex products, such as diesel power plants, heavy electrical equipment as well as solar and wind energy technologies, which are some of the export products, need large and continuous investments into R&D. In my opinion, these are the factors underlying the advancing but yet less innovative[140] energy industry in Finland.[141]

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[139] Hannus, S. 1996. *Energy technology from Finland.* In *Views on Finnish Technology 1996.* p. 4.
& Arnold, John. 1997. p. 22.
& TEKES. 1998. p. 9.

[140] Due to the fact that only product innovations are included in my new industrial pattern, the high number of process innovations are not taken into account.

[141] Sources in this section:
Arnold, John. 1997. p. 22-23.
Arnold, John. 1996. *Cogeneration and district heating – a cleaner and cheaper combination.* In *Views on Finnish Technology 1996.* pp. 26-27.
Hannus, Seppo. 1996. p. 4.
Timonen, Leena. 1999. p. 311.
Poje, Terence. 1998. *Energy technology responds to new realities.* In *Views on Finnish Technology 1998.* p. 13.
Homepage of Wärtsilä NSD Corp. (http://www.power.wartsila-nsd.com) – a machinery company.
Poje, Terence. 1999. *The power of Arctic winds.* In *Views on Finnish Technology 1999.* pp. 32-33.
Morgan, Nina. 2000. *A climate for change.* In *Views on Finnish Technology 2000.* p. 36.
Hawkins, E. 2000. *Lower prices, more efficiency.* In *Views on Finnish Technology 2000.* pp. 30-31.
& An article in Teollisuustieto 13/1999. *Suomi erikoistuu energiateknologiaan.* p. 21.

5.3. Stagnating / Receding and less innovative industries

5.3.1. Manufacture of textiles, wearing apparel and leather

The textiles and wearing industry is a sad part of Finnish industrial history. After the WW II, the growth started to stagnate. During the 1960s, the growth was much slower than in the other industrial sectors. One reason for this stagnation was the development of prices, which achieved only one-third of the common price level development of all industrial products.[142] Other factors for this slow growth were the increased demand of cheap tricot products, the more common role of synthetic fibres, and the increase in productivity that took place in the 1970s. Because of this growth in productivity, the production volume increased by 4% annually during that decade.[143]

The situation was still quite a good in the beginning of 1980s (compared with the situation in the 1990s), when the amount of employees was about 55.000 and export to the Soviet Union was sound. But in the late-1980s the downhill began: the level of costs in Finland started to increase, Swedish companies started to transfer their production utilities from Finland to low-cost countries, exports to the Soviet Union collapsed, and cheap but good-quality clothes from Germany, Holland and Denmark made their entry into Finnish markets. Then came depression, and the Finns cut down on the purchasing of new clothes. Some 40.000 jobs were lost, and the industry was in crisis.

After 1990's depression, the development of the textile and wearing branch has been slightly better, in fact. Finnish manufacturers have started to transfer their production utilities to low-cost labour countries, especially to Estonia and Russia. The structural change has also led to a new form of ownership in Finland. Only a few of the old, large traditional family companies are alive, while there has been an increase in the number of small and medium-size enterprises. These new companies have specialised in producing more individual, more expensive and more design-inclusive products, not only for domestic, but also for international markets. Co-operation with research centres has helped these enterprises to get the best knowledge available for producing new high-quality products with domestic and international demand.[144]

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[142] Hjerppe, Riitta. 1982. p. 425.
[143] Hjerppe, Riitta. 1982. p. 425.
[144] Sources in sections above (textile and wearing):
Ourila, Anne (ed). 1996. p. 46.
& Heiäng, Paula & Ourila, Anne. (eds). 1998. p. 94.
& *Textile and Clothing Industry Statistics 1999.* Federation of Finnish textile and Clothing Industries.
Also articles in Helsingin Sanomat (http://www.helsinginsanomat.fi) :
Anttikoski, Riitta. 22.08.1997. *Tekstiiliala lisää tuotantoaan Suomessa.*
Karismo, Anna. 05.05.1997. *Suomen vaateteollisuuden kasvu valuu alihankintoina ulkomaille.*

The innovation activity in the textiles branch has not been remarkable recently. The number of commercialised innovations is only 13, which is much lower than the average. Because of the small size of this branch, the UIN index is, however, 1.6. It is also worth emphasising, that 10 of these 13 innovations have been commercialised during the 1990s, which might be a result of an increased co-operation between companies and research centres. Finally, the ranking in the UIN, which is eighth, shows that there are great expectations for development in the future.

5.3.2. Manufacture of wood products and furniture

Wood products and furniture industries also have long traditions in Finland. Already in the beginning of last century, sawmilling was a large-scale industry, producing annually some 3-4 million cubic metres. When this figure is compared with the output of Finnish sawmills in 1999 we see that the wood products industry has only tripled its production during the whole century. The same companies, which dominated in the beginning of the 20th century, are important even today. In the case of exports, three-fourths of the production went abroad, mainly to the Great Britain and Germany, in the beginning of century. Today, the situation is exactly the same. Nothing have seems to changed in the sawmill industry during the last 100 years.[145]

Of course, some great developments have taken place in this sector. In the 1960s, the sawmill industry became more capital intensive and more automated. During the 1960s and 1970s, the manufacture of furniture increased faster than the total output of the industry, as a result of the growth of the building industry, rising incomes of households and increased furniture exports. Production processes were mechanised in order to respond to this increasing demand. The 1960s was also a period when annual cuttings were higher than the annual increment in the growing stock. This resulted in strong reactions, and with help of investments in, for instance, in ditching and fertilisation, the situation was soon repaired.[146]

There have been some large fluctuations in the development of wood products and furniture industries during the last two decades. The

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Juurus, Kati. 14.02.1999. *Tukisukkahousut – edelläkävijä!*
Siukonen, Timo. 26.04.1999. *Uusia työpaikkoja syntyi liki 200 000 neljässä vuodessa.*

[145] Sources in this section:
Sevola, Yrjö. 1999. p. 117.
Hjerppe, Riitta. 1982. pp. 413-415.
& Metsäteollisuuden tilastot vuodelta 1998. pp. 23-25.

[146] Sevola, Yrjö. 1999. pp. 117-121.
Hjerppe, Riitta. 1982. pp. 415-417.
& Pihkala, E. 1982. *Maa- ja metsätalouden uusi asema.* In Suomen Taloushistoria 2. pp. 401-404.

crisis in the beginning of the 1990s affected heavily these industries, but since then, growth has been rapid. During the period 1993-1998, the wood products industry has increased its volume by 27%, while the furniture industry has reached a growth of 20%. It can be stated that this growth has not been brought on by new products, as the number of commercialised innovations is only 16, which give the eleventh place on UIN ranking list with 0.8 on UIN scale. Despite a rapid increase in production after the crisis, the manufacture of wood products and furniture categorised as a stagnating industry, according to the Dahménian approach. The following paragraph analyses factors behind this growth after the crisis instead of investigating reasons for the stagnating nature of these industries.

In the case of wood products, the main emphasis has been placed on increasing the value added. Because forest resources in Finland are limited, new methods have to be found in order to develop the wood products industry. Preconditions for increase in value added include a more customer-oriented approach to basic research as well as the adoption and control of new information. The aim of research activities is to create a closer link between the wood raw material and processing technologies and a more customer-oriented approach. By developing, producing, marketing and competing with prices and services, the objective is to produce so many different variations that each customer is able to find products that will satisfy his expectations. In order to fulfil these criteria, the ability to react quickly and flexibility is needed.

