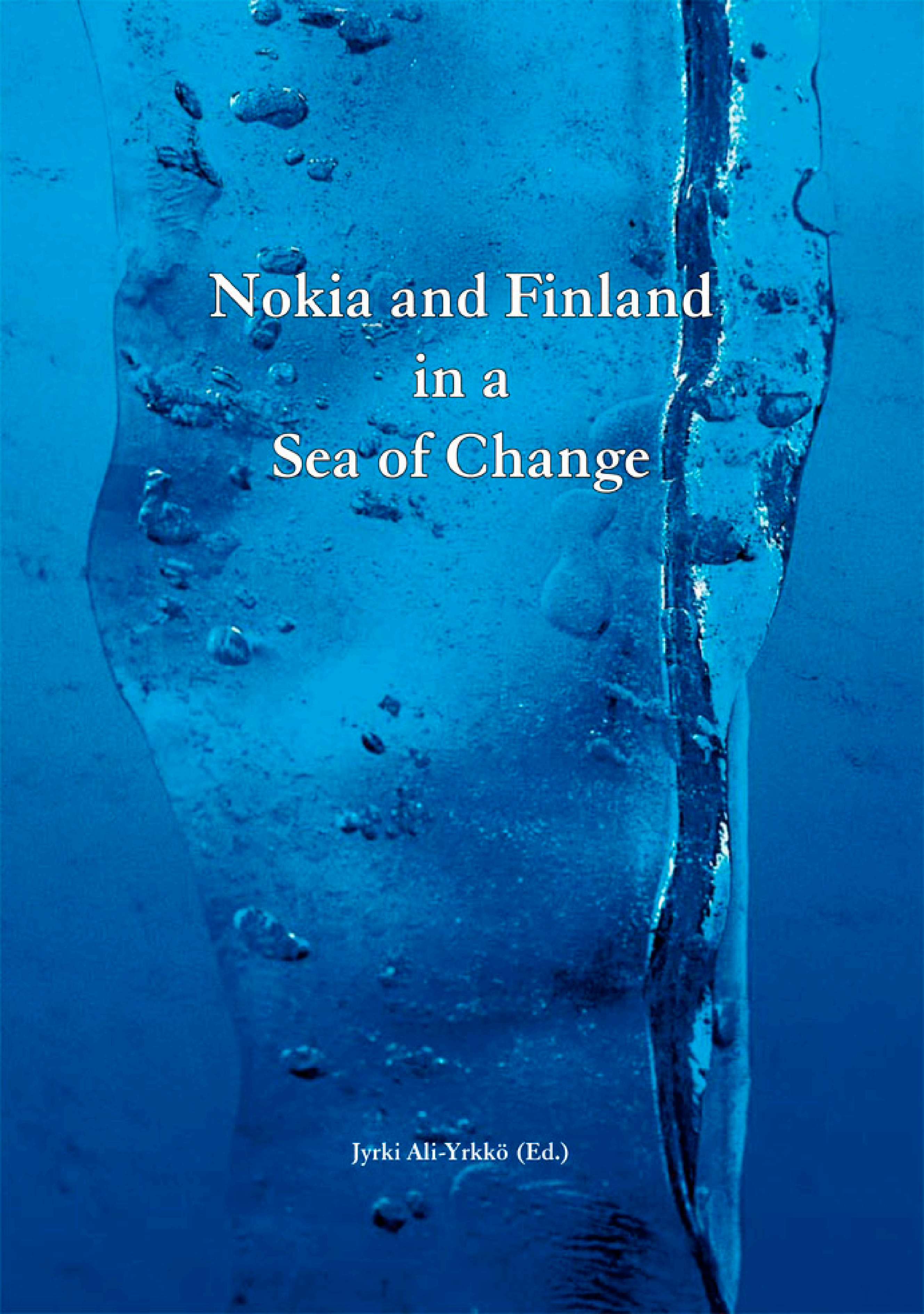

Nokia and Finland in a Sea of Change

Jyrki Ali-Yrkkö (Ed.)

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PREFACE

Since the late 1990s, a number of organisations and persons from different countries have asked ETLA about the role of Nokia in a small economy like Finland. This ample interest has motivated us to provide insight into the issue.

In addition to the editor of this book, Timo Seppälä (University of Jyväskylä and ETLA), Tuomo Nikulainen (ETLA) and Mika Pajarinen (ETLA) have written articles for this publication. It has been a pleasure to work with you, and I sincerely thank you for your collaboration

I would also like to thank Pekka Ylä-Anttila and Petri Rouvinen for their insights and comments during the research project. Moreover, Laila Riekkinen provided the final, and much appreciated, touches to this book.

