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POSSIBILITIES FOR A SMALL COUNTRY
IN HIGH TECHNOLOGY PRODUCTION -
THE ELECTRONICS INDUSTRY IN FINLAND

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June 1988
CP-88-3

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FOREWORD

The technological capabilities of advanced production automation, such as FMS and CIM, are highly dependent on the possibilities created by electronics and software engineering. On the other hand, industrial applications are generally believed to create new business as well as innovation possibilities for the electronics industry. Especially industrial applications seem to have segmented markets and to offer possibilities to customized products. This is generally believed to be an opportunity for a small company and for a small country to compete in the field of high technology.

The paper prepared by Raimo Lovio and Tarmo Lemola describes the development of the Finnish electronics industry as well as its innovation activities and innovation management. The paper also clearly points out the special problems of a small country competing in the field of high technology. One of the essential conclusions is that it is extremely important to ensure good contacts between final users and producers, when a specialized product is going to be developed. This has been one of the success factors of the Finnish industrial electronics sector. This is also important conclusion with regard to the capabilities of different countries to produce CIM-technologies.

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Possibilities for a small country in high-technology production - the electronics industry in Finland*

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* Paper presented at the IKE-workshop on "Technological Change and the Competitiveness of Small Countries", August 18 - 21, 1987, Aalborg, Denmark. Paper is a backgroundreport for the Finnish national TES-program, especially for the subproject on "Production of flexible manufacturing technologies in Finland".



1. Introduction

The present paper is based on the results of the STIU project which was carried out in the Planning and Marketing Office of the Technical Research Centre of Finland in 1984 - 87. The purpose of the project was to investigate innovative activity and innovation potential within the Finnish electronics industry.

Briefly, we have been interested in how this new high-technology industry is developing in a small (and semi-peripheral) industrialized country such as Finland. We have examined the Finnish electronics industry, and specifically its innovative activity, at three levels: the sector level, the business firm level and the innovation level. At the "innovation level" we have made case studies of 20 important innovations created by the Finnish electronics industry. We shall refer to some of these cases in our paper.

In the present paper we endeavour to interpret the results of our investigation by taking as our starting point the discussion regarding the special problems of small industrialized countries in the sector of high-technology production (results of the project are also presented in Lovio 1986, Lemola & Lovio 1987, and Lovio 1987).

2. Special features of Finland as a small Western European country

In general, small countries have little in common but the fact that they are different. Therefore we should first describe briefly what kind of a small country Finland is.

First, Finland is one of the youngest industrialized

countries of Western Europe. Industrialization in Finland began relatively late, and it was not until the early 1960s that the share of industry in the Finnish GDP exceeded that of agriculture and forestry. The growth rate of industry has, however, been quite rapid in the past 30 years.

The forest industry was Finland's most important industrial sector up to the late 1970s. No other country in the world obtains as large a proportion of its foreign-currency income from forest industry products as does Finland. In 1986, 37 % of Finnish exports consisted of exports of the forest industry, and about one-half of the country's net foreign-currency income was derived from this sector. However, in Finland the importance of the forest industry has continuously decreased, and the metal and mechanical engineering industries have grown to be an equally important sector alongside it. The metal industry has in the main been heavy industry. The research-intensive fields of chemical and electrical engineering industries have had very little significance in Finland.

Trade with the Soviet Union and other CMEA countries has been important for Finnish industry. In the 1980s, 20-25 % of the Finnish foreign trade has been with the European CMEA countries. This trade has been quite advantageous for Finland, since Finland exports to these countries primarily machinery, equipment and other processed products, and imports energy and raw materials (mainly oil).

At present the technological and economic potential of Finland is comparable among the OECD countries mainly with those of Norway, Denmark and Austria (perhaps also Belgium), as can be noted from the figures in Table 1. Finland clearly does not belong to the group of the most developed small Western European countries (Switzerland, Sweden and Holland) but also not to the group of the least developed countries (Greece, Portugal and Ireland).

Table 1. Indicators describing the size and the technological development level of the economies of Finland, Norway, Denmark, and Austria.

	Finland	Norway	Denmark	Austria
Population, thousands	4.9	4.1	5.1	7.6
GDP, billion USD 1986	70.5	68.7	80.4	94.0
Exports (goods only), million USD (total fob)	13.6	19.9	17.0	17.2
Industry's share of the labour force, %	31.9	27.8	28.1	38.1
GERD % of GDP	1.5	1.5	1.3	1.3
Share of high tech in the country's export 1983	5.2	8.4	9.1	11.1
Patents granted in the U.S./ million inhabitants 1982-84, on average	28	18	26	33
Unemployment rate	6.2	2.5	7.3	3.6

Sources: The OECD Observer April/May 1987, and Lemola & Lovio 1986.