Other preconditions for increases in value added are for instance improvements in technology, changes in organisations and processes, but also networking and co-operations – foreign and domestic. The wood products industry has only recently started to direct its activities along the lines described above, but the results of this approach can already be seen in the form of an increased output, as appendix 5 illustrates. Despite the less innovative nature of this industry, the branch has a strategy that aims at becoming more competitive in the future. Key factors in this strategy are networking and customer-oriented approach.[147]

While the manufacture of wood products has increased by 17%, the manufacture of furniture has decreased by 7%. The furniture industry can blame itself for its modest development. Few large manufacturers and a large number of small workshops have not succeeded in making

[147] Sources in this section:
Heiäng, Paula & Ourila, Anne. (eds). 1998. pp. 156-157.
Finnish Forest Idustries Federation. 1998. pp. 51-52.
Morgan, Nina. 1998. *A New Meaning of the Word.* In *Views on Finnish Technology 1998.* p. 16.
Morgan, Nina. 1998. *Seeing the Wood for the Trees.* In *Views on Finnish Technology 1998.* p. 17.

decision about a common national strategy. There were no networks nor co-operation between different companies, and this was the major factor behind the fall of the industry. In exports, transport costs are the major problem. Companies have tried to compensate large-scale exports with exports of design products, but markets for these products are steadily decreasing abroad. Despite a rapid increase after the crisis in 1993, which was caused by the devaluation of the mark, furniture industry has not managed to achieve the pre-crisis level in industrial output. At domestic markets, low-cost imports from Russia and Estonia have given new concerns to the furniture sector. Due to all these aspects the future does not look good for the furniture industry in Finland.[148]

5.3.3. Printing and publishing

Generally, printing and publishing sector has followed the common development of communication industries in society. During the years 1948-1977, the volume of production increased more slowly than total industry, while the amount of personnel doubled.[149] This industry has also faced many changes in production technology, in the form of developments in copying technology and filmsetting.

As appendix 5 illustrates, printing and publishing industry has recovered well after the crisis of 1990, but it has not managed to achieve the pre-crisis level of industrial output. After the crisis annual growth has been almost 4%, but it is interesting that this growth has not been caused by new innovations. With only five commercialised innovations, this sector places last on UIN ranking list. This indicates that there have to be some other factors behind the growth of this sector during the 1990s.

Advances in Information and Communication Technologies (ICTs) have largely affected the development of the printing and publishing sector during the 1990s. The use of digital printing is growing strongly, and printed products are becoming more colourful and complex and are being produced in ever smaller run lengths.[150] As digital printing is a specialised art it requires special types of paper. At this point of the

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[148] Sources in this chapter:
Articles in Helsingin Sanomat (http://www.helsinginsanomat.fi) :
Palm, Eeva. 16.07.1996. *Kenkäteollisuus elpyy varovasti, huonekalukaupan kasvua odotellaan.*
Jaakkola, Juha. 20.01.1997. *Huonekaluvienniltä puhti poissa.*
Pöppönen, Hannu. 03.06.1998. *Suomalainen muotoilu iskukunnossa.*
Kosonen, Markku. 06.07.1998. *Ovatko puusepät tarpeellisia?*
Forström, B, Kautonen, M & Toivonen, J. 1997. pp. 55-56.

[149] Hjerppe, Riitta. 1982. p. 426.

[150] Guy, Ken & Stroyan, James. 1998. *Electronic Publishing and Printing 1995-1999. Mid-term evaluation.* TEKES. pp. 5-7.
& Pagni, John. 1999. *Digital Paper – printing on the right stuff.* In *Views on Finnish Technology 1999*. TEKES publications. pp. 18-19.

process, forestry products companies play an important role by developing new and better quality products for printing and publishing industry. However, forestry products companies are not the only ones that co-operate with the printing and publishing sector. The use of networking, which started in 1996 at larger scale, has spread rapidly within the printing industry. This networking has resulted in better co-operation between the different printing and publishing companies, but it has been valuable in the export field as well. Printing exports to Russia have increased significantly as a direct result of this networking.[151]

5.3.4. Manufacture of other non-metallic mineral products

The development of this sector has followed largely the fluctuations in the construction industry. Especially during 1965-75, due to an increased construction activity in Finland, the growth of non-metallic product industry was quite rapid. It was during these years that the construction industry started to use industrially manufactured elements in large scale. Another reason for the growth of non-metallic industry was the role of export, which started during these years with glass, porcelain and ceramic products.[152]

The high demand from construction industry continued in the 1980s, and the manufacture of building bricks and window glass succeeded well.[153] Government set the standards in order to maintain the desired quality, but at the same time left little room for innovation. In the late 1980s the construction industry experienced a boom before a bust. During the expansive years in the late 1980s, the construction industry had relied on the booming home market and had not looked elsewhere,[154] and, suddenly, everything was gone.

After the depression, a new era saw its beginning in the construction industry in Finland with internationalisation. In 1994, the construction product industry was the leading private investor in R&D.[155] Research has mainly been focused on developing already existing materials in order to improve their quality (strength, viscosity), life-time and recycling.[156] Despite these large investments into R&D, the growth of other non-metallic product sector has been a disappointment. Credibility

[151] McArthur. 1996. *The Finnish printing industry moves towards networking.* In *Views on Finnish Technology 1996.* TEKES publications. p. 13.
[152] Hjerppe, Riitta. 1982. p. 428.
[153] Statitical Yearbooks of Finland.
[154] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 141-143.
[155] Saarnivaara, Veli-Pekka. 1996. *Finnish cosntruction goes international.* In *Views on Finnish Technology 1996.* TEKES publications. p. 8.
[156] Kuparinen, Alpo & Vuorinen, Pentti (eds.). 1997. *Tiellä teknologiavisioon – Suomen teknologisia tarpeita ja mahdollisuuksia.* Ministry of Trade and Industry. pp. 99-100.

of small companies, as well as the problems of small size in the international markets are some of the factors that slow down the development of this sector.[157]

The amount of innovations commercialised in this sector is 12, as table 5 illustrates. This is much under the average number of all industries, but due to the minor group weight index, the UIN is 1.2. Manufacture of other non-metallic mineral products sector has been able to get their share of the cake in R&D resources, but has not succeeded in achieving the prospects, which were set in the end of the 1980s. The fact is, that there are more than 12 innovations in this sector, but the problem has been how to commercialise them. The engineering industry has been unwilling to use and exploit these new innovations. In case of market demand, non-metallic industry follows largely the development of construction industry, which in turn follows the fluctuations of the economic life in Finland in general.