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Helsinki

April 2010

Jyrki Ali-Yrkkö

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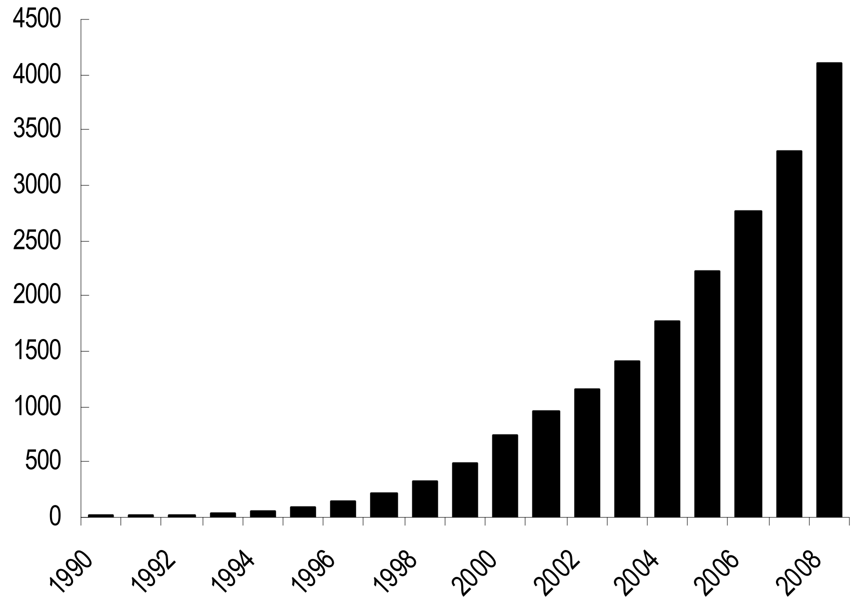
I. INTRODUCTION AND SYNTHESISING DISCUSSION

Jyrki Ali-Yrkkö

1 Background

Since the early 1990s, the mobile telecommunications market has grown rapidly. Between 1995-2008 the number of mobile subscribers drastically increased from 90 million to 4 billion (Figure 1.1). Hardly anyone could estimate beforehand how rapid the diffusion of mobile telephony would be.

Figure 1.1 Worldwide mobile cellular subscribers (millions)



Source: ITU World Telecommunication Indicators Database.

Nokia succeeded in utilising a booming telecommunication business. During 1995-1999 the company grew fast internally without major acquisitions. Nokia outsourced more and more its operations but it also increased its own production and R&D capacity[1]. As a result, Nokia hired thousands of employees in Finland but the focus became gradually more international (Figure 1.2). Since the late 1980s, the structure of Nokia has changed drastically. Nokia has focused on telecommunications and di-

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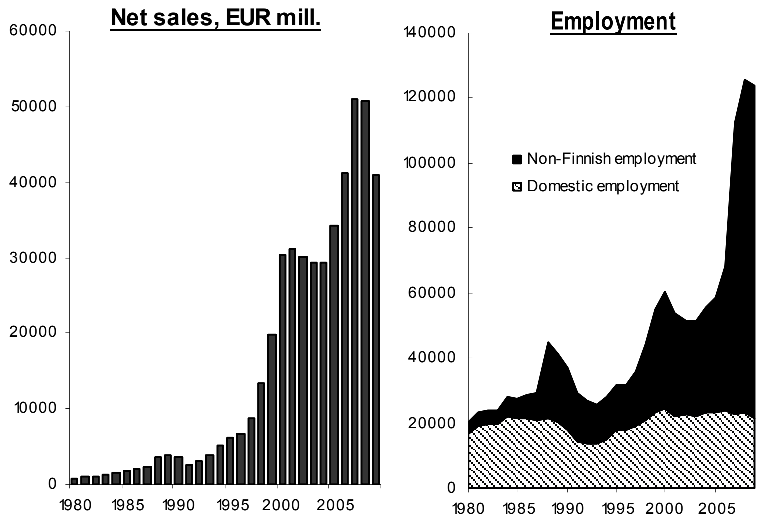
[1] It should be noted that in this book, we consider Nokia as group-level (including NSN)

vested all of its previous core competence businesses. From a conglomerate with a high number of differenct business lines Nokia has transformed into a pure telecommunications company.

Figure 1.2. Nokia's growth in terms of net sales and employment



Source: Nokia's annual reports.

During the 1990s, the ICT cluster was by far the fastest growing industrial sector and Nokia the fastest growing major company in Finland. But Nokia's operations were reflected in other companies.

The rapid growth of Nokia in the 1990s raises the question of the significance of a single company in a national economy. Moreover, in the beginning of the 21st century, Europe and the U.S. have witnessed a massive transfer of manufacturing activities to developing countries. China in particular has become a global centre for electronics manufacturing activities which has also been reflected in the Finnish ICT cluster. This book also sheds light on the recent offshoring development of the Finnish ICT sector and its impact on the Finnish economy.

2 An overview of the main results

The second section of this book, written by *Jyrki Ali-Yrkkö*, focuses on the role of Nokia in the Finnish economy using traditional measures such as the share of GDP (Gross Domestic Product) and contribution to GDP growth. Table 2.1 summarises Nokia's role using these and other measures.

Table 2.1. Summary of Nokia's role in the Finnish economy

	Nokia
Share of GDP	2.6% in 2008 (1.6% in 2009)
Contribution to GDP growth	-0.12 percentage points in 2008 (-0.99 percentage points in 2009)
Share of total employment	0.9% in 2008
Share of manufacturing employment	5.5% in 2008
Share of total R&D exp. (GERD)	36.9% in 2008
Share of business sector R&D exp. (BERD)	49.7% in 2008
Share of patents (EPO patent applications)	43% in 2006
Share of corporate taxes	9% in 2008
Share of manufacturing value added	11.5 % in 2008

Notes: GERD - Gross domestic expenditure on R&D, BERD - Business Enterprise Research and Development, EPO - European Patent Office

No doubt, Nokia is still the most important single company in the Finnish national economy. Notwithstanding Nokia's share of GDP has declined, in 2008 Nokia accounted for as much as 2.6% of GDP.