In the 1980s the economic development has been relatively favourable in Finland as compared with the other OECD countries (cf. Mjoset (ed.) 1986, Ylä-Anttila 1987). In 1980 - 85 the mean growth rate of industrial production was in Finland 3.9 % a year, whereas in the EEC countries it was 0.5 % and in the whole OECD area 1.7 %. However, recently the growth rate of Finnish industry has no longer exceeded the mean for the OECD countries (Teollisuus- poliittinen katsaus 1987). Also, the unemployment rate has remained relatively high (5-7 percent) as compared with the unemployment rates in countries such as Sweden, Norway and Austria.

It should also be pointed out that the so far relatively favourable development does not mean that Finnish industry does not continue to have structural problems, even serious structural problems. Since in many respects the development in Finland is lagging behind that in most older industrialized countries, problems of maturation are to be

expected later. The coalition government formed by the Conservatives and the Social Democrats in spring 1987 has indeed adopted "controlled structural change" (which means in practice positive adjustment policy recommend by OECD) as its principal slogan.

3. General characteristics of the development of the Finnish electronics industry

In Finland the electronics industry did not begin to develop on a larger scale until the mid-1960s. At present the sector employs about 25,000 people, which is about 4 % of the total industrial labour force. The electronics industry has a 5 % share of the total exports of Finland.

Quantitatively the success of the electronics industry in Finland has been quite similar to that in Norway, Denmark and Austria, as can be seen from Table 2.

Table 2. The production, export, import and market of the electronics industry in Finland, Norway, Denmark and Austria in 1985, in \$ M.

	Finland	Norway	Denmark	Austria
Production	959	812	1083	1166
Export	581	363	930	1000
Import	1119	1417	1324	1539
Market	1497	1866	1477	1705
Prod. % of GDP	1.8	1.4	1.9	1.8
E/I	0.52	0.26	0.70	0.65
E/P	0.61	0.44	0.86	0.86
I/M	0.75	0.76	0.90	0.90

Source: "Mackintosh" Yearbook, Electronics Data 1987.

A calculation of the value of production in proportion to the GDP shows that the importance of the electronics industry is almost the same in Finland, Denmark and Austria (1.8 - 1.9 %), whereas in Norway it is somewhat lower (1.4 %).

Finland's share of the production of the Western European electronics industry has been less than one percent, but the share has been slowly increasing within the past ten years. According to the data in the "Mackintosh" Yearbook, Finland's share of the Western European electronics production was 0.77 % in 1979, but as high as 1.10 % in 1985.

In the internationalization development the electronics industry of Finland (as also that of Norway) is clearly lagging behind the electronics industries of Denmark and Austria. The share of export in the production of the electronics industry in Finland in 1985 was 61 %, whereas in Denmark and Austria it was 86 %. The share of imports in the domestic consumption of electronic products in Finland was 75 %, whereas in Denmark and Austria it was as high as 90 %.

One-third of the exports of the Finnish electronics industry is to the other Nordic countries and 16 % to the Soviet Union. Thus the total share of the nearby markets (or extended "home" markets) in exports is one-half. Previously the share of these nearby markets was even greater. The next most important target countries for export from Finland are Great Britain, the Federal Republic of Germany, and the U.S.A. The most important countries of import into Finland are Japan, the United States and the Federal Republic of Germany. The Finnish balance of trade of electronics products in 1984 was clearly positive only as regards the Soviet Union but, interestingly enough, slightly positive also as regards Sweden, Denmark and Norway (Hienonen et al. 1985).

The breakdown of the electronics industry into product groups (Table 3) is in Finland relatively similar to that in other small Western European countries. The least developed fields are the manufacture of semiconductor components and that of computers and office machines. The manufacture of telecommunications equipment and that of

industrial and medical electronics are relatively the most strongly developed fields. The relatively high share of consumer electronics can be regarded as a special characteristic of the Finnish electronics industry.

Table 3. Product breakdown and export/import ratios of the Finnish electronics industry in 1984.

Product group	Percentage of production	Export/Import
Telecommunications equipment	27.8	1.3
Industrial electronics	21.8	1.0
Consumer electronics	20.9	0.7
Electronic components	10.7	0.2
Medical electronics	10.0	3.7
Computers and office machines	8.8	0.1
Total	100.0	0.5

Source: Hienonen et al. 1985.