5.3.5. Manufacture of transport equipment

During the years 1948-77, the transport equipment branch was, together with machinery industry, among top two biggest branches of the metal industry. The number of employees increased during this period in transport equipment sector from 33.000 to 61.000 persons. These two branches dominated also the export of metal industrial products. After the payment of war indemnities to the Soviet Union, exports there continued in form of same kind of equipment as before, but also in form of ships. The crisis, which faced the European shipbuilding industries in the 1960s, because of the shipbuilding expansion in Japan,[158] forced the Finnish manufactures to concentrate on the specialisation of their products. These new products included, for instance icebreakers, car ferries and the manufacture of other special ships, such as oilrigs later on in the 1970s.[159]

While many of the Finnish industries have been successful during the 1980s, the transport sector has been in constant trouble, as appendix 5 illustrates. Currently, some parts are quite competitive while others barely survive. For instance, passenger car manufacturing belongs to the latter group, despite efforts that have been made recently in improving systematic quality and rapid production start-up.[160] The manufacture of

[157] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 141-143.
[158] Ljungberg, Jonas. 1981. *Tillväxt och stagnation i varvindustrin 1950-1980 Del I.* Meddelande från Ekonomisk-Historiska Institutionen Nr. 21. Lunds Universitet. pp. 33-36.
[159] Hjerppe, Riitta. 1982. pp. 421-422.
[160] Mäenpää I, Viitanen M & Juutinen A. 1996. p. 88.
& Laitinen, Mikko. 15.10.1999. *Uudenkaupungin 30-vuotias autotehdas panostaa erikoisautoihin.* An article in Verkkouutiset (http://www.verkkouutiset.fi).

heavy trucks [161] and armoured troop transport vehicles has done slightly better, but the vehicle markets of the world seem to be quite limited in this case also.[162]

A look at the Finnish transport equipment history shows that Finland has produced virtually all kinds of transportation equipment at some point. The transport industry has been able to fulfil the domestic demand by Finnish suppliers in the past, but when the industry tried to operate globally it did not succeed. These experiences have led to a situation where companies have specialised in few products and often only serve selected industries.[163] These products include nowadays for instance industrial/passenger elevators and conveyers,[164] harbour equipment,[165] speciality vessels [166] and diesel-electric propeller systems.

As appendix 5 illustrates, the industrial output of transport equipment industry has started to increase after the crisis of 1990. Concentration on special and high-quality products, as well as increase in foreign orders in the shipbuilding industry, have been the most important factors behind this growth. This specialisation has also resulted in some new innovations, and the placement in the UIN ranking list is seventh. Despite the growth of the shipbuilding industry, the future of the transport equipment manufacturing in Finland does not look bright. The manufacture of cars includes only few special car models, such as Porsche Boxter and Euro Samara. Otherwise, an domestic car industry is missing in Finland. However, an increasing demand for luxury cruisers keeps the shipbuilding industry going. The success of this industry has also important effects on other industries, for instance metal industry, which produces materials for the shipbuilding industry.

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[161] Look at: Homepage of Oy Sisu Auto Ab (http://www.sisuauto.com) & Homepage of Valmet Automotive Inc. (http://www.valmet-automotive.fi) – two transport equipment companies.

[162] Hernesniemi H, Lammi M & Ylä-Anttila P. 1996. pp. 121-123.

[163] Mäenpää I, Viitanen M & Juutinen A. 1996. p. 123.
& Harmo, Maunu. 1995. *Teollisuuksien teollisuus – näkökohtia maailman autoteollisuuden tämänhetkisistä kehitysilmiöistä.* Kauppa- ja teollisuusministeriön tutkimuksia ja raportteja 110/1995, Teollisuusosasto. pp. 34-36.

[164] For more information, look at: Homepage of Kone / Kone Elevator (http://www.kone.fi) – a elevator systems company.

[165] Includes terminal tractors, container forklifts, and straddle carriers.
For more information, look at: Homepage of Partek (http://www.partek.fi) – a construction equipment company.

[166] Includes for instance luxury cruisers, ice-breakers and liquid natural gas tankers.

6. Conclusions

Finnish industry has faced and gone through many changes during the last two decades. Collapse of the Soviet Union, depression in the beginning of the 1990s, as well as membership in EU, have all influenced the economic development of Finland in general, and industrial development in particular. As export to the Soviet Union stopped, Finland was forced to find new trading partners. Fortunately, an integrating Europe quickly made up for the situation, and exports to Western Europe started to steadily increase. Nowadays, European markets are the major target of Finnish export products. Due to this large and increasing role of European markets, especially Western European, Finnish industries have acquired new marketing areas for their products. This phenomenon is called "expansion of markets", and has been an important factor in the development of Finnish industries.

Another factor underlying the industrial development in Finland, is the large investment in R&D, which started already in the late 1970s, but has since then increased continuously, recently even rapidly. In many industries, these investments into R&D have been the "key for success", in the form of new products – innovations. Some industrial sectors have realised the importance of these investments, while others have continued their businesses in traditional ways. It has been shown, that the production of R&D intensive goods is positively correlated to high productivity and high productivity growth. At the same time, R&D expenditures have become global.

In order to analyse the innovation activity in Finnish industries, I have developed a new method. This new pattern is a combination of the Dahménian approach (advancing, stagnating and receding industries) and the Sfinno approach. With the help of Sfinno, I have collected statistics of commercialised innovations in Finland, and developed the "Unit Innovation Number" (UIN). The results of these processes gives a new division of Finnish industries into four different categories:

I) Advancing & More Innovative Industries;
II) Advancing & Less Innovative Industries;
III) Stagnating / Receding & More Innovative Industries; and
IV) Stagnating / Receding & Less Innovative Industries.

This new division, called "the New Industrial Pattern", allows to answer the following questions:

I) Have industries that have commercialised more innovations, advanced their industrial production?
II) Have industries that have been less innovative stagnated or receded?

As the results of this study illustrate, *all* more innovative industries have also been advancing ones. In three cases, even industries which

have been less innovative, have managed to increase their industrial output and have become advancing ones. This phenomenon has occurred especially in industries, where the machines used in production are large and complex. Innovations in these industries have been incremental (process innovations), instead of radically new (product innovations). However, a major part of the less innovative industries have either stagnated or receded. These results indicate, that this new pattern can be used for analysing the innovative activity of Finnish industries, during the last two decades.

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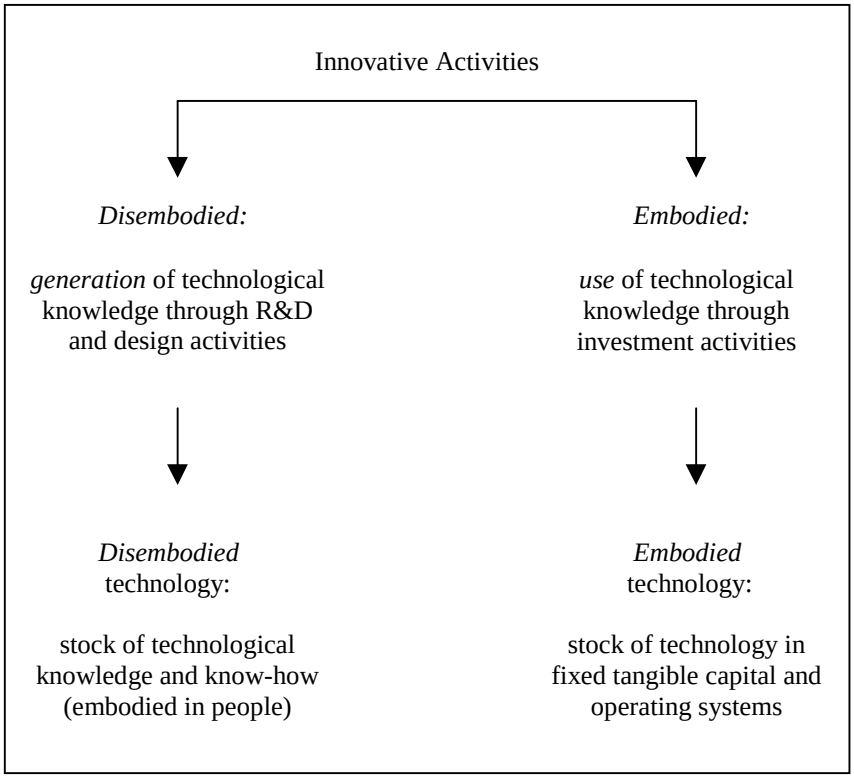
ABBREVIATIONS

ETLA	= The Research Institute of the Finnish Economy
EU	= European Union
GDP	= Gross Domestic Product
GTS	= Group for Technology Studies
GWI	= Group Weight Index
ICTs	= Information and Communication Technologies
OECD	= Organisation for Economic Co-operation and Development
R&D	= Research and Development
SET	= Federation of Finnish Electrical and Electronics Industry
SIC	= Standard Industrial Classification
SMEs	= Small and Medium Size Enterprises
TEKES	= Technology Development Centre of Finland
UIN	= Unit Innovation Number
VTT	= Technical Research Centre of Finland

APPENDIX 1. Embodied and disembodied views on technological change.

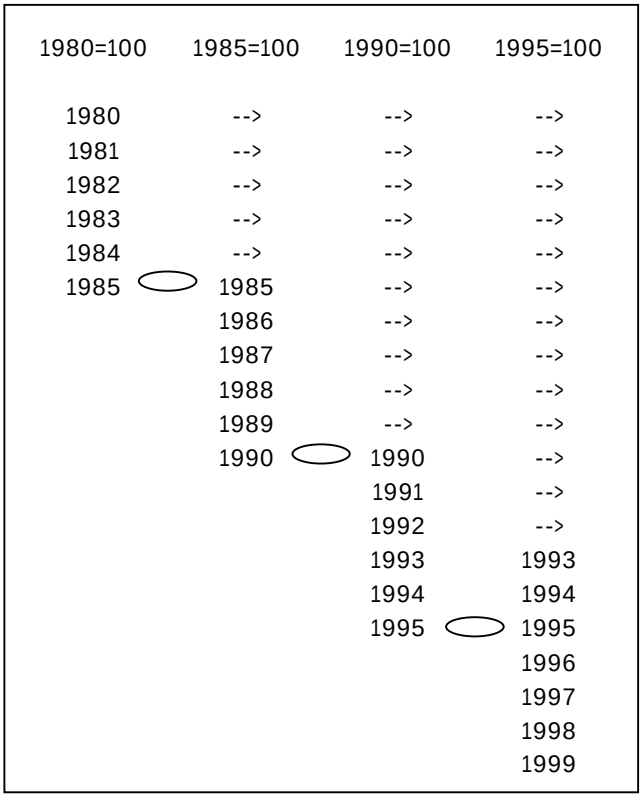


Source: Evangelista, R. 1999. *Knowledge and Investment: The Sources of innovation in Industry.* p. 69.

APPENDIX 2. Standard industrial classifications (SIC).

SIC 1995		**SIC 1968/80**	**SIC 1988**
C, D, E	**Whole industry**	2-4	C, D, E
C	**Mining and quarrying**	2	C
D	**Manufacturing**	3	D
15	Manufacture of food products, beverages	311-313	111-116
16	Manufacture of tobacco products	314	117
17	Manufacture of textiles	321	12
18	Manufacture of wearing apparel etc	322	131
19	Dressing of leather etc.	323,324	132,133
20	Manufacture of wood and wood products	33	14
21	Manufacture of pulp, paper, paper prod.	341	15
22	Publishing, printing etc.	342	16
23	Manufacture of coke, refined petroleum products and nuclear fuel	353,354	19
24	Manufacture of chemicals and chemical products	351,352	18
25	Manufacture of rubber and plastic products	355,356	21
26	Manufacture of other non-met. mineral products.	36	22
27	Manufacture of basic metals	37	23
28	Manufacture of fabricated metal products	381	24
29	Manufacture of machinery and equipment n.e.c.	382	25
30	Manufacture of office machinery and computers	3831	261
31	Manufacture of electrical machinery n.e.c	383	263
32	Manuf. of radio, television and communication equipment and apparatus	3832	262
33	Manuf. of medical, precision and optical instruments, watches and clocks	385	264
34 & 35	Manufacture of transport equipment	384	27
36	Manufacture of furniture; manuf. n.e.c	332	17
Other D	Other manufacturing & recycling	39	29
E	**Electricity, gas and water supply**	4	E

APPENDIX 3. "Linking"



Comments:
Numbers from period 1980-1985 (base year 1980) have been linked with numbers from 1985-1990 (base year 1985) in order to get numbers to period 1980-1984 with base year 1985. The same procedure has been repeated in other cases as well. Afterwards, when the linking was completed, I found numbers for 1993 & 1994 with 1995 as a base year. I have used these numbers instead of “linked” numbers in case of 1993 and 1994, and completed my tables with these numbers afterwards. In couple of cases, these “right” numbers (1993 & 1994) differed from my “linked” numbers by precision of one decimal, which indicates that the linking process has been successful and *quite* correct.

APPENDIX 4. Volume index of industrial output

(Change = Comparison between periods 1993-1998 & 1983-1988) 1995 = 100

Monthly data adjusted per working day

	Total	*C*	*D*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
1980	64,5	74,3	64,4	76,4	127,7	168,6	365,8	201,2	98,3	61,6	77,5	67,8
1981	66,2	76,6	66,2	79,0	176,7	158,1	398,4	217,6	88,1	62,1	82,4	63,0
1982	66,8	85,4	66,8	80,5	123,2	150,7	394,4	213,0	81,0	58,4	84,8	60,8
1983	69,1	85,2	69,1	82,3	122,8	142,8	369,8	197,1	88,4	63,8	89,9	65,6
1984	72,1	88,5	72,0	83,1	122,3	140,7	373,1	212,6	90,8	70,5	95,5	66,4
1985	75,0	91,7	74,4	85,0	120,5	135,5	384,5	224,4	87,3	69,8	97,8	67,9
1986	76,2	94,2	75,7	87,5	125,0	127,5	384,1	214,1	87,6	71,9	100,4	66,8
1987	80,1	92,4	79,6	88,7	129,8	132,4	342,2	202,8	92,3	74,5	104,4	75,8
1988	83,1	99,8	82,6	92,3	139,6	124,0	281,1	185,4	96,5	79,7	108,4	75,8
1989	85,3	107,6	85,6	93,0	130,3	119,4	243,8	147,8	105,6	80,5	113,1	69,9
1990	85,5	106,5	84,9	94,7	133,7	112,6	195,3	135,1	95,6	81,2	111,4	82,6
1991	77,8	97,2	76,3	94,8	119,9	93,0	149,8	112,8	75,1	79,0	100,8	86,3
1992	79,0	94,1	77,6	95,9	119,7	93,6	118,6	101,9	77,3	81,9	93,8	88,9
1993	84,8	89,6	83,7	96,9	111,8	93,2	109,0	101,6	89,0	89,1	91,2	88,5
1994	94,2	101,4	93,4	96,4	109,2	102,4	119,5	108,3	103,4	98,5	95,0	102,3
1995	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1996	103,5	100,7	103,0	103,2	95,9	104,8	99,2	98,1	103,2	95,5	102,2	106,9
1997	113,2	123,8	113,4	106,6	88,9	106,7	97,4	98,8	116,3	109,6	108,0	100,6
1998	122,2	92,6	123,7	107,4	87,1	107,1	92,8	102,2	123,4	113,1	110,8	115,4
1999	128,9	123,1	130,8	110,5	---	108,5	86,5	89,3	127,6	116,9	108,3	109,8
Change:	35,6%	10,2%	36,1%	17,6%	-22,0%	-23,5%	-71,1%	-50,7%	17,0%	40,8%	1,8%	46,7%
Correlation:		0,063	0,999	0,962	-0,774	-0,802	0,529	-0,065	0,856	0,929	0,989	0,551

	24	*25*	*26*	*27*	*28*	*29*	*30-32*	*33*	*34 & 35*	*36*	*Other D*	*E*
1980	63,8	61,2	99,2	54,2	58,0	61,2	16,7	28,7	92,6	97,1	70,6	65,2
1981	65,7	62,7	100,4	52,7	61,7	69,7	17,0	35,0	97,1	101,5	72,9	65,8
1982	63,0	66,2	108,9	55,1	70,2	71,3	17,4	37,6	110,0	106,3	77,4	64,9
1983	67,8	68,7	114,0	58,4	74,8	66,8	18,1	38,9	110,1	111,7	76,0	67,9
1984	71,1	70,0	107,4	62,8	74,4	73,2	19,1	50,2	105,2	110,1	80,0	72,5
1985	74,1	73,2	110,3	65,1	76,1	81,1	22,5	59,2	107,9	106,2	91,0	78,9
1986	73,7	78,4	107,6	66,3	80,3	77,2	26,2	64,6	107,6	105,0	96,5	79,2
1987	78,3	86,0	120,4	68,7	89,4	83,1	28,8	70,5	108,3	114,1	91,3	85,0
1988	84,3	89,4	124,8	72,5	94,4	86,5	31,5	78,3	102,3	122,9	97,5	86,8
1989	90,6	93,7	135,3	74,5	102,0	92,2	36,0	85,4	96,1	127,5	105,5	87,2
1990	88,6	94,2	133,5	76,0	99,7	91,9	37,1	84,8	91,3	117,5	106,2	89,0
1991	84,0	81,7	113,9	74,2	85,6	69,4	33,8	75,2	82,6	99,3	100,2	92,2
1992	85,2	83,1	99,5	82,3	79,3	67,0	43,2	74,6	86,3	92,5	101,0	91,6
1993	86,6	89,3	91,4	87,4	84,0	69,8	60,0	81,2	76,2	91,5	94,7	96,0
1994	97,7	97,4	99,4	94,3	93,4	82,0	79,1	87,6	87,7	100,6	98,5	101,6
1995	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
1996	103,1	101,1	106,5	105,7	104,7	103,9	114,3	113,0	97,1	101,4	103,1	109,1
1997	109,4	108,1	118,1	112,4	119,9	110,6	137,9	128,8	101,2	107,7	108,0	108,9
1998	112,2	115,7	124,1	120,0	129,2	111,1	199,7	132,2	106,4	109,5	109,5	110,3
1999	117,0	119,7	125,1	124,8	122,4	108,8	253,7	137,4	102,4	109,5	120,3	130,4
Change:	35,6%	31,3%	-6,6%	57,4%	29,0%	23,4%	372,5%	77,7%	-11,4%	-8,9%	15,3%	33,1%
Correlation:	0,936	0,949	0,758	0,989	0,963	0,948	0,953	0,971	-0,558	0,556	0,832	0,869

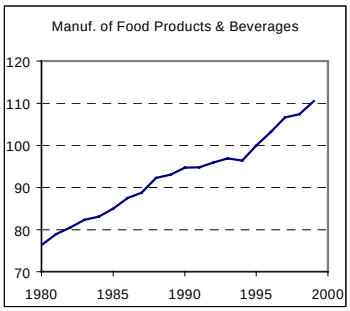
Source: Statistical Yearbooks of Finland & StatFin (28-03-2000).

APPENDIX 5. Advancing, stagnating and receding industries.
1 (4)