Over the past few decades, the share of research and development expenditure of GDP has grown strongly in Finland. In 2008, the share of R&D expenditure was as much as 3.4 %. Nokia has had a significant role in this development. According to the latest figure, Nokia accounts for approximately one third of the total Finnish R&D expenditure. If Nokia's share were taken out of the figures, in 2008 Finland's R&D spending would be about 2.4 % of GDP exceeding even then the average EU level.

In the third section, *Timo Seppälä* considers the transformation of Nokia's Finnish supplier network between 2000 and 2008. During that period, the demand for Nokia's mobile phones increased rapidly. While in 2000 Nokia delivered less than 130 million phones, in 2008 the annual volume had grown to 470 million phones. The product portfolio also expanded from mono blocks to a wider assortment covering clam shells, sliders and swivels as well.

The above-mentioned changes among the supplier strategy of Nokia led to the transformation of supplier networks. Before 2004, Finnish manufacturing suppliers operated rather individually meaning that they had a direct contact with Nokia. Thus, Nokia's Tier 1 level of supplier networks was very large. In response to the growing demand for phones, the biggest Finnish suppliers internationalised either by acquisitions or by investing in greenfield plants. However, some Finnish suppliers such as Protopaja and Laukamo decided not to invest abroad. During those years the field, however, started to change as Foxconn (from Taiwan) and Jabil Circuit (from the U.S) expanded their operations to new business segments. Later on, when Foxconn's position had significantly strengthened, Nokia started to search for competitors for Foxconn and as a result the Chinese BYD entered Nokia's supplier networks.

The strategy of these entrants differed considerably from their Finnish competitors. The Finns continued with their horizontal strategy by focusing on their existing core competences while the strategy of the new entrants was based on the vertical model which meant that they provided a wide range of functions from design, tooling and component manufacturing to final assembly and testing.

Step by step, Finnish manufacturing suppliers lost their positions to competitors. Some of these firms were acquired by Asian companies that sought new technological competences and/or new customers. For example, Eimo was acquired by Taiwanese Foxconn and Perlos was acquired by another Taiwanese firm called LiteOn. Furthermore, Aspocomp sold the majority of its operations to Meadville (from Hong Kong). On the other hand, some Finnish suppliers such as Protopaja, Savcor and Salcomp have succeeded in preserving their independence. However, in Finland their Nokia-related operations have contracted considerably. More than 99% of Salcomp's personnel is located overseas (mainly in China and India) and Savcor's Nokia-related business is also heavily concentrated in these low-cost countries, particularly in China.

One of the main findings of the article is an observation that the competition in the electronics component and EMS (electronic manufacturing services) industry has changed drastically. In the late 1990s and still in 2000, the industry suffered from a lack of manufacturing resources and consequently the suppliers' major challenge was their ability to invest in new capacity. Today, the major challenge is fierce cost competition which, in turn, has led to massive offshoring of manufacturing functions to low-cost countries. This relates to another important finding of the article: the manufacturing knowledge of complex electronic products such as mobile phones has metamorphosed from 'high tech' into commodity. Instead of a rare 'raw-material', high tech products' manufacturing can be described as 'bulk'. Thus, there is a great number of companies in both developed and developing countries with sufficient or even excellent manufacturing know-how.

In Section 4, *Tuomo Nikulainen* and *Mika Pajarinen* focus on the dominance of top R&D performer companies in the technological landscape of a selected sample of smaller European open economies. Instead of R&D expenditure, the dominant role of top R&D performers and their technological specialisation is approximated through patents.

The results of the article show that Nokia is very dominant in the patenting activities of Finland. During 2000-2006, Nokia's share of all Finnish patent applications from the EPO (European Patent Office) was as high as 48%. The share has decreased slightly, because in 2006 the corresponding share dropped to around 43%. In the Netherlands, Philips accounted for 36% (in 2006), and in Sweden, Ericsson accounted for 27% of all EPO patent applications. These shares suggest that there are also other small economies with dominant companies in technology development. On the other hand, when comparing the shares of patenting activity to the technological specialisation, interesting results emerge. Even though Philips is dominant in its national context, it represents a broad set of technologies. Ericsson is less dominant in Sweden, but is more focused on a limited set of technologies. Nokia instead is very dominant in Finland and is very specialised in a limited number of technologies.

For policymakers these results can be seen as somewhat alarming. For the future development and economic prosperity, it is necessary to have more than one stronghold. Therefore, policymakers should actively pursue and facilitate the broadening of Finland's technological landscape. In particular, this conclusion is further supported when taking into account the recent downward developments in the traditional strongholds of the Finnish export industry, such as paper and pulp.

In Section 5, *Jyrki Ali-Yrkkö* analyses the global value chain of mobile phones by considering a single product: Nokia N95. The N95 can be considered as an example of a commercially successful phone model with a number of technological novelties.

The breakdown of the N95's value added provides three main findings. *First*, the brand-owner Nokia creates approximately half of the total value (sales price to consumer). The N95 includes a few expensive components such as integrated circuits, 5 megapixel camera and display but even then the total cost of more than 600 components account for less than one third of N95's total value. The distribution channels including both the wholesale sector or distributors, and retail account for approximately 15%.