In Finland, the manufacture of telecommunications equipment has in recent years been the largest field, and in this field the balance of trade has in general been slightly positive. As late as the 1960s the most important manufacturers in this field were the Finnish subsidiaries of multinational firms (LM Ericsson, Siemens and ITT). At present the most important manufacturer in the field is the Finnish Oy Nokia Ab with its subsidiaries (data modems, Nokia-Mobira automobile telephones, Telenokia digital telephone switchboards, etc.).

The second most important product group in Finland is, perhaps somewhat surprisingly, consumer electronics - surprising especially if we take into consideration that there is no longer any subsidiary of a foreign company in this field in Finland (Philips gave up production in Finland in 1981). What is in question is mainly the manufacture of colour television sets. There are two domestic manufacturers in this field. The larger of these two is

Salora Oy, which, together with Luxor Ab (acquired from Sweden) and Oceanic S.A. (acquired from France), belongs to Oy Nokia Ab. The Salora-Luxor-Oceanic Group is at present the third largest manufacturer of colour television sets in Western Europe after Philips and Thomson. Owing to the success in the export of television sets, the Finnish trade balance in consumer electronics was in 1986 for the first time slightly positive.

Industrial electronics is the third most important field. The take-off of its development was in the mid-1960s along with the automation of the Finnish process industries. The strongest area in industrial electronics is automation systems for the forest industry. In this area Finnish companies perhaps have a leading position in the whole world. The largest company in this area is Valmet Oy, a state-owned company which is at present also the world's largest manufacturer of paper-making machines.

The only field of electronics production in Finland having a clearly positive balance of trade is the manufacture of medical electronics. Its importance is not as high in Finland as it is in, for example, Denmark, but its importance has been increasing rapidly. At present there are three important medium-sized companies operating in medical electronics in Finland (Instrumentarium Oy, Labsystems Oy and Wallac Oy).

Finland's balance of trade in computers and office machines has always been clearly negative, and domestic manufacture has until very recently been insignificant. However, in the mid-1970s Oy Nokia Ab began to manufacture computers (workstations), mainly for bank automation applications, and later, in 1981, also microcomputers for general applications. At present, Oy Nokia Ab is the largest manufacturer of microcomputers in the Nordic countries, and its size as a manufacturer of computers is almost comparable to that of Norwegian Norsk Data Ab.

In the field of components the Finnish trade balance has also always been clearly negative. Integrated circuits (so-called custom circuits) are manufactured in Finland on a small scale by two companies (Vaisala Oy and Micronas Oy). On the other hand, the manufacture of passive components is more extensive.

Dependence on foreign components has been perhaps the greatest item of concern in the development of the Finnish electronics industry. In some products the share of foreign components in the final value of the product is very high, a circumstance which reduces the possibilities for making profit. In the boom years of the semiconductor industry there have been difficulties in obtaining certain components. The question to what extent the best components are in general available for sale on the free markets is under continuous assessment.

Another item of continuous concern has been profitability in the electronics sector. Although there are no detailed studies on the matter, it is the general conception that, with a few exceptions, profitability in the sector has been relatively low; in many firms the sector has long operated at a loss. The Finnish companies operating in the electronics industry have therefore in general made greater inputs into growth and into the attaining of the critical size than into short-term improvement of profitability. "Our first goal is to survive," T.A. Koski, Director of Nokia Electronics, stated in 1985 (International Management, November 1985, p. 39). Electronics products are seen as spearhead products the development of which is indispensable for the restructuring and profitability of the Finnish industry as a whole.

4. Strategies for technological development

The Finnish electronics industry has, naturally, encountered

all the problems associated with the endeavours of a small country to develop high-technology production (limited R&D resources, a small domestic market, lack of experience in high technology, etc.). Rob van Tulder (1987) has quoted a sarcastic summing up by the managing director of Nokia-Mobira, the present-day star firm of the Finnish electronics industry, regarding these difficulties: "When an inventor in Silicon Valley opens his garage door to show his latest idea, he has 50 % of the world market in front of him. When an inventor in Finland lifts his garage door, he faces 3 ft. of snow!"

The Finnish electronics industry has nevertheless developed in spite of these difficulties. We have therefore reason to ask what the secret of the success of the Finnish electronics industry has been or, if we cannot speak of success, in any case of its development. What is the development strategy that it has followed? Below, we shall endeavour to give to these basic questions a few indicative answers which serve at the same time as hypotheses.

We distinguish four development strategies, or rather four perspectives into the development of the Finnish electronics industry (cf. Walsh 1986). They do not exclude one another. We have termed these strategies as follows: "inward investment by foreign multinational enterprises (MNEs)", "finding niches in the market", "exploitation of the technological gap and of the advantageous position of the follower", and "leaning on national production systems".

4.1. Inward investment by foreign MNEs

LM Ericsson, Siemens and ITT established in Finland subsidiaries engaging in production even before the Second World War. In addition, Philips established a consumer electronics factory in Finland in the 1960s (however, the factory was closed in 1981). At the early stage, foreign

firms thus played quite a considerable role in the Finnish electronics industry. These firms manufactured products mainly for the Finnish market (and to some extent also the Soviet market), and therefore their significance has proportionately decreased after the starting up of Finland's own electronics industry.

In addition, certain originally domestic firms have been sold to foreign companies. The clearly largest corporate acquisition occurred in 1986, when the Swedish company ASEA Ab purchased Strömberg Oy, which is the third largest Finnish firm in the electronics sector.

In total, the share of foreign-owned firms engaging in the manufacture of electronics products was in 1986 about 16 % of the labour force of the Finnish electronics industry; this share is not very high. The development of the Finnish electronics industry has thus clearly not leaned on inward investment by foreign MNEs. In this respect Finland differs from, for example, Ireland.

4.2. Finding niches in the market

One strategy for small countries is to look in the market for particular "niches" in which the large firms and even large-country small firms do not bother to compete, or are too inflexible to compete. The niche strategy has been widely recommended also in technology and industrial policy discussions in Finland in recent years.

The niche strategy has also been put into practice, even though the Finnish electronics industry is not as specialized in international terms as are, for example, the electronics industries of Denmark and Austria. Especially in industrial and medical electronics, Finnish firms have looked for relatively narrow market niches. Finnish companies have applied modern electronics to fields

in which the firms of other countries have not had experience, or have not had interest because of the small size of the markets (for example, automation systems and instruments for the forest industry, meteorological measuring instruments, and automatic analyzers for laboratories). Finnish firms have been successful in these fields, because for them the selected fields have been those of their primary business, whereas for most of their large international competitors the fields have been only small fields on the side.

However, following the niche strategy is not without problems. First, there is the risk that they form in the country separate enclaves of electronics production which do not back up each other's development. A second problem is very great dependence on the development of foreign markets (in several firms following the niche strategy the share of exports at present exceeds 95 % of the turnover). A third problem is the relative increase of marketing costs when products are exported to dozens of countries while the total export volumes nevertheless remain rather low.

There is also conceptual unclarity regarding the niche strategy. When we were making the survey of successful innovations in the Finnish electronics industry, the company directors interviewed almost always referred to the niche strategy, but their definitions of "niche" were very diverse. First, what seemed to be involved was the selection of some narrow area of application (for example, low magnetic field radiographic equipment). Second, it was specialization in high-quality products ("what we manufacture is a real Mercedes compared to what most of our competitors are manufacturing"), in which case the decisive competitive factor was not the price but the quality of the product. Third, it was flexible manufacture of products in accordance with customer needs ("custom-tailoring of products"). And fourth, it was orientation

specifically towards certain selected target countries for export (for example, the Nordic countries and the Soviet Union at the initial stage).

By defining the niche strategy thus diversely, even the Finnish manufacturers of colour television sets were able to say that they were to some extent following the niche strategy. Although at present the color television set is in general a mass-produced item and the price is the crucial competitive factor, Finnish manufacturers endeavour to reinforce their positions by specializing in large-sized colour television sets with distinctive new technical properties and design and with a wide selection of styles, in which case the possibilities for successful competition with the Japanese manufacturers are moderate, especially in the markets of the Nordic countries and the EEC countries.

The above example shows that the concept of the niche strategy is not without problems. The "niche" can be selected in very many ways, and on the other hand a company always endeavours to distinguish itself from its competitors somehow by specializing. It could even be said that for the electronics companies of a small country the following of the niche strategy is self-evident, a triviality which does not yet reveal anything about the essential questions, namely in what and how the company should specialize.

We have therefore concluded that in the analysis of the success factors of the Finnish electronics industry the following of the niche strategy is the point of departure for the analysis rather than its final result.

4.3. Exploitation of the advantageous position of the follower and of technological breakthroughs

The basic electronics technology has almost entirely been

imported to Finland from abroad. The Finnish electronics industry has also in general been a follower. Therefore there is reason to ask whether the relative success of the Finnish electronics industry can be explained by the advantageous position of the follower, i.e. the so-called "catching up" phenomenon. Has the Finnish electronics industry been able to save in research expenditure and reduce risks by importing "ready-made" technology from abroad? Is the production machinery of the Finnish electronics industry younger and at the same time more efficient than that in the countries with older electronics industries? Do Finnish companies produce electronics products which are more modern because the companies have not committed themselves to the manufacture of previous generations of equipment?

At the general level we would be ready to answer these questions affirmatively. However, it is necessary to specify a few points in order to give a correct picture.

First, the electronics technology was transferred to Finland mainly through diffusion, in which the import of components and above all national research and training played a crucial role, and not through direct technology transfer (licencing agreements, etc.). The number of licencing agreements has been small and their importance has, furthermore, continuously decreased, since Finnish companies have endeavoured to replace the technology which was initially obtained through licencing agreements with technology they have themselves developed.

In our opinion it is important to recognize the fact that in Finland research and training in electronics in universities, public research institutes and companies has in the main had the character of technology transfer, namely follow-up of the progressing of the technological frontier of the basic electronics technology, and its adoption and mediation to serve as a basis for technological

development in companies. The so-called national research projects in electronics, financed from public funds, have also basically had the nature of collective technology transfer projects.

Second, although with respect to the basic technology the Finnish electronics industry is a follower, this does not imply that the success of the Finnish electronics industry is at present based on the copying of foreign products and on producing them at low cost. Previously in the first stage electronics products were manufactured for the domestic market by copying solutions developed for problems abroad, but the current successful products which are being exported from Finland to the markets of the OECD countries are more and more based on technology applications developed by the Finnish companies themselves.

With respect to its most successful products, the Finnish electronics industry is in fact not a follower but a forerunner. Since Finland has had a relatively small amount of old electronics industry, Finland has perhaps been in a good position to (and indeed it has had to) apply rapidly to new areas the breakthroughs which have taken place in the basic technology of electronics. For example, Valmet Oy was the second company in the world to introduce to the market a microprocessor-based automation system (Damatic) applicable to the forest industry. Nokia-Mobira Oy was the first in the world to introduce a portable automobile telephone (Mobira Talkman) which was in compliance with the standard adopted in the Nordic countries. Vaisala Oy was the first in the world to introduce for use in meteorological measurements a sonde utilizing microelectronics and thin film technology (Humicap). Teleste Oy was one of the first companies in Europe to embark upon manufacturing cable television equipment based on digital technology.

Exploitation of the technological gap and of the

advantageous position of the follower does not thus in the case of the Finnish electronics industry mean that it is catching up forcefully (with a large production volume and at a lower cost) in the markets created by companies of other countries, but that the basic technology created in other countries is being applied rapidly by Finnish companies in their own strong fields. Thus the companies are in fact capable of remaining in the technological frontier in certain selected areas. In the basic technology, companies can afford to be lagging behind even by a couple of years as long as they are quick enough in applying the technology to their own areas. In terms of rapid application the relatively small size of the Finnish companies may be an advantage.

Success in this catching up does, however, presuppose that developments in the basic technology can be anticipated correctly with sufficient precision. Therefore the representatives of many companies emphasized in the interviews of our survey that an essential factor of success was close and confidential relations with the most important foreign component manufacturers. For a small Finnish company the creating of such a relationship requires many years of active work and sufficient technological knowhow of its own, since important information can in general be obtained only through exchange of information. The manufacturers of components do usually not tell a small Finnish company about their plans if they do not get some useful information in return.

4.4. Leaning on national production and innovation systems

The above explanation models are not capable of explaining the specialization structure of the Finnish electronics industry, namely, how it has been successful in those very product groups in which it has been successful. In this connection we have seen as the most fruitful explanation

model the concept of national production and innovation systems and the so-called development network thinking, to which it is possible to link many matters known from innovation research (cf. Andersen et al. 1981, Mistral 1983, Lundvall 1985).

First, in the development of the Finnish electronics industry we can observe clear specialization in product groups in the development of which it has been possible to make use of the cumulative experience obtained in previous production. It is not by chance that Finland, being a traditional country of forest industry, is one of the leading countries also in the electronics applicable to the forest industry. Or that Outokumpu Oy, an old copper company, is a notable company in the automation of mining and of metallurgical processes. Or that Kone Oy, the world's second largest elevator and lift manufacturer, is one of the leading companies also in elevator and lift electronics. Or that Strömberg Oy, an important manufacturer of cage induction motors, was the first in the world to develop an electronic frequency transformer for controlling the speed of such motors.

It is also in the very sectors in which Finland has previously had traditions that it has been relatively easy to create fruitful interaction between the researcher, the producer and the user of new technology. In several of the cases we have investigated there was in the background of innovation fruitful co-operation between the research institutes (universities or Technical Research Centre of Finland), the future producer and some national pilot customer. We call this co-operation between three parties the "innovation triangle".

In the greater part of the successful Finnish industrial electronics the situation has been that there has been in Finland exactly in that field a knowledgeable customer who has known why and what has to be measured and controlled

in a production process. In medical electronics the electronics companies have had close contacts with medical research and with the construction of new hospitals. Telenokia Oy, which is Oy Nokia Ab's subsidiary currently manufacturing digital telephone switchboards, was at the start-up stage of the switchboard development project the manufacturing unit of the Finnish National Board of Post and Telecommunications. The basis for the development of Nokia Oy's first computer-models was the exceptional interest that Finnish banks had in real-time funds transfer systems, precipitated by the character of the Finnish banking system. The second model of the Nokia computer, a workstation to the funds transfer information system, was actually commissioned by Kansallis-Osake-Pankki and the banks are still the largest buyers of Nokia's microcomputers.

Often the product groups selected as fields of specialization have thus been those in which the small Finnish domestic market has been relatively the largest, and/or in which there has for some other reason been high-level research and/or in which there have been innovative users of new technology.

This explanation model is, however, rather poorly applicable to the manufacture of colour television sets. This field is a rather detached enclave in the production structure of Finnish industry. Within the past ten years the manufacture of television components has, however, expanded rapidly. Only certain integrated circuits and picture tubes are still being imported. Salora Oy currently manufactures also the microcomputer monitors for Nokia and IBM. The television manufacturers regard this knowhow in component manufacture as one of their important competitive factors.

There are even other factors in the success of television set manufacture. First we have to remember the relatively

low wage level in Finland compared with the Central European countries. Another important factor is the fact that for Salora Oy and Lohja Oy colour television sets were the only products during the years of crisis in the 1970's. The only possibility for the banks financing the companies to avoid bankruptcy resulting in large financial and social losses was to continue the input in the development of the products and production of the companies. The fast change in television technique in the 1980's has certainly also aided the Finnish television set manufacturers. Television sets have actually gone through a relatively radical change in the 1980's along with the application of microelectronics (remote controls, digital channel selection, video connections, cable television and satellite broadcasts) and the development will continue in the near future (digital image processing, flat screen). Along with the changing product the production processes have also had to be changed. During such changes the small technically advanced manufacturers have had their chance alongside the large manufacturers.

The extensive manufacture of colour television sets in Finland is a good example of the fact that the explanation of the development and of the successful products of the Finnish electronics industry cannot be forced into one narrow explanation model. Although specialization leaning on old national production systems and on rapid application of breakthroughs in the basic technology serves relatively well as a general explanation model of past development, room must also be left for subjective factors and for the exploitation of exceptional historical situations.

5. Small companies of a small country and the problem of attaining the critical size

The problems of small countries are multiplied at the business firm level: in a small country the firms are also

on the average small.

The importance of attaining the critical size has been described by Professor Hans Andersin, former director of the Automation Group of Valmet Oy, Finland's largest industrial electronics company: "When in 1978 I became the head of the Automation Group, we set a turnover of one milliard Finnish marks as the target for the second half of the 1980s. The target will be reached this year. Now we have realized that the turnover should be one milliard dollars, i.e. five-fold; only then will we be internationally large enough as a supplier of process automation" (Helsingin Sanomat April 23, 1985). "We have considered and still consider it important that we can expand abroad, and in the reaching of this objective the maximization of profitability is a secondary factor. The problem continues to be that our competitors are many times larger than we are, although in this field there is no firm like IBM" (Insinööriutiset November 25, 1985).

In Finland there are at present about 200 firms operating in the electronics industry, and most of them are small firms of 5 - 30 employees. There are in the sector about 30 - 40 companies with more than 100 employees. Table 4 lists the 10 largest companies in the sector, as measured by the number of personnel.

Table 4. The 10 largest Finnish electronics industry firms, as measured by the number of personnel in 1986.

<u>Firm</u>	<u>Staff in electronics</u>	<u>Products</u>	<u>Owner</u>
1. Oy Nokia Ab	11,640	all fields of electronics	Private
2. Oy Valmet Ab	2,290	industrial electronics	State
3. Oy Strömberg Ab	1,200	industrial electronics	ASEA (1986)
4. Oy Lohja Ab	1,120	consumer electronics, components	Private
5. LM Ericsson Ab	990	telecommunications	LME
6. Oy Kone Ab	620	industrial and medical electronics	Private
7. Oy Siemens Ab	500	telecommunications	Siemens
8. Teleste Oy	500	telecommunications	Private
9. Oy Vaisala Ab	500	industrial electronics	Private
10. Standard Electric	480	telecommunications	Alcatel

It can be seen from the table that the Finnish electronics industry is highly centralized. Oy Nokia Ab, the largest company, alone represents about one-half of the sector, and the share of the 10 largest companies is about 80 % of the total personnel in the sector.

The growth problems of new companies specializing in electronics in a country like Finland are indicated by the fact the five largest domestic electronics companies are old large diversified companies, which set out to diversify into electronics relatively early in the 1960s. In addition to internal growth, corporate acquisitions have been used to a great extent for increasing the companies to the critical size. The commonness of corporate acquisitions is illustrated by the fact that in Finland there is only one company which has grown from a small electronics firm into a notable company (Vaisala Oy) and has remained an independent company.

In Finland, the use of state-owned companies has traditionally been in the primary metal and chemical industries one method of increasing the companies to the critical size. Nevertheless, the endeavour in 1970s to create in the country electronics industry owned by the state miscarried with a picture tube factory project which was a total failure. Perhaps the electronics sector requires such rapid movements that the traditionally rather rigid state companies do not have as good possibilities for success in it as in the primary industries.

Among the Finnish electronics firms Oy Nokia Ab is the only one which is a relatively large company even in international terms. Oy Nokia Ab is at present the second largest electronics firm in the Nordic countries, after LM Ericsson Ab. The growth of Oy Nokia Ab reflects well even more generally the features typical of Finnish electronics firms. First, Oy Nokia Ab is a very old firm (established

in 1865). Second, on the Finnish scale it is a large firm; in fact, as measured by the number of personnel it is at present Finland's largest industrial firm. Third, Nokia is a diversified group of companies; its operations are divided into 11 divisions, of which 4 belong to the electronics industry. Electronics did not become the company's largest sector until 1984, and the share of electronics in the turnover of the company is at present about one-half. Oy Nokia Ab began to diversify into electronics in 1960 as an extension of the operation of the cable factory which belonged to the company. From 1960 to 1978 Oy Nokia Ab developed its electronics industry almost completely without corporate acquisitions, and was able to increase its electronics industry into a division of 2,300 employees, with a 15 % share of the total turnover of Oy Nokia Ab.

After this, Oy Nokia Ab changed its strategy and began to start up joint venture projects (Mobira Oy and Telenokia Oy) and to engage in corporate acquisitions. Its most important corporate acquisition was the joint acquisition of the Finnish company Salora Oy and the Swedish company Luxor Ab in 1984; through this acquisition Oy Nokia Ab doubled the turnover of its electronics. As late as the 1970s the growth of Nokia's electronics production was largely based on the domestic market, but during the 1980s its strategy has been the internationalization of operations. At present Oy Nokia Ab aims to be a Nordic rather than a Finnish firm.*

In order to attain the critical size Oy Nokia Ab operates in almost all fields of electronics. Its principal product groups are microcomputers, office information systems, data modems, digital telephone switchboards, PCM instruments, radio links, colour television sets, and automobile telephones. In addition, Oy Nokia Ab is clearly Finland's largest manufacturer of electronic components.

At present the internationalization of operations and

*In the beginning of 1988 Oy Nokia Ab took a new major step to grow up to an international big electronics producer: SEL AG (FRG) and the computer business of LM Ericsson Ab (Sweden) were acquired by Oy Nokia Ab. After these acquisitions the personnel in electronics of Oy Nokia Ab is about 27 000.

thereby attainment of the critical size, are central in the strategies of large Finnish electronics firms. Subcontracting and OEM agreements, joint ventures, and corporate acquisitions have been used as the principal forms of internationalization. It seems that creating a successful internationalization strategy is of central importance for the future development of the Finnish electronics industry. The developing of cooperation and division of labor among firms in the Nordic countries is an important initial phase of this development.

6. Priority areas of Finnish innovation activity

Innovation activity of the Finnish electronics industry has been investigated in our project with the aid of two sets of material. First, we collected material regarding electronics patents granted in Finland to Finnish firms during 1968 - 85 (416 patents), and second, with the assistance of experts at the Technical Research Centre of Finland, we selected the 20 most important domestic innovations in electronics (they have not all been patented). In the following the results yielded by the material we have collected are interpreted from only one viewpoint: which fields of electronics have been the priority areas of original innovation by Finnish firms?

Table 5 shows the breakdown of the patent and innovation materials into product groups of electronics.

Table 5. Number of patents granted in Finland to the Finnish electronics industry during 1968 - 1985, and the number of significant innovations selected by experts, according to product groups.

<u>Product group</u>	<u>Patents</u>	<u>Significant innovations</u>	
		<u>First suggestions</u>	<u>After ranking</u>
Industrial electronics	280	19	10
Medical electronics	64	7	3
Telecommunications	24	4	3
Consumer electronics	20	1	1
Components	18	5	2
EDP and office machines	10	4	1
Total	416	40	20

The breakdowns of both the patents and the significant innovations yield very similar results: there has been original Finnish innovation activity relatively most in industrial and medical electronics. On the other hand, in the fields of computers, electronic components and consumer electronics there have been few innovations.

This result supports well the general conception that in small countries there are hardly any possibilities for significant innovations in the basic technology of electronics and in fields requiring large R&D resources. On the other hand, there are better possibilities for success in the application of the basic technology to fields in which the country already has traditions, technological knowhow and innovative customers. For example, 15 % of the significant innovations selected for the material and 16 % of the patents were directly associated with forest industry automation systems and instruments.

Alongside this "result in accordance with the theory" we wish, however, to emphasize the fact that technically significant and in part also commercially successful innovations have been made in Finland also in fields in which, according to the theory, there should hardly be any possibilities for success. For example, in the manufacture of components Lohja Oy has developed the world's best method of producing flat display modules based on electroluminescence technology. So far this product development project has not led to commercial success. Oy Nokia Ab has developed a microcomputer which is commercially very successful, at least in the Nordic market. Nokia's success in this field is to a large extent due to the fact that its microcomputers are still sold as workstations to the information systems of large customers and not as separate microcomputers and hardly at all as home computers. Telenokia Oy has created, with small resources, a competitive small and medium-sized digital telephone switchboard DX-200 which is suitable not only for the

Finnish and Soviet markets but also for the markets of the developing countries, for example. DX-200 has been a commercial success in Finland but the profitability of the product will be secured only after possible successful export to the Southeast Asian countries in the near future.

The above observation again emphasizes the fact that reality, and in particular innovative activity, must not be "forced" into any narrow formula. Sometimes success may also be based on courageous exploitation of a situation which has come about by chance. In such cases, however, commercial success presupposes very good business management ability and the daring to take risks deliberately.

7. Summary

Quantitatively the success of the Finnish electronics industry has been similar to that of the corresponding industry in Denmark and Austria. The share of the Finnish electronics industry is 1.8 % of the GDP, 4 % of the industrial labour force, and 5 % of the exports.

Even rapid development of the electronics industry will not by itself solve the structural and employment problems of the national economy. In a small country such as Finland the question is rather of renewing the old production structure and production processes with the aid of electronics than replacing them with electronics. The indirect importance of the electronics industry may be even greater than its direct importance. For this reason, from the viewpoint of the national economy the profitability of this sector can be lower than average.

The development strategy of the Finnish electronics industry can be characterized as being fundamentally a kind of an intelligent and independent follower's strategy for technological development. It has not been based on the

operation of subsidiaries of multinational firms or on licenced manufacture, nor on a low cost of labour, although it must be borne in mind that in Finland the labour costs are lower than in the most highly developed OECD countries. The development has in the main been based on the following of the international technological frontier on the basis of national research and training, on specialization leaning on the old national production systems, and on rapid application of breakthroughs in the basic technology to selected fields. The same development strategy has in the main been applied during this century also in other sectors in Finland.

Success in electronics requires such a great deal of resources and knowhow that in a country like Finland the bringing together of the resources is an indispensable prerequisite for success. Therefore it will be increasingly necessary in the future to develop cooperation between different firms and different sectors, between firms and public research institutes, and between the producers and the users of technology. At the same time it can be seen that good international cooperation agreements have become an essential prerequisite for commercial success at the business firm level.

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