Division of industries according to Dahménian approach

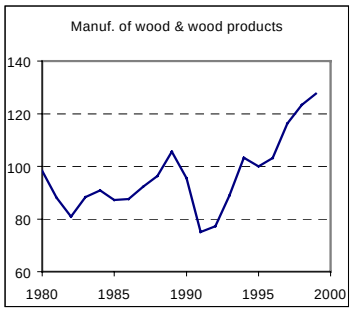
ADVANCING INDUSTRIES 1995 = 100

15 17,6%



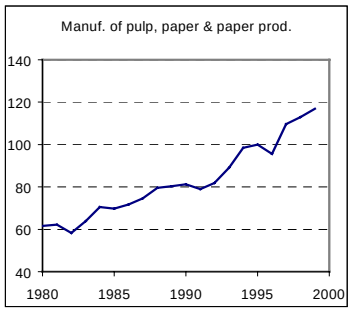
12,1% 10,8%

20 17,0%



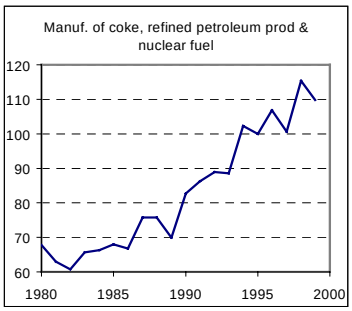
9,1% 38,7%

21 40,8%



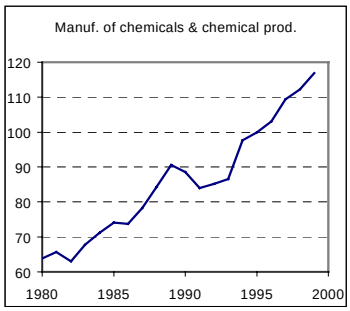
24,9% 26,9%

23 46,7%



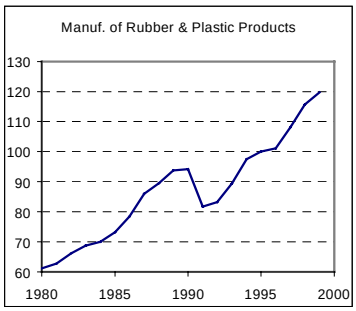
15,5% 30,3%

24 35,6%



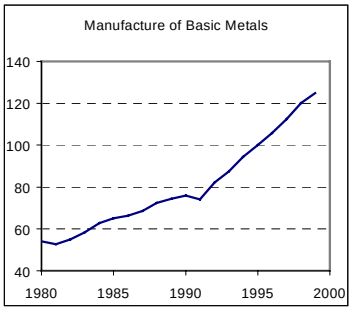
24,3% 29,6%

25 31,3%



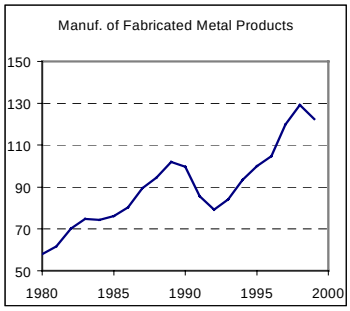
30,1% 29,5%

27 57,4%



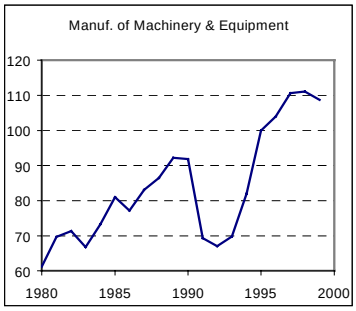
24,2% 37,3%

28 29,0%



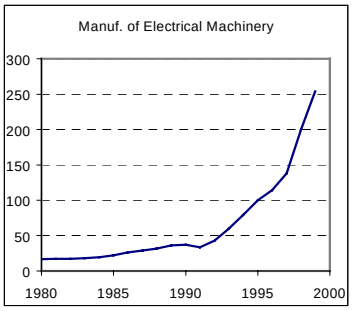
26,3% 53,8%

29 23,4%



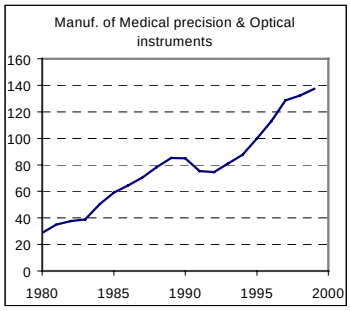
29,5% 58,3%

30-32 372,5%



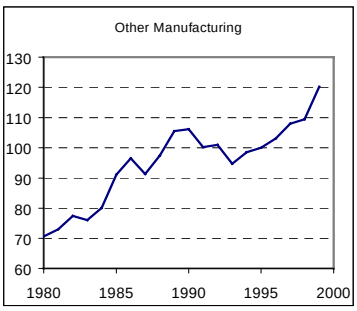
74,1% 232,7%

33 77,7%



101,5% 62,8%

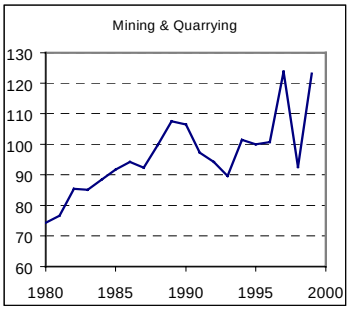
Other D 15,3%



28,3% 15,6%

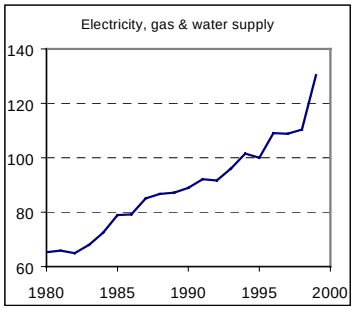
APPENDIX 5.
2 (4)

C 10,2 %



17,3 % 3,3 %

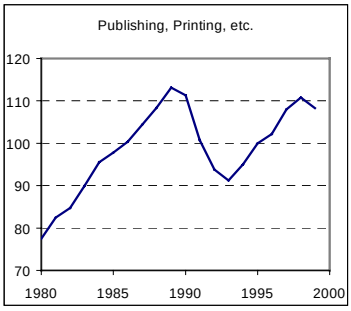
E 33,1 %



27,7 % 14,9 %

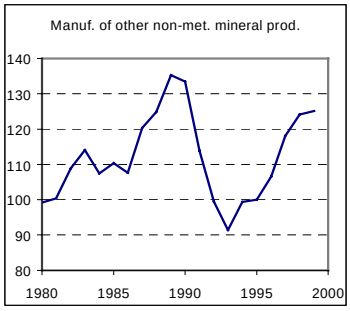
STAGNATING INDUSTRIES

22 1,8%



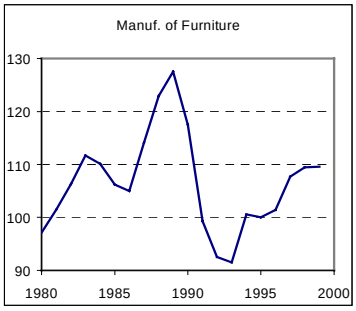
20,5% 21,5%

26 -6,6%



9,5% 35,8%

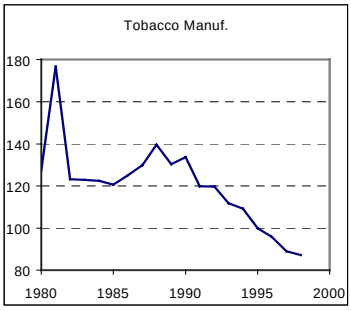
36 -8,9%



10,1% 19,6%

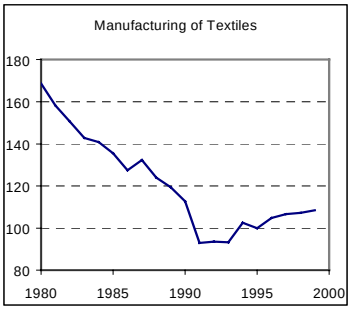
RECEDING INDUSTRIES

16 -22,0%



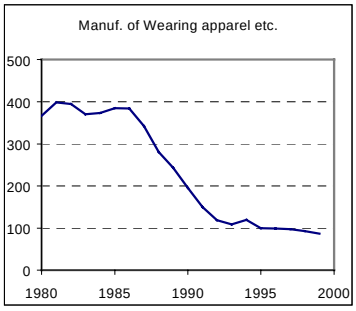
13,6% -22,1%

17 -23,5%



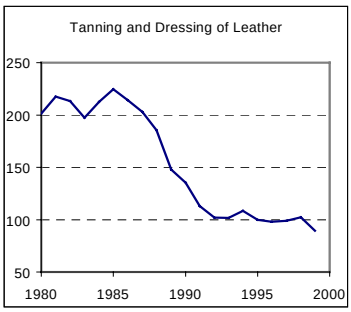
-13,1% 15,0%

18 -71,1%



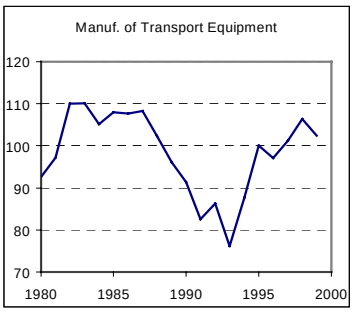
-24,0% -15,9%

19 -50,7%



-5,9% 0,6%

34 & 35 -11,4%

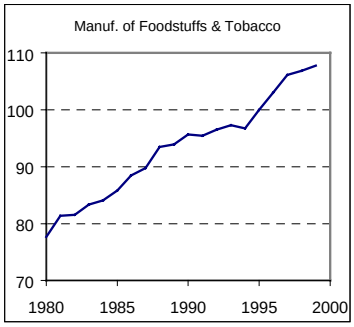


-7,0% 39,7%

Division of industries according to New Industrial Pattern

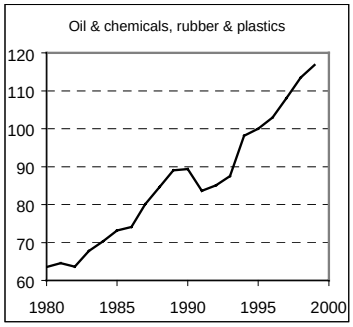
ADVANCING & MORE INNOVATIVE INDUSTRIES

15&16 16,2 % 2,9



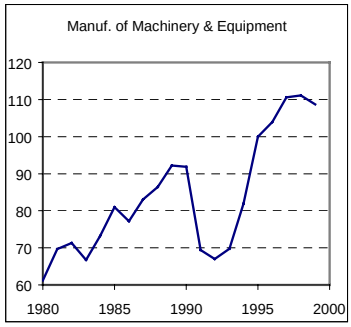
12,2 % 9,9 %

23-25 35,6 % 3,1



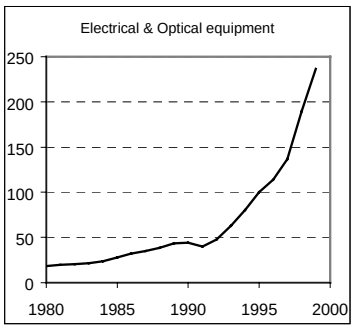
24,9 % 29,7 %

29 23,4 % 6,2



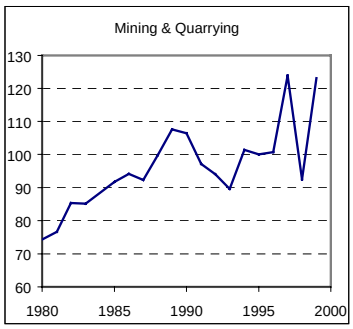
29,5 % 58,3 %

30-33 284,6 % 6,1



81,4 % 200,7 %

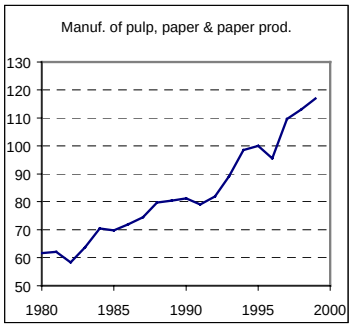
C 10,2 % 3,1



17,3 % 3,3 %

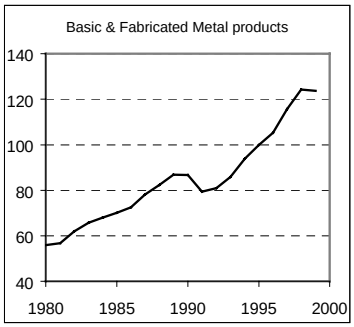
ADVANCING & LESS INNOVATIVE INDUSTRIES

21 40,8 % 1,1



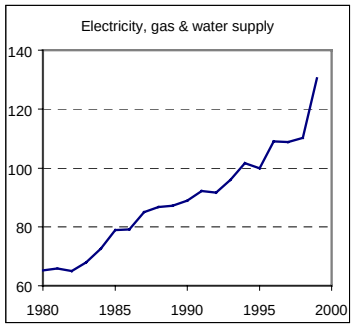
24,9 % 26,9 %

27 & 28 43,1 % 2,1



25,3 % 44,6 %

E 33,1 % 0,5

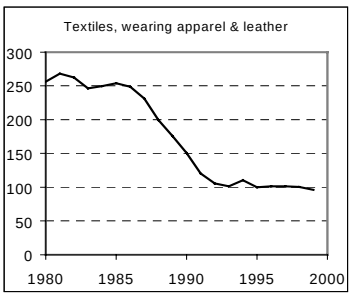


27,7 % 14,9 %

APPENDIX 5.
4 (4)

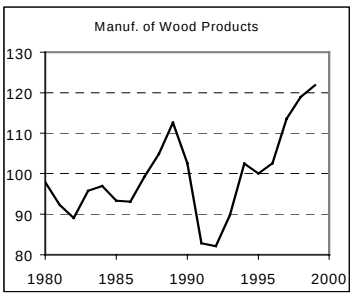
STAGNATING / RECEDING & LESS INNOVATIVE INDUSTRIES

17-19 -57,0 % 1,6



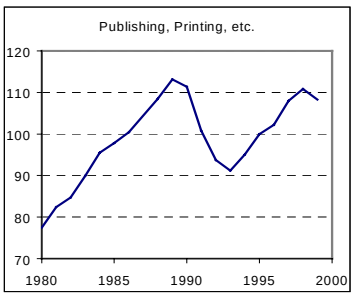
-19,0 % -0,8 %

20 & 36 7,6 % 0,8



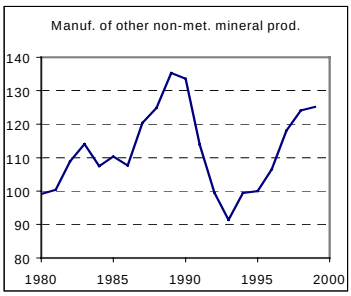
9,5 % 32,5 %

22 1,8 % 0,3



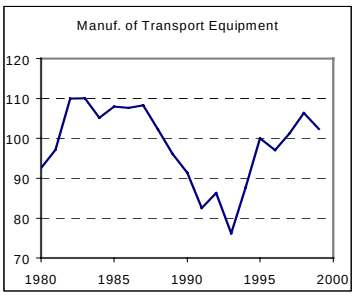
20,5 % 21,5 %

26 -6,6 % 1,2



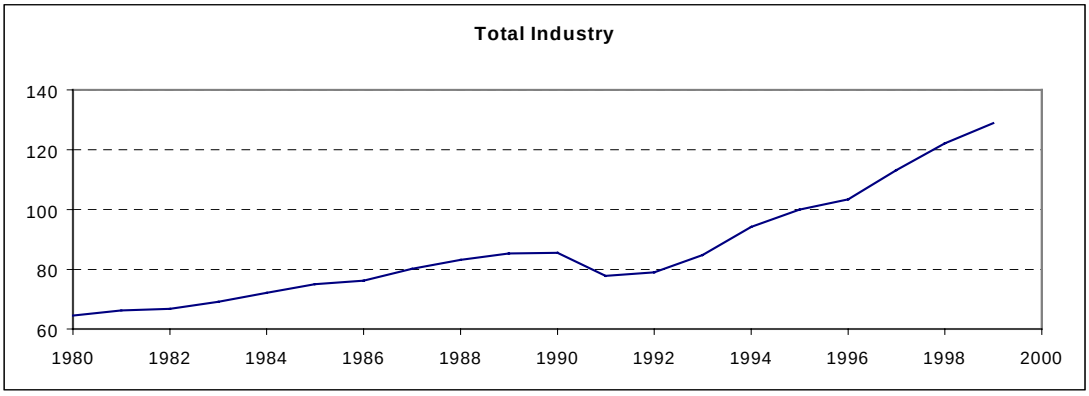
9,5 % 35,8 %

34 & 35 -11,4 % 1,9



-7,0 % 39,7 %

Total Industry 35,60 %



20,3 % 44,10 %

Comments:

Numbers above the figures:

On the left hand side:	The SIC Classification Number
In the middle:	Comparison between periods 1983-1988 & 1993-1998.
On the right hand side:	Unit Innovation Number

Numbers below the figures:

On the left hand side:	Growth in Production 1983-1988.
On the right hand side:	Growth in Production 1993-1998.

APPENDIX 6. Industrial Output Calculations.

SIC 1995 -numbers and Name of industries		Change in Industrial Output *	Annual Change in Industrial Output ***	Growth in Production 1983-1988 (Trend)	Annual Growth in 1983-1988	Growth in Production 1993-1998 (Trend)	Annual Growth in 1993-1998	Correlation 1983-1988 vs. 1993-1998	Correlation *against* Total Industry	Number of Innovations (Sfinno)	Uni Innova Numb (UIN)
	Total Industry	**35,6 %**	**3,09 %**	20,3 %	3,77 %	44,1 %	7,57 %	0,9987			
Advancing & Innovative Industries											
15 & 16	Manufacture of foodstuffs and tobacco	**16,2 %**	**1,51 %**	12,2 %	2,32 %	9,9 %	1,90 %	0,9596	0,9389	**84**	**2,9**
23, 24 & 25	Oil and chemicals, rubber and plastics	**35,6 %**	**3,09 %**	24,9 %	4,55 %	29,7 %	5,34 %	0,9543	0,9725	**92**	**3,1**
29	Manufacture of Machinery and Equipment	**23,4 %**	**2,13 %**	29,5 %	5,30 %	58,3 %	9,74 %	0,9480	0,9053	**191**	**6,2**
30-33	Electrical and Optical Equipment	**284,6 %**	**14,42 %**	81,4 %	12,65 %	200,7 %	24,63 %	0,9629	0,9694	**200**	**6,1**
C	Mining and quarrying	**10,2 %**	**0,98 %**	17,3 %	3,22 %	3,3 %	0,65 %	0,0630	0,7581	**11**	**3,1**
Advancing & Less Innovative Industries											
21	Pulp & Paper	**40,8 %**	**3,48 %**	24,9 %	4,55 %	26,9 %	4,88 %	0,9290	0,9720	**46**	**1,1**
27 & 28	Manuf. of Basic & Fabricvated Metal products	**43,1 %**	**3,65 %**	25,3 %	4,61 %	44,6 %	7,66 %	0,9926	0,9877	**60**	**2,1**
E	Electricity, gas & water supply	**33,1 %**	**2,90 %**	27,7 %	5,02 %	14,9 %	2,81 %	0,8690	0,9471	**19**	**0,5**
Stagnating / Receding & Innovative Industries											
Stagnating / Receding & Less Innovative Industries											
17, 18 & 19	Textiles, wearing apparel & leather	**-57,0 %**	**-8,09 %**	-19,0 %	-4,12 %	-0,8 %	-0,17 %	0,2906	-0,7772	**13**	**1,6**
20 & 36	Manufacture of Wood products, incl. furniture	**7,6 %**	**0,73 %**	9,5 %	1,83 %	32,5 %	5,79 %	0,7711	0,7792	**16**	**0,8**
22	Printing & Publishing	**1,8 %**	**0,18 %**	20,5 %	3,81 %	21,5 %	3,97 %	0,9890	0,6558	**5**	**0,3**
26	Manuf. of other non-metallic mineral products	**-6,6 %**	**-0,68 %**	9,5 %	1,83 %	35,8 %	6,31 %	0,7580	0,3330	**12**	**1,2**
34 & 35	Manufacture of Transport Equipment	**-11,4 %**	**-1,20 %**	-7,0 %	-1,45 %	39,7 %	6,91 %	-0,5580	0,0200	**21**	**1,9**
Total:										**770**	**30,8**
Average:										**59**	**2,4**

***** A comparison between periods 1983-1988 and 1993-1998. (Look at "The Objectives of the study"). [1993/98 over 1983/88]

****** UIN = Number of Innovations / Group Weight Index

******* A comparison between average values of industrial ouputs during periods 1993/98 over 1983/88.

APPENDIX 7. Unit Innovation Number (UIN) calculations.

SIC 1995	**1988** Value added FIM million *	GWI	Sfinno	UIN
15 & 16	12 116	11,3	19	1,7
17 - 19	4 524	4,2	3	0,7
20 & 36	7 039	6,6	4	0,6
21	15 850	14,8	11	0,7
22	7 462	7,0	1	0,1
23 - 25	10 056	9,4	33	3,5
26	4 299	4,0	6	1,5
27 & 28	9 398	8,8	13	1,5
29	10 551	9,9	50	5,1
30 - 33	8 406	7,9	46	5,8
34 & 35	4 327	4,0	4	1,0
C	1 473	1,4	2	1,5
E	11 376	10,6	7	0,7
Total	106 877		199	24,4
Average				1,9

SIC 1995	**1993** Value added FIM million *	GWI	Sfinno	UIN
15 & 16	13 420	11,8	30	2,5
17 - 19	2 926	2,6	4	1,6
20 & 36	7 051	6,2	5	0,8
21	16 473	14,5	21	1,4
22	6 660	5,9	2	0,3
23 - 25	12 535	11,1	29	2,6
26	3 041	2,7	1	0,4
27 & 28	11 053	9,7	27	2,8
29	10 944	9,6	58	6,0
30 - 33	11 031	9,7	68	7,0
34 & 35	4 150	3,7	10	2,7
C	1 390	1,2	4	3,3
E	12 809	11,3	4	0,4
Total	113 483		263	31,8
Average				2,4

SIC 1995	**1998** Value added FIM 1000 *	GWI	Sfinno	UIN
15 & 16	11 522 278	7,7	35	4,5
17 - 19	3 452 539	2,3	6	2,6
20 & 36	10 916 021	7,3	7	1,0
21	20 890 684	14	14	1,0
22	8 777 370	5,9	2	0,3
23 - 25	14 607 242	9,8	30	3,1
26	4 011 767	2,7	5	1,9
27 & 28	15 487 189	10,4	20	1,9
29	16 590 271	11,1	83	7,5
30 - 33	23 099 590	15,4	86	5,6
34 & 35	5 723 298	3,8	7	1,8
C	1 675 428	1,1	5	4,5
E	12 822 828	8,6	5	0,6
Total	149 576 505		305	36,2
Average				2,8

	Average of Unit Innovation Number (UIN)			
	1988	1993	1998	Average
15 & 16	1,7	2,5	4,5	**2,92**
17 - 19	0,7	1,6	2,6	**1,62**
20 & 36	0,6	0,8	1,0	**0,79**
21	0,7	1,4	1,0	**1,06**
22	0,1	0,3	0,3	**0,27**
23 - 25	3,5	2,6	3,1	**3,07**
26	1,5	0,4	1,9	**1,24**
27 & 28	1,5	2,8	1,9	**2,06**
29	5,1	6,0	7,5	**6,19**
30 - 33	5,8	7,0	5,6	**6,14**
34 & 35	1,0	2,7	1,8	**1,85**
C	1,5	3,3	4,5	**3,06**
E	0,7	0,4	0,6	**0,53**
Average				**2,4**

Comments: * At current prices.
Value added numbers have been taken from Statistical Yearbooks of Finland
GWI = Group Weight Index (= value added by specific industry divided by value added of total industry
Sfinno = Amount of innovations during three different periods: 1985-89, 1990-94 & 1995-99
UIN = Unit Innovation Number (= Sfinno / GWI)

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