Second, pure production or manufacturing function contributes only a minor share of the entire value of a high tech product such as a mobile phone. In the N95 case, the final assembly of the phone costs approximately EUR 11.5 accounting for only 2.1% of the total value added and 4.3% of the valued added generated by Nokia. This implies that the final assembly of a high tech electronics product is in fact very low tech because the manufacturing function generates only a small amount of value added.

Third, our case demonstrates how global a single electronics product can be. Finland, South Korea, Japan, the U.S, the UK, Germany and China, among many other countries, have contributed to the total value added of the N95. However, approximately 35% of the total value added is created domestically if the country of final sale is abroad. If the handset is sold in Finland (the value added of distributor and retail are attributed to Finland), then even 50% of the total value is created domestically.

More than ten years ago, we (Ali-Yrkkö et. al. 1999) concluded that "*In this phase of the ICT revolution it is service producers and content providers who are taking the lead.*" During the past ten years, the digital convergence of media, information technologies and communications has proceeded but at a slower pace than expected. In any case, the trend towards services and content is clear and Nokia has also taken several steps in order to follow this trend. Since 2000, Nokia has acquired several companies related to services. The acquisitions include companies such as Loudeye (the provider of digital music platforms), Twango (media sharing solutions), Enpocket (the provider of technology and services for mobile advertising), to name just a few. Moreover, Nokia made its history's biggest (in value terms) acquisition in spring 2008 when it acquired Navteq, the provider of map data platforms. Nokia has integrated its individual Internet services under the Ovi brand. Due to the convergence development in the ICT sector, Nokia has faced new competitors such as Google, Apple and Tele Atlas. Rather than physical products, the core competences of these competitors are related to services pushing also Nokia to metamorphose into a company providing more services and content.

Currently the market position of Nokia is completely different than in the early 1990s. Fifteen years ago Nokia was the challenger and companies such as Motorola, Siemens and Ericsson were the market leaders in the telecommunication business. But today, Nokia is the market leader in mobile phones and all the other firms challenge Nokia with new products, design, applications and software platforms. Competing platforms include for instance Android, Blackberry OS and iPhone OS. Recently, Nokia has reacted to this competition by announcing that it will merge its Linux-based operating system Maemo with Intel's Moblin software platform.

Even if Nokia succeeds in this new market situation, it is unlikely that its role in the Finnish economy would be restored to the level it was in the late 1990s and 2000. While ten years ago the shortage of skilled labour accelerated the international expansion of Nokia and its Finnish suppliers, currently the key drivers of overseas investment are low cost country offshoring and the market potential of large developing countries. While Nokia hardly grows in Finland, the company still has a very significant role in the Finnish national economy.

II. THE ROLE OF NOKIA IN THE FINNISH ECONOMY

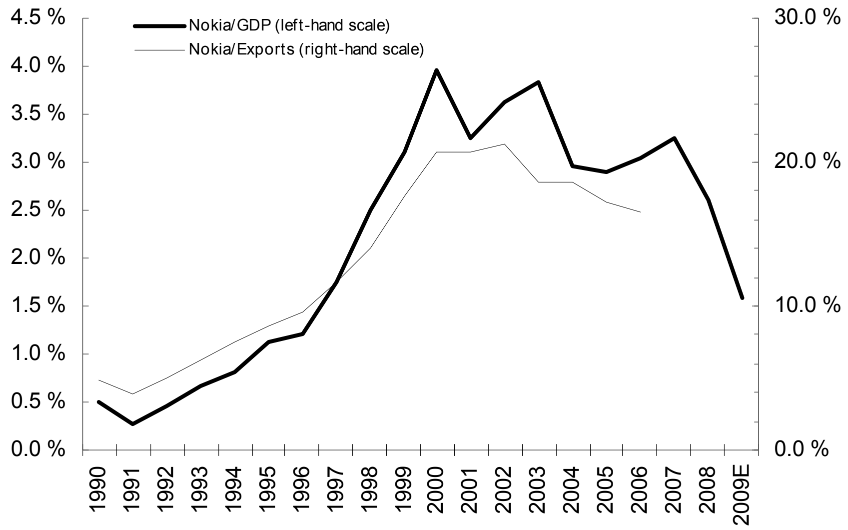
Jyrki Ali-Yrkkö

1 Introduction

1.1 The impact of Nokia on GDP and productivity

During the latter half of the 1990s, the Finnish economy enjoyed exceptionally rapid growth rates. Average GDP growth exceeded 4.5%, a rate well above the average growth in most of the other OECD countries. This can be partly explained by the country's recovery from the deep recession that it underwent in the early 1990s. Another key factor is the growth of demand for handsets and telecommunications network equipment, which led Nokia to expand considerably.

Figure 1.1. Nokia as a share of exports and GDP, %



Note: including NSN. Sources: Author's own calculations (Sources: Nokia Corporation, Statistics Finland, National Board of Customs)[2]

[2] The calculations are partly based on Nokia's own report of the value of exports, which does not fully correspond to the official statistics.

Nokia has had a significant impact on the Finnish gross domestic product (GDP) for more than 15 years. In 1995, Nokia's share of the Finnish GDP was only 1 percent, but five years later, in 2000, the share had quadrupled to as much as 4 percent (Figure 1.1). During the period from 2001 to 2007, the share varied between 2.9 and 3.8 percent, but due to the economic crisis, Nokia's value added generated in Finland dropped in 2008-2009, and the company's share of the Finnish GDP decreased to approximately 1.6 percent (in 2009)[3].

It should be kept in mind that notwithstanding Nokia's engagement in a great deal of collaboration and subcontracting, the above-mentioned figures do not take into account multiplier effects.

Not surprisingly, the development of Nokia's share of Finnish total exports has been similar to the development of the GDP share. The share of exports rose rapidly during the late 1990s, but in the early 2000s, the share declined because the exports from other industries grew more rapidly. Nokia's exports include both tangible goods and non-tangible services.

Changes in GDP further emphasise Nokia's impact. Thanks to the increased value added of Nokia, the company has contributed significantly to total GDP growth (Figure 1.2).

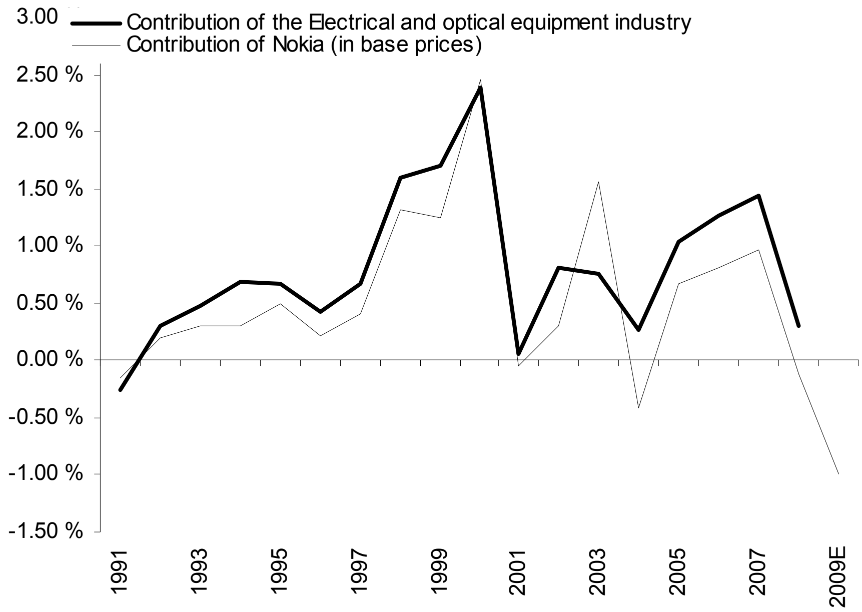
In 2000, Nokia's contribution – that is, its effect on GDP growth – was almost 2.5 percentage points when total GDP growth was 5 percent[i]. Consequently, Nokia was responsible for almost half of the total GDP growth in 2000. Conversely, in 2001, the Finnish GDP growth slowed to 2.6 percent, and Nokia's contribution to this growth was

---

[3] Working from our previous calculations reported in Ali-Yrkkö et. al. (2000) we have updated our estimation method. To calculate the impact of Nokia on Finnish GDP, we proceeded as follows. First, we estimated the value added of Nokia's activities in Finland. The starting point of this estimation was the financial statements of the parent company. However, we adjusted the reported figures of the parent company in years when the original figures included exceptional gains due to group restructuring (for instance, in 2007, the operating profit includes a non-taxable gain of EUR 1.88 billion related to the formation of Nokia Siemens Networks). Second, Nokia's share of GDP was calculated by dividing Nokia's Finnish value added (in current prices) by the Finnish GDP (in current prices).

close to zero. During the period 2005-2007, Nokia's contribution to GDP growth rose again, but due to the global recession, it turned clearly negative in 2008-2009.

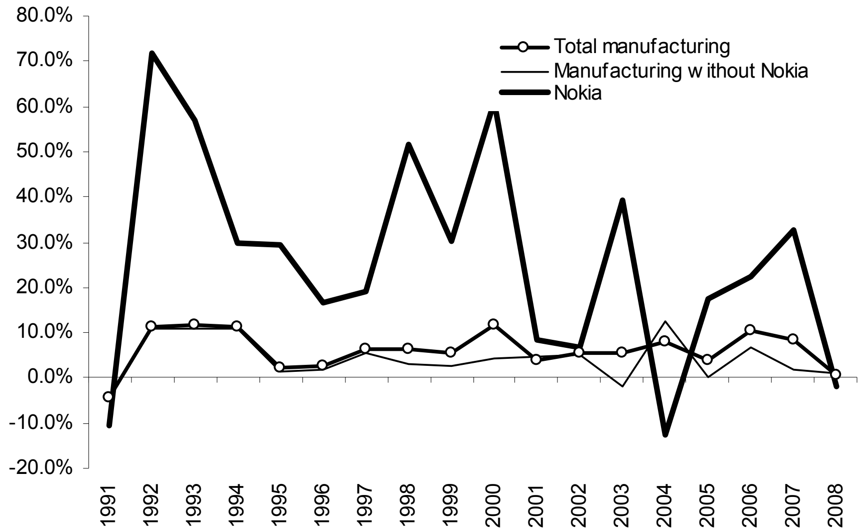
Figure 1.2. Contributions of Nokia and the electronics industry to Finnish GDP growth, %-points



Author's own calculations (Data sources: Nokia Oyj, Statistics Finland)

In addition to GDP share and GDP growth, Nokia has significantly impacted productivity growth in the Finnish manufacturing sector (Figure 1.3). In the late 1990s, fast productivity growth pushed the productivity level of Finnish manufacturing above the U.S level (Maliranta 2009).

Figure 1.3. Labour productivity (value added by employee) of Nokia's Finnish units and Finnish manufacturing, %-changes



Note: The productivity of Nokia's Finnish units (including NSN) was calculated by deflating Nokia's value added in Finland by the producer price index (2000=100) for DL 322 (Manufacture of television and radio transmitters and apparatus for line telephony and line telegraph). After deflation, we divided the deflated value added by the number of Nokia's employees in Finland. Correspondingly, the productivity of total manufacturing was calculated by deflating the value added associated with the manufacturing sector by the producer price index (2000=100), after which we divided this deflated value added by the total number of employees working in the manufacturing sector.

Source: Author's own calculations (Sources: Nokia Corporation, Statistics Finland)

According to aggregate figures, labour productivity in the Finnish manufacturing sector has grown rapidly. During 1992-1999, the annual growth rate was some 7 per cent, and in the early 2000s, the pace was virtually the same. Nokia has contributed significantly to these figures, with the productivity of Nokia growing, on average, 19 percent annually over the 2000s.

Once we have removed Nokia from the aggregate manufacturing figures, we find that productivity grew, on average, 6 percent annually in the 1990s. In 2001-2008, the corresponding figure (for the manufacturing sector excluding Nokia) was 4 percent on average.

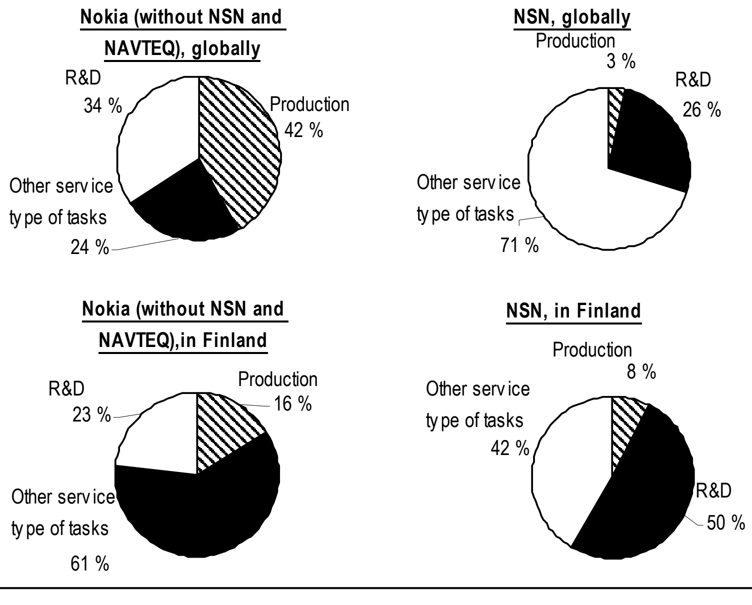
BOX.1. Nokia – A manufacturing company?

In official statistics – for example, by Statistics Finland or Eurostat – Nokia is classified as a company operating in the manufacturing industry. However, a remarkable share of manufacturing firms' operations is often related to other functions than the pure production of goods. Gunnar Eliasson observed as early as the late 1980s that in practice, different kinds of in-house services account for the majority of labour costs of manufacturing firms (Eliasson et. al. 1986, 1990).

To consider this issue, we classify Nokia's total employment into three categories: production employees, R&D employees and employees working on other tasks. As seen in the following figure, the minority of Nokia's employees works directly in production. In the parent company (Nokia without NSN and Navteq), roughly 40 percent of employees are working directly on production, while in NSN, the corresponding share is only 3 percent (Nokia Form 20-F 2008). While NSN has a significant number of employees in delivery execution, logistics, global procurement and other tasks related to manufacturing, the great majority of employees are working on R&D, sales and marketing, and other service types of tasks.

Outsourcing could be a potential explanation for the low share of production employees. Although in principle, this explanation could be valid, the real figures do not support this view. In 2008, Nokia outsourced approximately 17% of its manufacturing volume of mobile phone engines, while Nokia Siemens Networks outsourced approximately 20% of its production (Nokia Form 20-F 2008). In March 2009, Nokia announced that as a response to recession, the company had holded using subcontractors in the manufacturing of mobile phone engines. Earlier, Nokia had used assembly subcontracting mainly to balance variation in capacity utilization rates. When the demand for phones decreased in the autumn of 2008, no external manufacturing capacity was needed (Helsingin Sanomat, March 26, 2009).

Box Fig 1. The Employment of Nokia and NSN by tasks (2008) globally and in Finland



1.2 Nokia and the public sector

Nokia's growth and success have substantially impacted the tax revenues of Finland, but the company has also received R&D grants. Next, we examine in detail the flow of funds between Nokia and the public sector.

Period 1995-2000

During the 1995-2000 period, Nokia paid corporate taxes in Finland that totalled EUR 2.7 billion (in 2000 prices)[4]. Furthermore, based on calculations by Ali-Yrkkö & Hermans (2002), Nokia's employees paid income taxes worth EUR 1.4 billion over the years 1995-2000 in addition to taxes on management options worth EUR 1.2 billion. Over the same time period, Nokia paid EUR 1.2 billion in social security payments for its employees. Altogether, the corporate taxes, income taxes, taxes on management options, and social security payments for the employees exceeded EUR 6.5 billion (in 2000 prices) over the years 1995-2000. In the same period, R&D grants from Tekes to Nokia totalled slightly below EUR 80 million (in 2000 prices).

Period 2001-2008

R&D grants from Tekes (The Finnish Funding Agency for Technology and Innovation) to Nokia totalled EUR 96.5 million (in 2000 prices) over the years 2001-2008. In the same period, Nokia's employees paid income taxes worth EUR 2.8 billion. Moreover, Nokia paid EUR 2.0 billion in social security payments for its employees and EUR 6.13 billion in corporate taxes (in 2000 prices).

In 2003, Nokia accounted for 23% of total corporate tax revenue (Figure 1.4).

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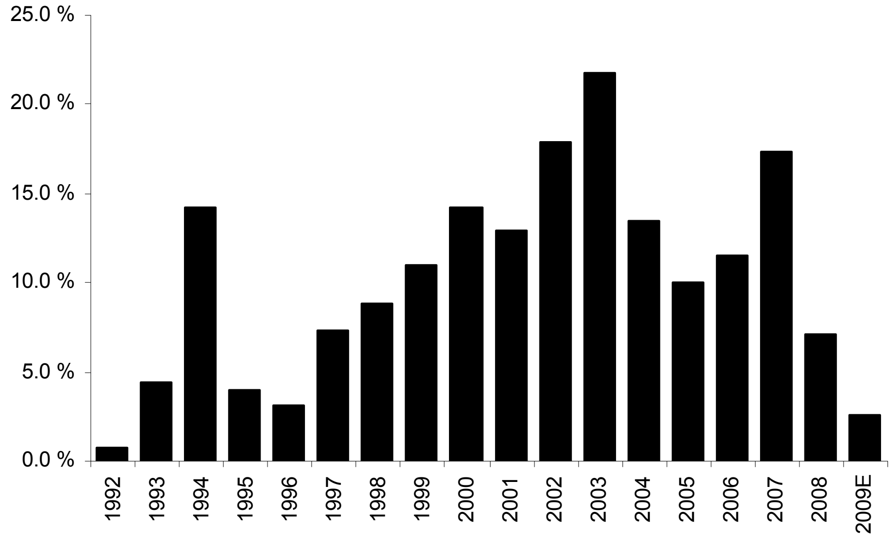
[4] See Figure 1.4 and its notes.

Figure 1.4. Nokia's annual share of corporate taxes, %



Author's own calculations (Data sources: Nokia Oyj, Finnish Tax Administration and Statistics Finland).

Note: For 1999-2008, the data source for corporate taxes paid by Nokia is the Finnish Tax Administration. For 1992-1998, we have used the tax expenses (Finland) reported in Nokia's annual reports[5]. However, we have corrected these figures by assuming that the real corporate tax revenues received by Finnish tax authorities are 91% of those reported figures. This percentage is based on the fact that during 1999-2003, the average share of real corporate tax revenues of reported tax expenses for Nokia was 91%.

After 2003, Nokia's share varied between 15% and 21%, but in 2008 the share dropped to 9%, back to the 1997-1998 level. Based on our preliminary estimate, in 2009 the share dropped to 2.5%. In addition to the adverse impact on the state budget, on the local level the effect was potentially even more severe. The extreme example is that of Salo (a rather small town located in the Southwestern part of Finland), where Nokia's mobile phone manufacturing plant and a large R&D site are located. In 2008, approximately 90 percent of corporate tax revenues received by Salo came from Nokia. However, it

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[5] It should be noted that the country-level corporate tax expenses indicated in annual report are not of exactly the same amount as that of corporate tax revenue received by the country.

should be noted that corporate tax revenues account for about one fifth of Salo's total budget.

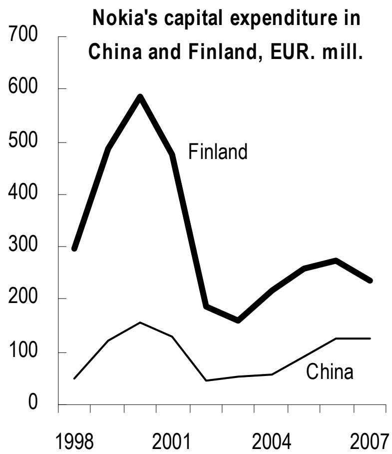
Altogether, the corporate taxes, income taxes, taxes on management options, and social security payments for employees exceeded EUR 12.1 billion (in 2000 prices) over the years 2001-2008. In current prices, this equals EUR 12.7 billion.

Box. Nokia in China

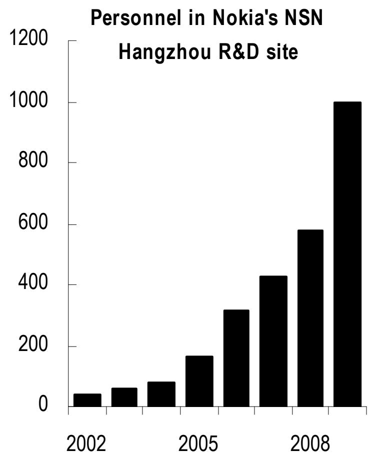
Nokia has operated for more than 20 years in China. In 1985, Nokia established its first representative office in Beijing. Ten years later, Nokia set up its first manufacturing unit in China, originally serving a mainly local market.

After three years (in 1998), the company was ready to take the next step: to start R&D activities in China. The Nokia Research Center Beijing was established to do long - erm research projects with highly educated staff: 30% of staff hold Ph.D degrees and 60% masters degrees (Hariharan 2005). In 1999, the Beijing Product Creation Center was set up. Initially, the purpose of the site was to expand Nokia's capability to localise and develop mobile phones for the Chinese market and other Asian markets, but later, its role expanded to other countries, too. For instance, Nokia phone models like 2100 and 6108 were developed by the Beijing Product Creation Center (Nokia press release May 21, 2004).

In 2008, Nokia's operations in China included two network manufacturing facilities, two mobile phone manufacturing facilities and six R&D units. China had become the most important single country to Nokia, accounting for nearly 12 % its total net sales and employing more than 14.500 employees. Nokia's plants in China manufacturer products not only for local customers but also for overseas markets. This global role has become more important during the past years that can be seen in exports statistics (see Figure). The total exports of Nokia's Chinese units exceeded EUR 6.2 billion in 2007 while four years before (in 2003) the corresponding figure was only EUR 1.7 billion.



Source: Nokia, annual reports



Sources: NSN, Vodde & Yi (2006)

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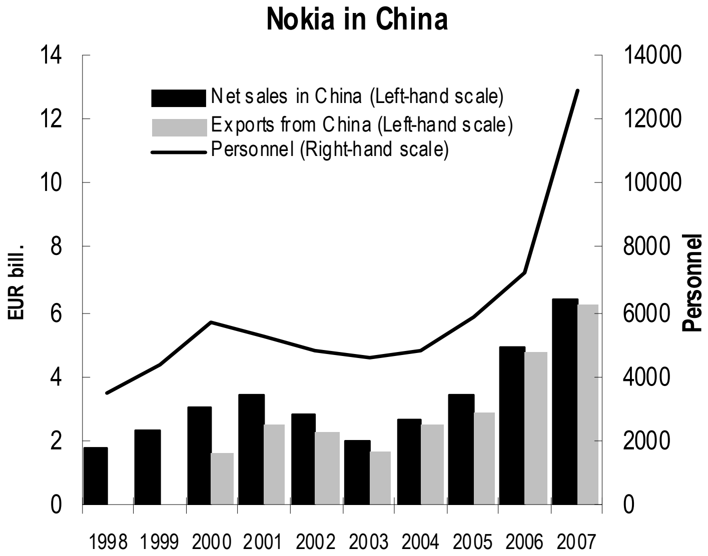


Sources: Mäkinen (2004), Reuters (22.2.2008), Nokia

Nokia's R&D operations in China have grown rapidly. A good example is the development of Nokia's R&D center in Hangzhou established in January 2002. Originally the site was established to develop software for 3G telecommunications systems. Not withstanding that Chinese software developers were rather inexperienced1, Nokia succeed to ramp up the site and after the first years Nokia recruited hundreds of R&D employees in Hangzhou. In March, 2009, more than 1,000 R&D employees worked at Nokia's Hangzhou site.

2 Nokia and the Finnish innovation environment

This chapter examines Nokia's role in the Finnish innovation system. The term "innovation system" refers to the operations and interaction of universities, research institutions, other public sector organisations, and private businesses, which together influence the creation, diffusion, and utilisation of novel know-how.

Nokia has a two-way role in the Finnish innovation system. On one hand Nokia utilises resources from the innovation system. At the same time, on the other hand, the company produces innovation resources that diffuse outside the company.

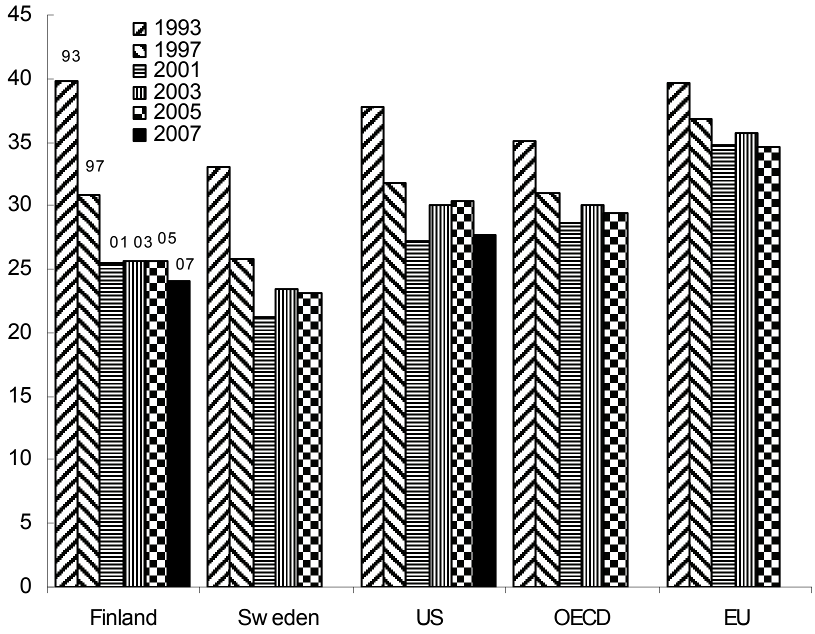
In Finland, Nokia has benefited from innovation resources such as the educational system, skilled labour, and Tekes' research and development (R&D) funding, to name a few. Similarly, Finland has reaped benefits from Nokia. The latest knowledge in the field has been passed onto universities through Nokia (Ali-Yrkkö & Hermans 2002). Know-how has also spread to Nokia's company partners owing to its networking policies. