ETLA ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 609 900 Telefax 601753

Keskusteluaiheita - Discussion papers

No. 480

Kati Korhonen

ADVANTAGE FINLAND -

METALS PRODUCTION TECHNOLOGY

ISSN 0781-6847

15.02.1994

ETLA Discussion papers no. 480

Kansallinen kilpailukyky ja teollinen tulevaisuus -projektissa tutkitaan, millaista teollista toimintaa voidaan harjoittaa Suomessa menestyksekkäimmin. Siinä tutkitaan menestyneitä vientiyrityksiämme ja pohditaan, miten niiden toimintaympäristöä tulisi kehittää, jotta ne pystyisivät saavuttamaan kilpailuetuja kansainvälisiin kilpailijoihin verrattuna.

Projektin päärahoittajina ovat Suomen itsenäisyyden juhlarahasto (SITRA), Elinkeinoelämän Tutkimuslaitos (ETLA), kauppa- ja teollisuusministeriö (KTM) sekä eri alojen tärkeimmät yritykset.

"The Competitive Advantage of Finland" research project evaluates the competitiveness of Finnish export industries and crucial elements behind their performance. The project focuses on what kind of industrial activities have the best possibilities for success in Finland.

The project is organised by Etlatieto Ltd and financed mainly by the Finnish national Fund for Research and Development (SITRA), The Research Institute of the Finnish Economy (ETLA), Ministry of Trade and Industry (KTM) as well as major companies in various fields.

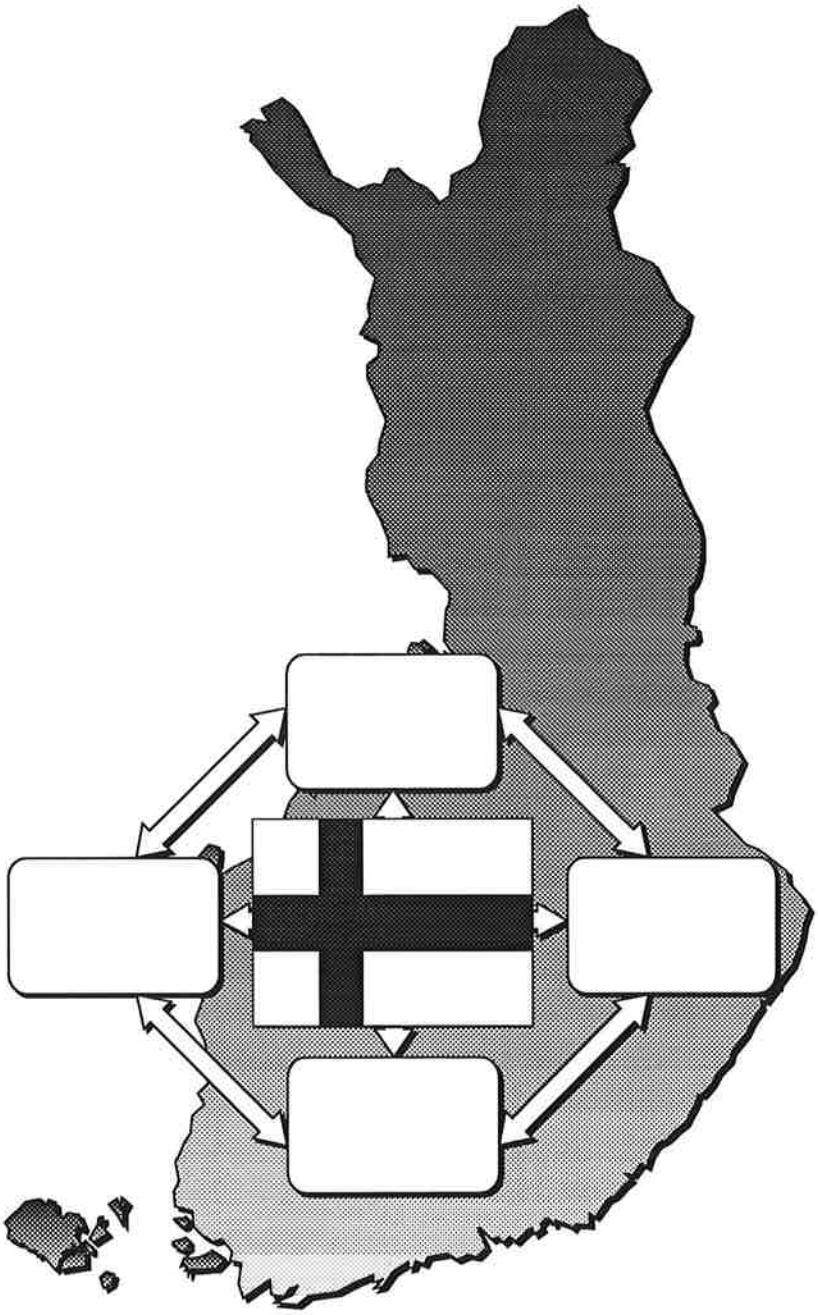
ETLATIETO
(ETLAn projektitutkimus- ja tietopalveluyksikkö)
Lönnrotinkatu 4 b 00120 Helsinki Finland
90 - 609 901 fax: 90 - 601 753

Kati Korhonen

Kansallinen kilpailukyky ja teollinen tulevaisuus

The Competitive Advantage of Finland

ADVANTAGE FINLAND - METALS PRODUCTION TECHNOLOGY



KORHONEN, Kati, **ADVANTAGE FINLAND - METALS PRODUCTION TECHNOLOGY**. Helsinki, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 1994, 34 p., (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; No. 480)

ABSTRACT: This study is a partial project of Competitive Advantage of Finland - research project coordinated by the Research Institute of the Finnish Economy. The purpose of this study is to analyze the competitiveness of metals production technology by using Michael E. Porter's theory of Competitive Advantage of Nations. The linkages between metals production and technology proved to be unquestionable. All the important players in the industry are part of a large metals producer consolidation. Industry strategy, structure and rivalry interacting with demand conditions turned out to be the most crucial elements in the diamond model of the Finnish metals production technology. The greatest source of competitive advantage lies in concentrating on solving the constantly growing environmental and energy problems in metals production.

KEY WORDS: metals production technology, competitive advantage, international operations

TIIVISTELMÄ: Tämä tutkimus on osa Elinkeinoelämän Tutkimuslaitoksen koordinoimaa Kansallinen kilpailukyky ja teollinen tulevaisuus tutkimusprojektia. Tutkimuksen tavoitteena on analysoida metallin valmistuksen teknologian kansainvälistä kilpailukykyä. Teoriapohjana tutkimuksessa on käytetty Michael E. Porterin teosta "Competitive Advantage of Nations". Yhteydet metallin perustuotannon ja valmistuksen teknologian kehityksen välillä osoittautuivat kiistattomiksi. Kaikki alan tärkeimmät yritykset Suomessa ovat osa isoa metallintuottajakonsernia. Porterin timanttimallista metallin valmistuksen teknologian suhteen ratkaisevimmat tekijät ovat kysyntäolosuhteet yhdessä toimialan rakenteen, strategian ja kilpailuolosuhteiden kanssa. Suurin kilpailuedun mahdollisuus suomalaiselle alan teollisuudelle on keskittyä teknologiaan, joka ratkaisee jatkuvasti kasvavia ympäristö- ja energiaongelmia metallien perustuotannossa.

AVAINSANAT: metallin valmistuksen teknologia, kilpailuetu, kansainväliset toiminnot

TABLE OF CONTENTS

1. SUMMARY

Advantage Finland research project, which is coordinated by the Research Institute of the Finnish Economy (ETLA), is composed of several industry cluster researches. This study is a partial project of the metals cluster research. The function of this study is to analyze the competitivity of metals production technology and to identify the connections between metals production and technology. The research subject is approached by using Michael E. Porter's theory of the Competitive Advantage of Nations.

The interviews with the companies' executives turned out to be the most important source of information. Interviews with the researchers of the industry provided also valuable information especially about the development of metals production technology and the basic factors controlling the development.

The linkages between metals production and technology proved to be unquestionable. All the important players in the industry are part of a large consolidation, because without a producer's own reference plant, it is almost impossible to ascertain the customer that the production technology is worth buying.

Huge technological leaps are seldom made and the industry is rather characterized by continuous improvement. By selling technology, companies are able to cover at least part of the R&D costs, they get quick information from the markets and they also get an image as a continuously developing company. Excellent spin-offs can also generate remarkable profits.

The importance of international operations is extremely vital in the metals production technology in Finland, because there is neither remarkable domestic rivalry nor demand. Scarce metal resources have forced the companies to upgrade technology. But there has been a big difference in metals production technology innovation strategy, when comparing steel industry and non-ferrous metals industry in Finland. It is obvious that non-ferrous metals production technology is the most competitive, for Outokumpu alone accounts for 90% (1,7 mrd Fim) of total technology sales in Finland. In steel production technology there have not been any new process inventions and the most promising business opportunities seem to be rather in process controlling equipment.

Industry strategy, structure and rivalry interacting with demand conditions turned out to be the most crucial elements in the diamond model of the Finnish metals production technology. More intensive co-operation with supporting industries would be reasonable, because the greatest source of competitive advantage in the Finnish metals production technology lies in concentrating on solving the constantly growing environmental and energy problems in metals production. The tightening environmental legislation and energy taxation will be the two key factors in the near future.

2. INTRODUCTION

2.1 Backround

Advantage Finland -research project, which is coordinated by The Research Institute of the Finnish Economy (ETLA), is composed of several industry cluster researches. The purpose of the Advantage Finland project is to assess the competitivity of the most important industry clusters in the Finnish national economy in order to find out the competitive advantage of the whole nation. This study is a partial project of the metals cluster research. The function of this study is to analyze the competitivity of metals production technology.

2.2 Objectives of the Research

The most important objective of this study is to identify the connections between metals production and technology (1) and to estimate the international competitive position of metals production technology (2). What also is essential, is to find out, what are the especially strong metals production technology areas in Finland, when comparing to other nations (3). The fourth objective is to analyze the relations between engineering workshops and technology development (4).

2.3 Scope of the Research

Mining technology is often included, when talking about mineral industries and metals production technology. However, this study will concentrate only on metals production technology and other technology, which is based on synergy between metals production and technology. The products that originate from this co-operation might sometimes be utilized in a totally different industry, but in any case the technology is grounded on metals production.

2.4 Research Methods

The research subject will be approached by using Michael E. Porter`s theory of Competitive Advantage of Nations. The most important research methods are literature study, company interviews and interviews of the researchers of the industry.

3. METALS PRODUCTION TECHNOLOGY

3.1 Industry Structure

Metals production technology industry consists of iron and steel making process technology and non-ferrous metals production technology. Because of the constant aim towards optimal process efficiency and better quality of outputs, different process controlling equipment play also an important role in metals production technology.

3.2 Most Important Companies in the Industry in Finland

Table 1 Companies in the industry: Net sales and personnel 1992[1]

COMPANY	NET SALES (Fim million)	PERSONNEL
*Outokumpu Mintec	362	704
*Outokumpu Engineering	413	1 179
*Outokumpu Candor	151	151
*Outokumpu EcoEnergy	124	244
*Rautaruukki Engineering	70	80
*Rautaruukki New Technology	50	35
*Kuusakoski Engineering	50	5

3.2.1 Outokumpu Technology

In Outokumpu, technology has traditionally played an important role. In addition to R&D needed for the company's own production, Outokumpu has been selling technology since the 1960s. Outokumpu Technology was founded in 1991, because there were so many subsidiaries selling technology that coordination of operations became too difficult[2]. Outokumpu Technology is a holding company, which consists of seven operational subsidiaries. Of those

[1]Source: Annual Reports, Outokumpu, Rautaruukki and Kuusakoski
[2]Interview Jussi Asteljoki , Technology Director of Outokumpu Technology, Espoo Nov 29, 1993

subsidiaries, Outokumpu Mintec, Outokumpu Engineering, Outokumpu EcoEnergy and Outokumpu Candor are included in this study, because their main business area is base metals production technology and other technology, which is based on process know-how.

3.2.1.1 Outokumpu Mintec

Outokumpu Mintec offers processes, equipment, instruments and automation for minerals processing industry. Most important products are floating cells and capillary filters as well as complete concentrator deliveries. Outokumpu Instruments and Turula Works are also part of Mintec Group. Instrument`s products are based on X-ray technology and therefore they are applicable to a wide range of industries. Turula Works is an engineering workshop, which manufactures many of the products sold by Mintec Group.

3.2.1.2 Outokumpu Engineering

Outokumpu Engineering consists of three main operational companies: Contractors, Wenmec and Castform. Contractors sells flash smelting technology for copper, nickel and lead and flash converting technology for copper. Flash converting was developed together with Kennecott Corporation of the U.S.A and because the process is quite new, till yet there is only one converting process in function, namely in Kennecott. Tankhouse equipment and anode casting systems are sold by Wenmec and upcast continuous casting systems by Castform.

3.2.1.3 Outokumpu Candor

Galvatek, Candor and Linnhoff form Outokumpu Candor Group. The Group operates in surface treatment industry. Environmental problems, connected with surface treatment are often remarkable and that is why Candor emphasizes its focus on ecologically beneficial electrolytic and chemical surface treatment.

3.2.1.4 Outokumpu EcoEnergy

Outokumpu EcoEnergy has focused on environmental technology business. Hazardous waste treatment and biological treatment of municipal waste are the most important businesses. In hazardous waste treatment EcoEnergy can utilize its know-how of metallurgical processes in another industry.

3.2.2 Rautaruukki Engineering

Rautaruukki Engineering was separated from Rautaruukki to an independent organization year 1987. Its operations are divided in four business groups: coke, iron and steel making process automation, tube mill manufacturing, surface treatment and consultancy. MAS Seuthe, which is a subsidiary of Rautaruukki Engineering, manufactures pipe machines and complete lines as well as modifications to existing plants. However, the most important business group is process automation, concerning especially blast furnace technology. Surface treatment business doesn`t actually support the base production of Rautaruukki Group, but it`s seen as a good business opportunity in the future.

3.2.3 Rautaruukki New Technology

Rautaruukki New Technology was founded year 1988 in Technology Park Oulu. The basis for the foundation of the company was the search for new solutions to measurement problems in the production and upgrading of steel. Rautaruukki New Technology is specialized in optoelectronics and solutions for measurement problems are therefore searched utilizing the know-how in optoelectronics. The most important operating principles are to co-operate intensively with steel production plant of Rautaruukki, outsource from small high-tec companies specialized in various aspects of optoelectronics and take part in international research programs.

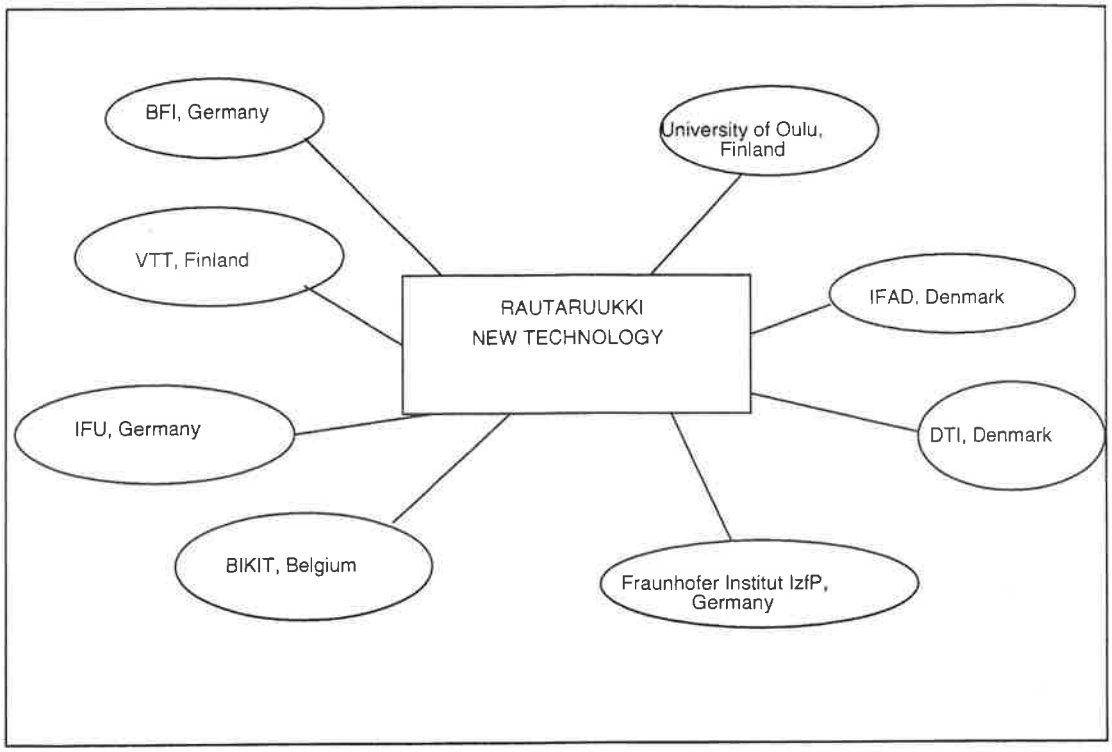


Figure 1 Rautaruukki New Technology: Research activities in Europe[3]

3.2.4 Kuusakoski Engineering

Kuusakoski Engineering is a part of Kuusakoski Group and its main business area is secondary metals production technology. Kuusakoski Engineering has developed its own technology to separate difficult metal compounds. Process equipment is manufactured in an engineering workshop, Myllyojan Metalli, which is a subsidiary of Kuusakoski Engineering.

3.3 New Production Technology and Innovations

Huge technological leaps are seldom made in base metals industry. Technical change is rather characterized by continuous, incremental, small-scale improvement and innovativeness[4].

According to Pavitt, process innovations are dominant over product innovations, while equipment manufacturers also provide important innovations[5]. As

[3]Source: Rautaruukki New Technology
[4]Ala-Härkönen Martti, Technological Innovation and Competitiveness in the Mining Industry, Center for Resource Studies Queen`s University Kingston, Ontario 1993, pp. 4 - 27
[5]Pavitt K. , M. Robson and J. Townsend, Technological Accumulation, Diversification and Organization in UK companies 1945 - 83, Management Science Vol. 35 / 1989, pp. 358 - 359

an example Outokumpu has made 71 major innovations in the period 1947-1991, of which 63% were process innovations and 37% product innovations. Due to scale intensiveness of base metals industry, innovative activities are driven mainly by the reduction of costs.

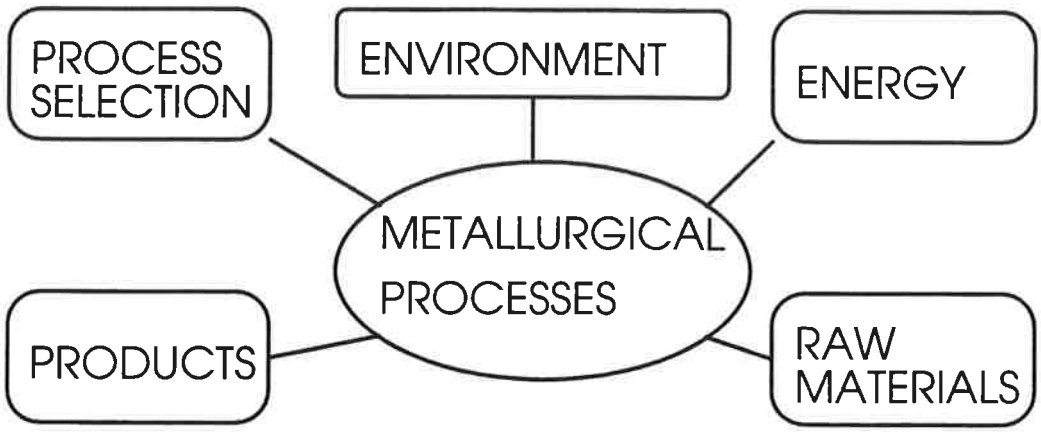


Figure 2 Basic factors controlling the development of metallurgical processes[6]

In Finland there has been a big difference in production technology innovation strategy when comparing steel industry and non-ferrous metals industry[7]. In Finland most of the basic steel production technology has been imported from the former Soviet Union and then the process automation systems and process analyzing solutions have been developed in Finland. Outokumpu, which has focused its operations on non-ferrous metals production and technology, has in addition to engineering skills also developed totally new production technology. The most famous invention was made in copper flash smelting 1949.

[6]Source: Holappa Lauri and Jalkanen Heikki, Outlines of Development of Metals Production and Metallurgical Processes to the Next Century, Materials and Society, Vol. 15, No. 4, pp. 423 - 447

[7]Interview Professor Lauri Holappa, Helsinki University of Technology, Espoo Nov 4, 1993

3.4 Diffusion of Technology

Unlike in many other industries, the diffusion and transfer of new technology within the base metals industry can be described as rapid due to several reasons[8]:

1) Despite some major process innovations, like flash smelting, many major technological advances in the base metals industry were not actually developed by mining and metallurgical companies themselves. In Sweden, for example, besides major minerals producers such as Boliden or LKAB, the country boasts a wide range of mining and metals processing technology and equipment suppliers, for example Atlas Copco and Scania.

2) Many innovations in the metals sector were adapted from other mineral sectors, for example, the low-cost solvent-extraction/ electrowinning technology in the United States copper industry.

3) Because orebodies around the world do have similar geological and physical properties, some technologies and methods have been standardized.

4) The capital intensiveness of the industry has given a lot of power to financial institutions and those usually prefer companies to employ proven, widely used technologies.

5) Mining and metallurgical companies which have been successful in inventing new processes and products are typically eager to sell their technologies. Outokumpu is a good example of a company, which has continuously been selling its own process know-how to other companies. This openness has naturally furthered the rapid diffusion of technology in the industry.

[8]Ala-Härkönen Martti, Technological Innovation and Competitiveness in the Mining Industry, Centre for Resource Studies Queen`s University Kingston, Ontario 1993, pp. 4 - 27

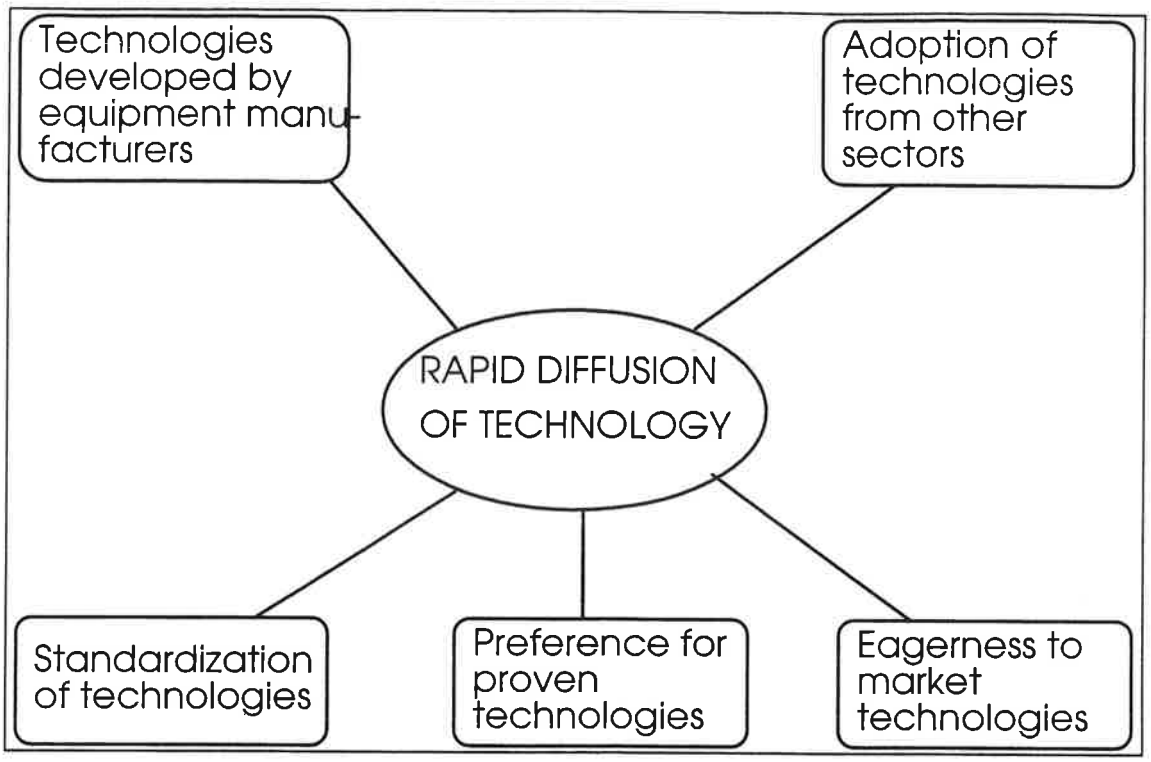


Figure 3 Factors which account for rapid diffusion of technology[9]

3.5 Linkages between Base Production and Technology

3.5.1 Cyclic Nature of the Business

Cyclical fluctuations have got a great impact on metals production industry and expanding possibilities are limited in base production, especially concerning steel[10]. That is why companies want to invest in technology business and upgraded metal products. In the long run technology subsidiaries are of course expected to be profitable as such, but they are also important because they carry out a large part of the R&D work important for the whole consolidation.

The cycles of production and investments don`t normally coincide. That means that when metal prices are extremely low, technology sales equalize income on the consolidaton level[11]. During the period 1975 -1989, the cumulative net income of the companies selling technology in Outokumpu Group was 800

[9]Ala-Härkönen Martti, Technological Innovation and Competitiveness in the Mining Industry, Centre for Resource Studies, Queen`s University Ontario 1993, pp. 6
[10]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18, 1993
[11]Interview Jussi Asteljoki, Technology Director of Outokumpu Technology, Espoo Nov 29, 1993

million FIM, which was 20% of the net income of the whole consolidation.

3.5.2 Why to Sell Technology?

One might easily wonder why a company sells technology to its competitors, being a metal producer itself. Doesn`t that mean selling competitive advantage? There are several reasons[12].

First, while selling technologies that are based on its own process know-how, company can cover at least part of its own R&D costs. In any case metal producer has to upgrade processes continuously, if the company wants to keep up with the competition.

Second, by selling technology the company learns to understand business area`s operations and strategies. If you want to beat your competitor, you must also know him properly. By supplying technology to your competitor, you get quick information from the markets and are able to be all the time one step forward to your competitors.

Third, because nowadays know-how spreads fast and almost each and every technology has got a competitor. In any case companies are not able to prevent their competitor metal producers from improving their competitive position. So why not sell the technology , before somebody else does it.

Fourth, by concentrating on core competences and growing wisely, technology subsidiary can also generate remarkable profits.

And last but not least: Company that also sells its own technology has got an image as a respected, modern and continuously developing company.

3.5.3 Selling Spin-Offs

The danger of selling competitive advantage to competitors doesn`t appear when selling technology that may be is based on production technolology, but has been upgraded to a new type of product. Some of those spin-offs can be utilized also in the base production and others are spin-offs to another industry.

Outokumpu Instruments, which is a part of the Mintec Group, has developed a

[12]Based on several interviews in Rautaruukki , Outokumpu and Kuusakoski

metal detector for security monitoring[13]. General know-how in chemical analysis, material testing and X-ray technology have been combined and the result is a market leader in a totally different business area from metals production. About 20 000 Metor metal detectors are in operation around the world, at airports, at industrial plants and in prisons.

Another excellent spin-off is SC 3000 Oil Detector which was originally developed for the measurement of oil residues in rolling mills by Rautaruukki New Technology[14]. When the product was lanced, surprisingly the biggest market area was not found in the metals industry but in the car industry. Namely for car industry it`s important that there is the right amount of protective oil on the surface of metal, when it is used for production.

The equipment is completely unique in the world and there are no competitors yet. A job which previously required laboratory analysis performed on a sample sheet, can now be done in a couple of seconds on a production line. The production of the oil detector began in the beginning of the year 1993 and during the year dozen of detectors were delivered with the average price of 200 000 FIM. The uniqueness of the technology used and the wide application area make the oil detector an especially promising product in the near future.

3.5.4 Organizing Operations and Concentrating on Core Competences

Co-operation between base production and technology is the right method to make innovations[15]. But it has to be emphasized that unless operations are not well organized, resources are not effectively utilized and overlapping operations are carried out in different subsidiaries. Rautaruukki has divided its R&D and engineering operations so that research centre in Raahe is responsible for materials research, Engineering developes process automation and New Technology searches for new solutions to measurement problems in the production and upgrading of steel.

Core competences should be kept all the time in mind when planning to branch out into a new business. Just running after new excellent business opportunities is not wise in the long run. Not only the technology must be suitable for another industry, but also the structure of the industry has to match. Outokumpu Technology has made several mistakes in acquiring new

[13]Outokummun Sanomat 1 / 1992 pp. 14 - 16
[14]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18, 1993
[15]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18 , 1993

companies in the end of 1980s. Acquisitions were financed almost totally by foreign debt and devaluation of the Finnish mark led companies to serious debt-servicing problems.

Slow and bureaucratic decision making processes that are typical of large companies are not suitable for small and middlesized technology companies, because needed expertise is different. That is why one has to remember that although there are many advantages in combining base production and technology, the operating model differs considerably. A technology company has to have much more flexibility and it has to be able to react fast to changes in the market.

4. FACTOR CONDITIONS

4.1 The Roots of Competitiveness

According to standard classic economic theory, factors of production -labour, land, natural resources, capital, infrastructure - will determine the flow of trade. A nation will concentrate on those goods that make most use of the factors with which it is well endowed. In reality this theory has proved to be incorrect. Especially in sophisticated industries, because competitiveness is not a static model where a nation inherits a competitive advantage.

Sustainable competitive advantage is based on continuous improvement and that is why upgrading is much more important than the state now. Basic and generalized factors are only the ground on which advanced and specialized factors are upgraded. To really support the competitive advantage, a factor must be highly specialized to an industry`s special needs.

4.2 Advanced and Specialized Factors in Finland

4.2.1 The Quality of the Finnish Engineers

In Finland, the system of education is of a fairly high level. General education level as such is only a basic factor, but what is even more interesting is the unique structure of the studies in metallurgy in Finland. Namely there are no separate degree programmes for copper and iron engineers, although there are of course several subjects for specialization[16]. That means that Finnish engineers are not only highly skilled but also have got a wider perspective in metallurgy and are able to utilize their knowledge over traditional barriers between ferrous and non-ferrous metals production.

Traditionally it has been possible to study metallurgy and process engineering in Helsinki University of Technology. However, the most important companies and their plants are not located in Helsinki[17] The process engineering degree programme was started in the University of Oulu year 1991, to promote the co-operation between university and industry, for for example Rautaruukki Engineering and Rautaruukki New Technology are located in Oulu. Research

[16]Interview Professor Lauri Holappa, Helsinki University of Technology, Espoo Nov 4, 1993
[17]Interview Harri Gröhn and Jouko Peussa Federation of Finnish Metal, Engineering and Electrotechnical Industries (FIMET), Helsinki Nov 4, 1993

in the university that is tied up with a certain project in a company in the industry is naturally wise and creates synergy, but it alone is not enough. In the long run it is vital for development that universities are able to do research also for purely scientific reasons. Remarkable cuts in the university budgets would endanger this type of research.

4.2.2 Inventions and Innovations

Internationally R&D expenditures in the base metals industry have been fairly low. An average company spends less than one percent of its yearly turnover on R&D. Anyhow, Outokumpu belongs to the strategic group which has traditionally emphasized innovation and R&D and Outokumpu spends about 2,4% of its yearly turnover to R&D. This kind of strategy tends to be typical of companies highly downstream-integrated[18].

Some companies, rather than spending a lot of money in developing new process technology, emphasize basic engineering-centered innovative activity. Instead of doing R&D internally, the company`s engineering teams innovate by developing specific skills in adapting, applying, and synthesizing the newest available technologies for exploitation within the company. The engineering oriented innovative activity is typical of companies like Rio Tinto Zinc (RTZ), especially with regard to mining business.

No matter which innovation strategy the company has chosen, it has been proved that innovativeness is clearly fundamental to the competitiveness and economic success of base metals industry. The importance of R&D can not be underestimated, because it obviously is vital to downstream dominant companies like Outokumpu, which is both inventive and innovative. Anyhow R&D centres should be located near production operations, since that is where most technical change appears to originate. The most successful innovations seem to be driven by strong needs arising from the company`s production operations

[18]Ala-Härkönen Martti, Technological Innovation and Competitiveness in the Mining Industry, Centre for Resource Studies Queen`s University Kingston, Ontario 1993, pp. 4 - 27

4.3 Turning Disadvantages into Advantages

A disadvantage in a static factor condition model can be even an advantage in the dynamic one. If there is a shortage of a resource, a company continuously tries to develop and operate more effectively. In Finland there are only a few mines and scarce natural resources what comes to metals[19]. Outokumpu imports more than 70% of its ores. The main import areas are Chile and Australia. The biggest zinc mine Tara in Ireland also belongs to Outokumpu. Most of the mine projects are joint ventures with other international companies in the mining industry.

The scarce metals resources have pressured Finnish metals industry to continuously develop and improve the production technology. But disadvantages can be turned into advantages only under certain conditions. First, they must send companies proper signals about circumstances that will spread to other nations, thereby equipping them to innovate in advance of foreign rivals. Second, there must be favourable circumstances elsewhere in the diamond. The company must have access to skilled people and home demand conditions must send the right signals. Without active domestic rivalry, there is a danger that a company takes an easy way around the disadvantage rather than using it as a spur to innovation.

As discussed earlier, skilled metallurgy engineers are without controversy an asset to the industry in Finland. There is almost no domestic rivalry, because each and every company has specialized to its own sector: Outokumpu Technology to non- ferrous metals production technology, Rautaruukki Engineering and New Tecnology to steel process automation and Kuusakoski to secondary metals production technology. But what is remarkable to notice, there is barely no domestic demand either! That implicates that global market is actually also the home market.

[19]Outokummun Sanomat 3 / 1992 pp. 6 - 9

5. DEMAND CONDITIONS

5.1 Customer Structure

According to Porter, the composition and character of the home market usually has a disproportionate effect on how companies perceive, interpret, and respond to buyer needs. A nations companies gain competitive advantage if domestic buyers are the world`s most sophisticated and demanding buyers for the product. And what is most interesting when analyzing metals production technology - the size of home demand proves far less significant than the character of home demand.

Although there is no domestic market as such in Finland, all the important players in the industry are part of a large consolidation. Who could be more demanding a customer than a company in the same group? Rautaruukki can anticipate the trends what sort of special measurement problems there are and will be in the steel production process and then Rautaruukki New Technology searches solutions for those problems.

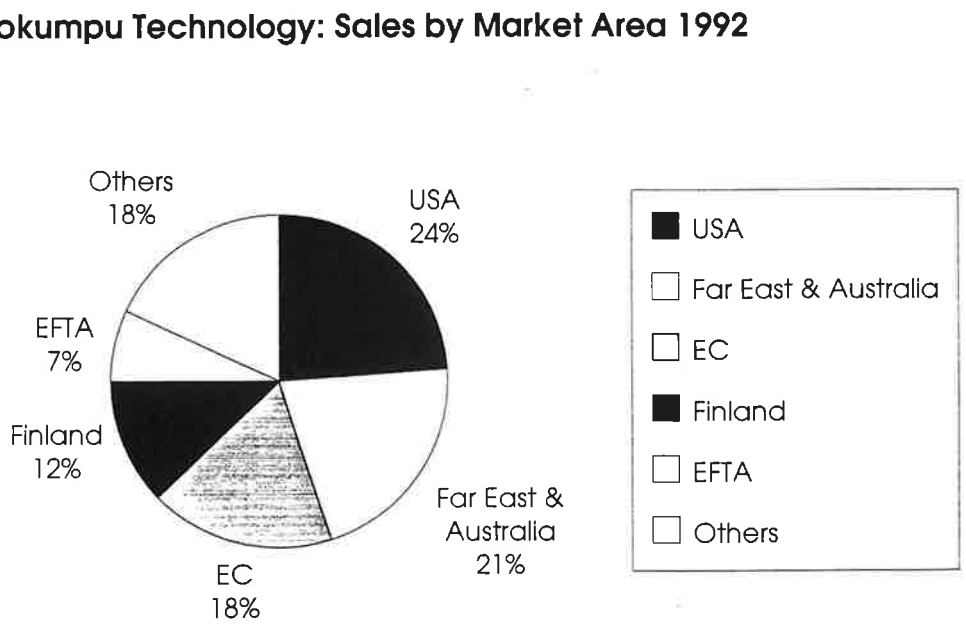


Figure 4 Market Areas of Outokumpu Technology[20]

[20]Source: Outokumpu Annual Report 1992

Metals industry can be described as a very highly capital intensive industry. Because investment decisions have usually very long-term implications, customers are reluctant to pioneer in using a new type of production technology[21]. That is why it is essential to a company selling process technology to have a reference plant of its own. Only that way the customer is able to ascertain that your production technology is worth buying.

Totally new production innovations are made seldom and continuous development of production technology is an absolute prerequisite, if the company wants to keep up with the competitors. Because the basic production technology changes slowly and is that way usually available to competitors, the key question is how well the company is able to apply the method. One of the key factors for example in developing Outokumpu `s flash smelting method has been the continuous customer feedback.

5.2 The Development of the Demand

Like Rautaruukki, most of the big western steel producers have their own engineering subsidiaries, that also sell their own technology. Because of that the most important market area for process automation is found outside of Europe and North America. Blast Furnace Supervision and Control Systems of Rautaruukki Engineering are a good example of Finnish engineering skills. The basic blast furnace solutions were imported from the former Soviet Union, but all the high-tech automation concerning blast furnaces has been developed in Finland. Because of the overcapacity in the steel industry, the demand for process automation will probably not be rising in the near future.

Anticipation of general trends is possible if nations values are spreading. Most of the metals production processes are highly energy consuming. Decision not to build the fifth nuclear power station caused a lot of concern in the mining and metallurgical industry in Finland[22]. It is true that moderately priced electricity is important, but the crucial question is that are the energy costs competitive comparing to competitors and what is the global trend in energy taxation?

---

[21]Interview Jussi Asteljoki, Technology Director of Outokumpu Technology, Espoo Nov 29. 1993
[22]Tekniikka & Talous, Kari Pehkonen 35 / 1993 pp.4

General economic growth should be no more in the 1990s the only aim of a nation[23]. Environmental questions are becoming more and more important in political as well as in economical decision making. Those nations and companies that don`t take that into consideration, will be losers in the future.

Finnish base metals industry has been traditionally at the top, when talking about energy efficiency and less emissions[24]. The roots of energy efficiency lead as far as back to the 1940s, when Finland was suffering from energy shortage after the second world war. The government insisted Outokumpu to reduce its energy consumption and what was the effect: the sensational innovation flash smelting, which was the base for both, the growth of the production and sales of the technology.

Table 2 Energy consumption in Finnish blast furnace system is according to statistics most effective in the world. In the following table is shown how many kilograms of coking cole, coal and oil is needed to produce one ton of cast iron[25].

COUNTRY	**1970**	**1980**	**1990**
Finland	530	470	460
Sweden	585	530	465
Germany	580	500	475
England	-	540	500
USA	655	580	-
Japan	520	470	-

[23]Heinonen Jarmo, Energy Technology Today , presentation Sept 28, 1993
[24] Mannerkoski Markku, The Head of the Technical Research Centre of the State of Finland, The Future of the Finnish Mining Industry, presentation March 19, 1993
[25]Source: Association of the Finnish Steel and Metal Producers

5.3 The Effect of Environmental Legislation on Demand

The competitiveness of many Finnish process and product innovations in the metals production technology is based on uniqueness in energy consumption costs and less pollution. But the demand of such technology depends a lot on the development of the environmental legislation in the world.

The sulphur recovery of the Outokumpu`s (Outokumpu Engineering Contractors) newest copper flash converting process is as much as 99,9%, so it certainly meets the strictest environmental regulations[26]. However, there is only one pilot smelter in the world yet, namely Kennecott in the USA. Because required investments are high and although operating costs would be remarkably lower, changing over to a new system goes slowly. The tightening of environmental standards would obviously speed up the shifting to a more ecologically beneficial technology.

Surface treatment industry is one of the most polluting industries[27]. Outokumpu Candor, which sells electrochemical surface treatment technology, has utilized access to the latest hydrometallurgical technology, when being part of the Outokumpu Group. It has a world wide unique technology in surface treatment. Candor has delivered 500 surface treatment plants to more than 25 countries. And again, tightening of environmental legislation would have a positive effect on demand.

Rautaruukki Engineering operates also in the surface treatment business, but unlike in Outokumpu, it is hard to find synergy between steel production and selling of surface treatment robots. Surface treatment business is only seen as a good business opportunity for Rautaruukki Engineering. Yearly sales are around 15 million FIM . The future seems to be promising, especially when manual sand blasting will be legally prevented, because of the health risks it causes for the worker.

---

[26]Interview Jussi Asteljoki, Technology Director of Outokumpu Technology, Espoo Nov 29, 1993 and Outokummun Sanomat 3 / 1992, Timo Ylönen, pp. 11 - 14

[27]Based on interviews with Taisto Hannukainen, President of Rautaruukki Engineering and Jussi Asteljoki, Technology Director of Outokumpu Technology

6. RELATED AND SUPPORTING INDUSTRIES

The third broad determinant of national advantage is the presence in the nation of related and supporting industries that are internationally competitive. Home-based related and supporting industries promote innovation and upgrading, which is based on close working relationships. Quick and constant flow of information and ongoing exchange of ideas and innovations benefit both parties.

6.1 Synergy with Subcontractors and Customers

Subcontractors play an important role in the industry. Companies try to focus only on activities that really add value on their operations[28]. For example Rautaruukki Engineering, when producing process automation for steel industry, buys the basic mechanical automation system and concentrates only on high-tec. However, it`s not possible to use always the same supplier, because in most cases the customer already has some kind of automation system, which has to be improved and linked with the higher level information systems. Important automation system suppliers are ABB, Honeywell, Valmet and Siemens. Because co-operation partner depends on the project , the relationship between the supplier and producer can not be described as very intensive or persistent.

Engineering workshops are important for the industry for at least two reasons[29]. Generally, because that is the best channel to provide quick and accurate information from the markets. And particulaly in Finland, when almost 90% of the technology is exported, the danger of losing the market touch must be taken into consideration. Deliveries are often made on turn-key solution principle and assembling is then also included. Due to turn-key solutions, assemblers are the best source for practical product development.

Outokumpu Mintec has an engineering workshop Turula in its company group, which subcontracts extensively for other Mintec companies, for example capillar filters and flotation cells[30]. An engineering workshop as a subsidiary in a company group is of course a good solution only if there are many such special components that can not be easily outsourced. Logistic

---

[28]Interview Taisto Hannukainen, President of Rautaruukki Engineering , Oulu Nov 18, 1993
[29]Interview Timo Miettinen, President of Kuusakoski Engineering, Espoo Nov 29, 1993
[30]Interview Jussi Asteljoki, President of Outokumpu Technology, Espoo Nov 29, 1993

expenses are often the reason for not using a constant subcontractor in every basic component.

Customer feedback is a vital source for process development and upgrading. Process technology has always to be tailored for special customer needs. From components to complete processes and from modernizing a plant to a greenfield facility. For example the chemical composition of the ore used, has a great effect on the concentration and smelter technology.

6.2 Specialized Supporting Industries

The entity is more important than separate relationships with suppliers[31]. An excellent example of a small technology cluster specialized in various aspects of optoelectronics is in Technology Park Oulu. Resources are combined by using the research expertise of the Technical Research Centre of the State of Finland, University of Oulu and in addition to Rautaruukki New Technology, five small high-tec companies specialized in optoelectronics. The Technology Park is an ideal environment where resources and know-how from multidisciplinary scientific research, are transferred to the development and manufacturing of highly advanced products.

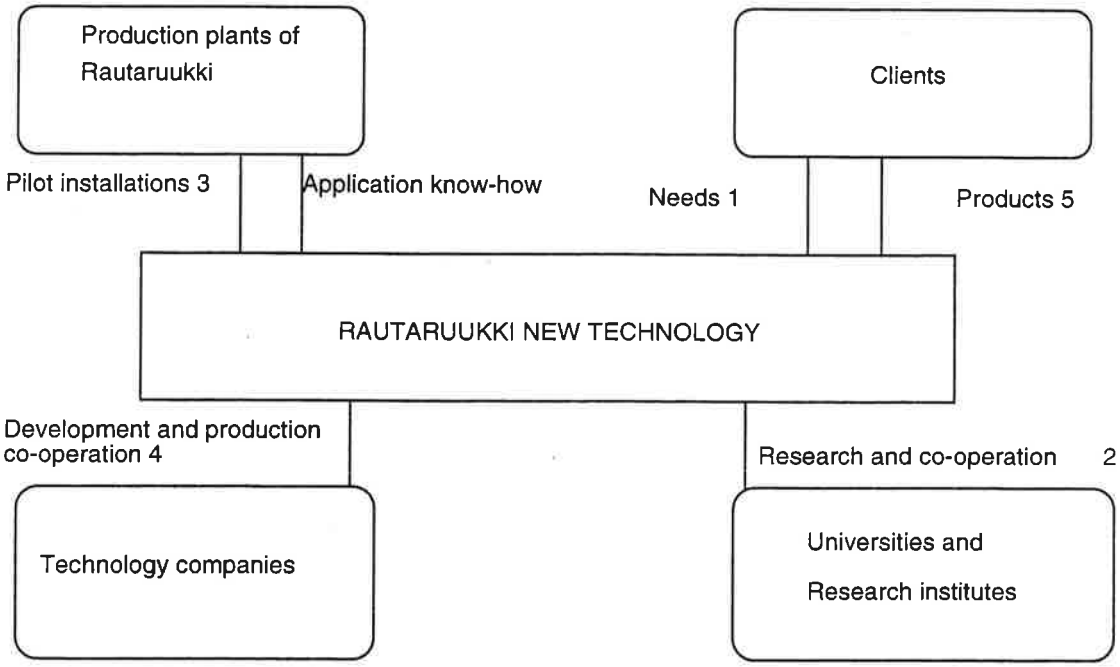


Figure 5 The operating model of Rautaruukki New Technology[32]

[31]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18, 1993
[32]Source: Rautaruukki New Technology

The closures of mines in the peripherial regions have intensified the trend that activities are becoming more concentrated in southern Finland. So also from the regional policy point of view, it is reasonable that small high-tec companies, related to the metals industry are located near by the production plants[33]. And as already said, that`s where the most technical change seems to originate.

6.3 Research and Development with Supporting Industries

Energy technology and environmental technology appear the most important supporting industries. The price of energy is steadily rising and environmental aspects have to be taken into consideration because of the tightening legislation . In according to forecasts, environmental markets in the industry will double before year 2000[34].

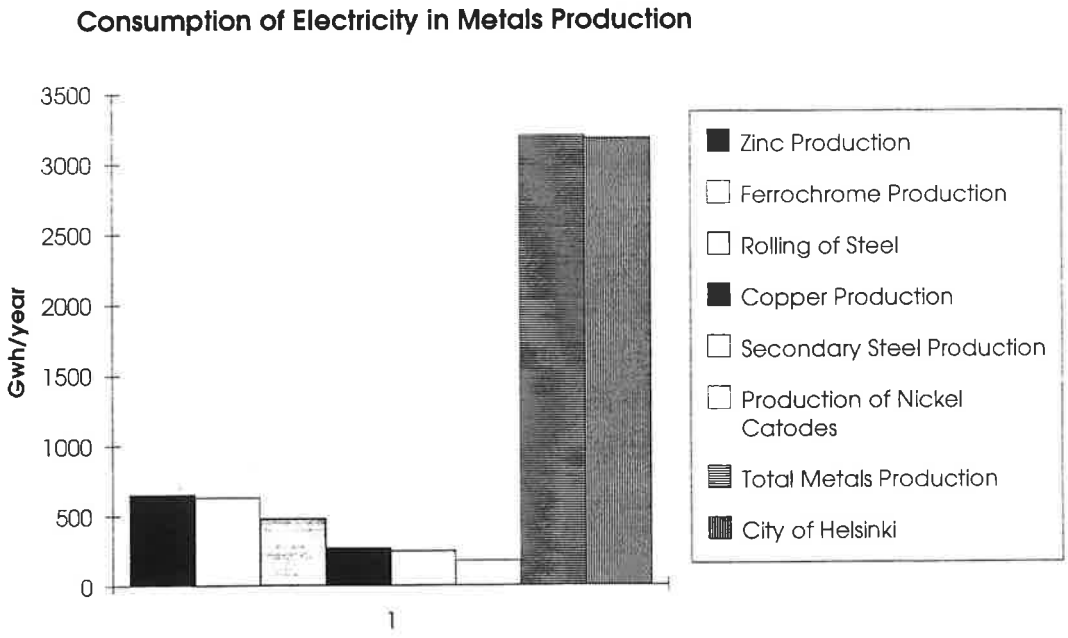


Figure 6 Consumption of electricity in metals production (Gwh / year) compared to the city of Helsinki[35]

[33]Raumolin Jussi, Restructuring and Internationalization of the Forest, Mining and Related Engineering Industries in Finland, The Research Institute of the Finnish Economy, Helsinki 1988 pp. 1 - 86
[34]Tekniikka & Talous, Riitta Ekholm, 40 / 1993, pp.15
[35]Source: SULA-project

The Finnish Ministry of Trade and Industry has been a partial financer in the research for less energy consuming metal production processess[36]. Outokumpu began to develop in the "SULA project", new production technology for zinc production. The new production technology would be based on pyrometallurgy and therefore the process would consume 30 % less energy than when using zinc tankhouse equipment. If for example the zinc production in Kokkola would be replaced with the new process, electricity savings would be 230 GWh in a year. The development of the pyrometallurgic process will still last at least three years, but if the project is successful, the markets for the new process are enormous.

Between environmental technology and metals production technology is a lot of synergy. Kuusakoski co-operates with AEM, a small high-tec company specialized in environmental technology, which has developed filter technology that is also suitable for secondary aluminium production in Kuusakoski. Finnish small and middle-sized environmental technology companies have been criticized for not co-operating and therefore employing a strategy that is not suitable for such an international type of business as environmental technology[37]. AEM is a good example of a joint venture, owned by Savon Teknia, an engineering company from the United States and Kuusakoski Engineering.

Flash smelting can also be used in hazardous waste treatment. In addition to hazardous waste, normal municipal solid waste can also be treated with the biological process developed by Outokumpu EcoEnergy. However, EcoEnergy has not recently been profitable, although the competence needed in hazardous waste treatment, flash smelting, should theoretically be one of the strengths of Outokumpu Group. May be EcoEnergy failed also in acquiring promising businesses that were not part of its core competences.Year 1992 EcoEnergy sold its non-profitable boiler business to the A.Ahlström Corporation[38] and seeks now to strengthen its environmental technology business with new partners.

---

[36]Energy Technology Today, SULA - project, 1993
[37]Tekniikka & Talous, Tuija Käyhkö, 7 / 1993 , pp. 12
[38]Outokumpu Annual Report 1992

7. COMPANY STRUCTURE, STRATEGY AND RIVALRY

7.1 Strategic Groups and Organizational Differences

Global mining and mineral companies can be divided into three different strategic groups in according to growth and diversification strategy[39]. 55% of companies in the industry are minerals-driven, 15% business opportunity driven and 30 % are technology driven like Outokumpu. The trend, which has developed from early 1970s minerals-driven to mid 1980s technology-driven and to late 1980s business-opportunity driven is now shifting back to the beginning. On average performance in the technology driven group can be described as only modest compared to the minerals driven group. Vertical integration is not always the best path to increased profitability. When considering vertical integration, the company should remember that it`s not only that the technology is suitable but also the industry structures should match. Often the way of doing business downstream is in striking contrast to upstream mining operations.

The more compatible the management practices and industry structure are, the more likely the industry is going to succeed. Finns can be categorized to a group that avoids uncertainties and power distance is small[40]. High-tec companies must react fast to changes in the market and then organization culture that is not so bureaucratic is an advantage. However, reasonable risks in R&D should also be taken if a high-tec company wants to succeed. In general Finns don`t value risk taking and that implicates that companies do well in mature businessess. But when there is no risk capital available, it´s more difficult to operate in relatively new businesses like metals technology.

7.2 Competitive Forces

When analyzing the competitive forces, the fact that every company in the metals production technology business is a subsidiary of a metal producer must be taken into account. That`s why it`s not possible to analyze the competitive forces of technology industry separated from metals production.

---

[39]Ala-Härkönen Martti, Corporate Growth and Diversification Paths within the Minerals Industry pp. 2 - 17
[40]Hofstede Geert, Organization Dynamics, A Division of American Management Associations, 1980

Another fact that has to be remembered is that there is almost no domestic demand in Finland and therefore all the competitive forces must be analyzed in the global context.

7.2.1 Threat of New Entrants

There are two main factors that limit the threat of new entrants. First, required investments for R&D are huge, especially when developing new processes. After laboratory tests a pilot process has to be constructed and that is extremely costly. Second, without own reference plant it is almost impossible to ascertain the customer of a new process. So threat of new entrants not operating in the metals production is small.

7.2.2 Industry Rivalry

Large number of competitors, high fixed costs and slow industry growth are typical charasteristics of industries with intense rivalry. Metals production industry is a good example of intense rivalry. Almost every country has its own steel production plant, profitable or not, needed invesments are high and business is mature[41]. Metal is a rather undifferentiated product where profits are typically low. These factors have lead base metals producers to concentrate on technology development.

When developing new technology, needed investments are usually high. Technology business is international and first mover advantages are valuable[42]. That is why new products and processes are right away lanced internationally. The intense rivalry in metals production industry implicates the rivalry in the technology business. Therefore the industry rivalry can be described fairly strong, at least stronger than in high-tec business in average.

7.2.3 Threat of Substitutes

Threat of substitutes doesn`t exist, because nothing can replace technology. There are only technologies that compete with each other.

---

[41]Interview Harri Gröhn and Jouko Peussa, Federation of Finnish Metal, Engineering and Electrotechnical Industries (FIMET), Helsinki Nov 4, 1993

[42]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18, 1993

7.2.4 Bargaining Power of Buyers

The buyers possess bargaining power because of several reasons. Especially, when selling process automation technology to steel industry or mineral processing and metal refining processes to non-ferrous metals industry, when there are only a few buyers[43]. In addition to that, buyers are competitors in metal production, they have full informaton on demand and there is a threat of integrating backwards. The only factor that reduces the bargaining power is the fact that processes are always tailormade for the special customer needs and therefore the customer is not likely to change the supplier without weighty arguments[44].

The bargaining power of customers is not so remarkable, when not offering processes but equipment like analyzers and detectors. The application area is considerably larger and therefore there are more customers.

7.2.5 Bargaining Power of Suppliers

Companies in the industry focus mainly on technological know-how and use a lot of subcontractors. Although suppliers, especially engineering workshops, are an important source of practical product development, they are rarely unreplaceable. An exception to the rule are small high-tec companies that have some kind of special expertise, that is vital for the product development[45]. For example Rautaruukki New Technology has five small high-tec suppliers: Noptel, Inoptics, Solitra, Fincitec and Idesco that have all specialized in different aspects of optoelectronics. Thus, in general the bargaining power of suppliers is relatively small.

---

[43]Based on Interviews with Jussi Asteljoki, Outokumpu Technology and Taisto Hannukainen, Rautaruukki Engineering

[44]Interview Professor Heikki Jalkanen, Helsinki University of Technology, Espoo Nov 5, 1993

[45]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18, 1993

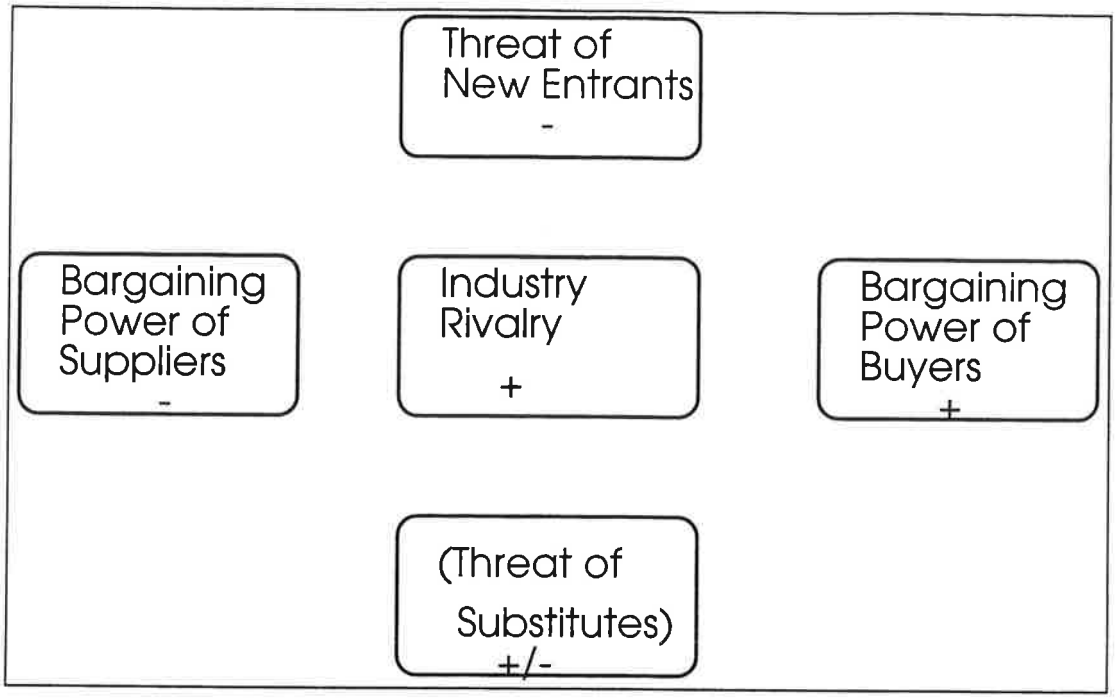


Figure 7 Competitive forces in metals production industry

8. EXTERNAL FACTORS

8.1. The Role of Government

The proper role of government is as a challenger and catalyst. Therefore the government should avoid intervening in factor and currency markets. For example devaluation, although it creates a short-term advantage to the exporting industry, is not the method for a sustainable competitive advantage.

One big problem between politicians and industry is the time perspective. Most policies that would make a real difference are for politicians too slow or carry with them the sting of short-term pain. It`s often easier to involve directly to the markets than concentrate on creating the right environment for the industry.

When well organized, co-operation between production and technology creates considerably synergy. There should be much more incentives for small and middlesized companies to carry on that sort of business. The lack of risk capital available in Finland is in general a bottle neck factor for innovative small high-tec companies, where risk capital is a crucial determinant of success[46]. Especially noticable this problem is in the metals production technology industry[47]. Although most of the companies in the industry are relatively small, they are all subsidiaries of a large metals production company and therefore are not entitled to same benefits as other small and middlesized companies in Finland.

Government quarantees are important in CIS trade. CIS is a very potential market area especially for process automation in steel industry, but after the end of clearing trade no deals have been made[48]. German and Italian companies have dominated the market, because of their access to better financing arrangements in the EC. Government securities could be described as direct involving and the competitive advantage they create is somehow unfair and not based on upgrading and innovativeness. Anyhow, if financing arragements are the block to success, because of an unfair competitive advantage of another nation, the government should take correct actions.

---

[46]Tekniikka & Talous, Jouko Kivistö, 11 / 1993, pp.7
[47]Interview Martti Karppinen, President of Rautaruukki New Technology, Oulu Nov 18, 1993
[48]Interview Taisto Hannukainen, President of Rautaruukki Engineering, Oulu Nov 18, 1993

8.2 International Operations

Porter emphasizes in his diamond model of national competitiveness, the importance of domestic rivalry. However, weaknesses in the diamond of a nation can be reduced by operating internationally. The importance of international operations is extremely vital in the metals production technology industry in Finland, because there is neither remarkable domestic rivalry nor demand.

Fortunately Finnish companies in the industry have understood the inevitability of operating internationally[49]. For example alone Outokumpu Mintec has got subsidiaries in Canada, U.S.A, Mexico, Peru, Chile, South Africa, Australia, CIS, Germany and France. With world-wide network company can be connected to diamonds of other nations and can utilize their strengths.

[49]Interview Professor Heikki Jalkanen, Helsinki University of Technology, Espoo Nov 5, 1993

9. CONCLUSION AND RECOMMENDATIONS

9.1 Base Production and Technology

The linkages between metals production and technology are unquestionable. Without a reference plant, it is almost impossible to ascertain the customer that your production technology is worth buying. In addition to that, it seems that intensive co-operation between base production and technology is the right method to make innovations. Huge innovations are made seldom, and the industry is rather characterized by continuous, incremental improvement. In any case metals producers have to upgrade processes continuously, if the company wants to keep up with the competition, so why not cover at least part of the R&D costs and sell also the technology. Other advantages of selling technology are quick, accurate information from markets and imagerial reasons.

It has to be emphasized that unless the operations in a large consolidation are well organized, overlapping operations are carried out in different subsidiaries. The Finnish companies could utilize even better the synergy between their subsidiaries. In the late 1980s companies acquired new businesses that did not actually match their core competences. Not only the technology but also the structure of the industry has to be suitable.

9.2 The Competitive Position of Metals Production Technology

In Finland, there has been a big difference in metals production technology innovation strategy, when comparing steel industry and non-ferrous metals industry. Rautaruukki has focused on developing engineering skills and process automation. Outokumpu has been both inventive and innovative. The most remarkable invention, copper flash smelting, was made in 1949. The invention of copper flash smelting created the ground for technology sales. When comparing the net sales of companies in the metals production technology industry in Finland, it is obvious that non-ferrous metals production technology is the most important of metals technologies. Outokumpu alone, accounts for 90% (1,7 mrd Fim) of total metals technology sales in Finland.

In steel production technology, the most promising business opportunities seem to be rather in process controlling equipment than in process automation.

Certain measurement problems in steel making processes, for example surface inspection, have been solved in a unique way in Finland. Rautaruukki New Technology is a rather new company and only a couple of its products have been lanced yet, but its internationally competitive products, wide R&D network, intensive co-operation with production and wise outsourcing strategy should yield profit in the future.

Secondary metals production technology, which is sold by Kuusakoski Engineering, is especially competitive in separating difficult metal compounds. Secondary metals production will to some extent increase in the future and the competitive position of Kuusakoski should be fairly good.

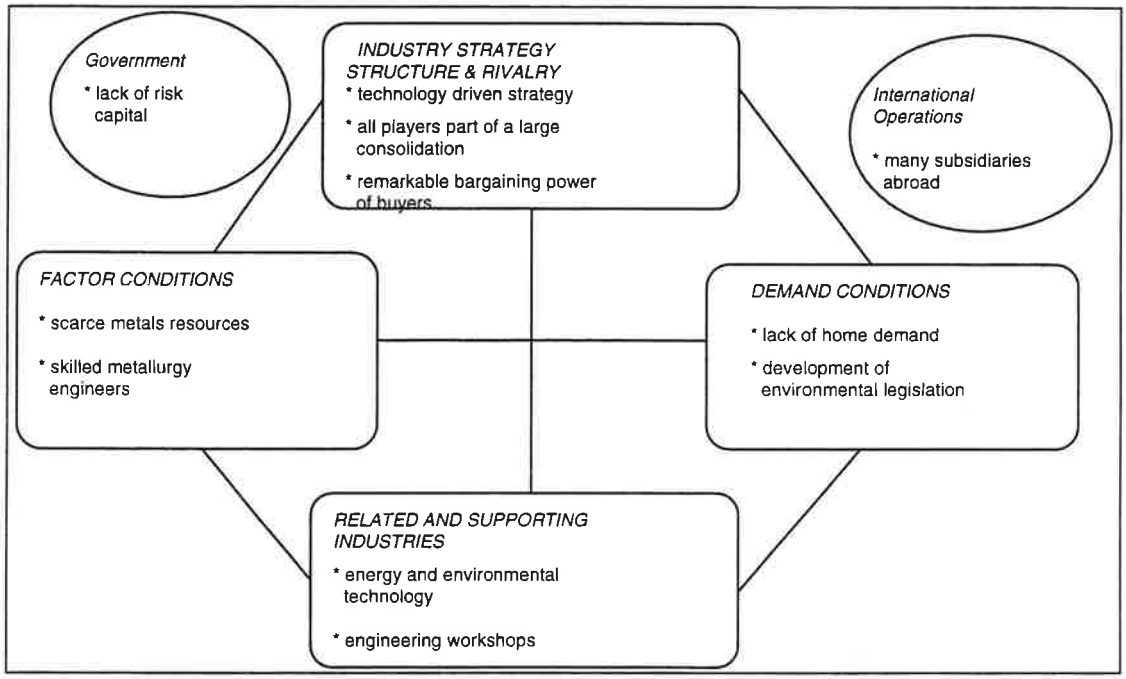


Figure 8 Important factors in the Finnish metals production technology diamond model

Research and development in companies selling metals production technology is characterized by intensive co-operation with base production. Process technology has always to be tailored for the special customer needs and that is why customer feedback is a vital source for upgrading. Engineering workshops are important for practical product development, because deliveries are often made in turn-key solution principle and assembling is then also included. The other fact is that , when almost 90% of the technology is exported, the danger of losing the market touch must be taken into

consideration. Engineering workshops provide accurate information from the markets.

9.3 Environmental Effects and Energy Consumption - Two Key Factors

The greatest opportunity for the Finnish companies lies in concentrating on solving the constantly growing environmental and energy problems. The tightening environmental legislation and energy taxation will be the two key factors in the near future. Process development is focusing more and more to energy saving and direct utilization of energy. It will be a very important task to eliminate harmful by-products and still reduce emissions. How fast this trend towards more ecologically beneficial metals production technology is, depends a lot on the rapidity of the development of legislation. The sulphur recovery of the Outokumpu`s new copper flash converting process is as much as 99,9% so it certainly meets the strictest environmental regulations. Anyhow, required investments are huge when changing over to a new production technology and metals producers often defer the decision until the environmental regulations force them to invest.

List of References

Ala-Härkönen Martti, *Corporate Growth and Diversification Paths within the Minerals Industry*, Helsinki 1993

Ala-Härkönen Martti, *Technological Innovation and Competitiveness in the Mining Industry*, Centre for Resource Studies Queen`s University Kingston Ontario, 1993

Energy Technology Today, Heinonen Jarmo, Neste Öljy, 1993

Energy Technology Today, the Finnish Ministry of Trade and Industry, SULA-project, 1993

Future of the Finnish Mining Industry, Mannerkoski Markku, presentation March 19, 1993

Hofsteede Geert, *Organization Dynamics*, A Division of American Management Associations, 1980

Kuusakoski Annual Report 1992

Materials and Society, Holappa Lauri, Jalkanen Heikki, Outlines of Development of Metals Production and Metallurgical Processes to the next Century, Vol. 15, No. 4

Outokummun Sanomat, Kaivostoiminta supistuu Pohjoismaissa, No.3 1992

Outokummun Sanomat, Outokummulta maailman puhtain kuparisulatto Kennecotille, No. 3 1992

Outokumpu Annual Reports 1988 - 1992

Pavitt K., Robson M., Townsend J., Technological Accumulation, Diversification and Organization in UK companies 1945 - 1983, *Management Science*, Vol. 35, 1, Jan 1989

Rautaruukki Annual Reports 1988 - 1992

Raumolin Jussi, *Restructuring and Internationalization of the Forest, Mining and Related Engineering Industries in Finland*, The Research Institute of the Finnish Economy (ETLA) Helsinki 1988

Tekniikka & Talous, Käyhkö Tuija, Ympäristöyritysten yhteistyö takeltelee, No. 7 1993

Tekniikka & Talous, Kivistö Jouko, Riskiraha ratkaisevaa kansainvälistymiselle, No. 11 1993

Tekniikka & Talous, Kinnunen Lauri, Outokumpu odottaa sinkkiprosessistaan miljardimenestystä, No. 29 1993

Tekniikka & Talous, Pehkonen Kari, Teollisuuden energiaverotus kiristymässä 70%, No.35 1993

Tekniikka & Talous, Ekholm Riitta, Ympäristömarkkinat kaksinkertaistuvat muutamassa vuodessa, No. 40 1993

List of Interviews

Ala-Härkönen Martti, Outokumpu Metals and Resources, Espoo Dec 9, 1993

Asteljoki Jussi, Technology Director of Outokumpu Technology, Espoo Nov 29, 1993

Hannukainen Taisto , President of Rautaruukki Engineering, Oulu Nov 18, 1993

Professor Lauri Holappa, Helsinki University of Technology, Espoo Nov 4, 1993

Professor Heikki Jalkanen, Helsinki University of Technology, Espoo Nov 5, 1993

Karppinen Martti, President of Rautaruukki New Technology, Oulu Nov 18, 1993

Miettinen Timo, President of Kuusakoski Engineering, Espoo Nov 29, 1993

Peussa Jouko and Gröhn Harri, Federation of Finnish Metal, Engineering and Electrotechnical Industries (FIMET), Helsinki Nov 4 , 1993

List of Figures and Tables

ELINKEINOELÄMÄN TUTKIMUSLAITOS (ETLA)
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, SF-00120 HELSINKI

Puh./Tel. (90) 609 900 Telefax (90) 601 753
Int. 358-0-609 900 Int. 358-0-601 753

KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

No 453 KARI ALHO, An Assessment of the Economic Consequences of EC Enlargement: The Case of Finland. 03.11.1993. 26 p.

No 454 PAULA HIETA, Energiatoimialan kehitys Suomessa. 23.11.1993. 31 s.

No 455 JARI HYVÄRINEN, Alueellinen kilpailukyky Suomen itäisellä rannikkoseudulla, Pietarissa ja Virossa. 03.12.1993. 105 s.

No 456 MARKUS TAMMINEN, Sähkön siirron ja jakelun tekniikka. 15.12.1993. 37 s.

No 457 MIKA WIDGRÉN, Voting Power and Decision Making Control in the Council of Ministers Before and After the Enlargement of the EC. 16.12.1993. 38 p.

No 458 JUSSI RAUMOLIN, Ahlström: Shift from Forest Products Company to Environmental Technology. 27.12.1993. 15 p.

No 459 MARIA KALOINEN, Suomen kilpailuetu Venäjän transitoliikenteessä. 27.12.1993. 62 s.

No 460 PER HEUM - PEKKA YLÄ-ANTTILA, The Internationalization of Industrial Firms - Foreign Production and Domestic Welfare in Finland, Norway and Sweden. 28.12.1993. 18 p.

No 461 JUKKA LASSILA, Tax Policies under Central and Local Wage Bargaining. 31.12.1993. 18 p.

No 462 RISTO PENTTINEN, Summary of the Critique on Porter's Diamond Model. Porter's Diamond Model Modified to Suit the Finnish Paper and Board Machine Industry. 11.01.1994. 82 s.

No 463 JUHA KETTUNEN, Suomen teollisuuden palkkarakenteen muutos 1980-luvulla. 14.01.1994. 17 s.

No 464 SEPPO SAUKKONEN, Työn hinta, Elintarviketeollisuuden työvoimakustannukset 1992-1994. 27.01.1994. 53 s.

No 465 SEPPO SAUKKONEN, Työn hinta, Tekstiili- ja vaatetusteollisuuden työvoimakustannukset 1992-1994. 27.01.1994. 45 s.

No 466 SEPPO SAUKKONEN, Työn hinta, Metsäteollisuuden työvoimakustannukset 1992-1994. 27.01.1994. 53 s.

No 467 SEPPO SAUKKONEN, Työn hinta, Graafisen teollisuuden työvoimakustannukset 1992-1994. 27.01.1994. 42 s.

No 468 SEPPO SAUKKONEN, Työn hinta, Kemian- ja rakennusaineteollisuuden työvoimakustannukset 1992-1994. 27.01.1994. 51 s.

No 469 SEPPO SAUKKONEN, Työn hinta, Metalliteollisuuden työvoimakustannukset 1992-1994. 27.01.1994. 53 s.

No 470 SEPPO SAUKKONEN, Työn hinta, Talonrakennusalan työvoimakustannukset 1992-1994. 27.01.1994. 40 s.

No 471 JUHAPEKKA SUUTARINEN, Työn hinta, Tukkukaupan työvoimakustannukset 1992-1994. 27.01.1994. 45 s.

No 472 JUHAPEKKA SUUTARINEN, Työn hinta, Vähittäiskaupan työvoimakustannukset 1992-1994. 27.01.1994. 45 s.

No 473 JUHAPEKKA SUUTARINEN, Työn hinta, Autoalan työvoimakustannukset 1992-1994. 27.01.1994. 46 s.

No 474 JUHAPEKKA SUUTARINEN, Työn hinta, Majoitus- ja ravitsemisalan työvoimakustannukset 1992-1994. 27.01.1994. 44 s.

No 475 SONJA SAASTAMOINEN, Kotimaisen sähkömoottoriteollisuuden kilpailukyky. 26.01.1994. 42 s.

No 476 PASI AHDE, ETLAn ennustejärjestelmän panos-tuotoskehikko. 31.01.1994. 60 s.

No 477 SYNNÖVE VUORI, Yritysten ja toimialojen väliset teknologiakytkennät Suomen teollisuudessa. 31.01.1994. 41 s.

No 478 OLLI TAHVONEN, CO_2 Taxation and Dynamics of Fossil Fuel Prices. 31.01.1994. 31 p.

No 479 TEPPO I. KYHERÖINEN, Teletoiminnan kansallinen kilpailukyky. 04.02.1994. 91 s.

No 480 KATI KORHONEN, Advantage Finland - Metals Production Technology. 15.02.1994. 34 p.

No 481 PASI KUOKKANEN, Energian tuotannon koneet ja laitteet. 15.02.1994. 46 s.

Elinkeinoelämän Tutkimuslaitoksen julkaisemat "Keskusteluaiheet" ovat raportteja alustavista tutkimustuloksista ja väliraportteja tekeillä olevista tutkimuksista. Tässä sarjassa julkaistuja monisteita on rajoitetusti saatavissa ETLAn kirjastosta tai ao. tutkijalta.
Papers in this series are reports on preliminary research results and on studies in progress; they can be obtained, on request, by the author's permission.

E:\sekal\DPjulk.chp/15.02.1994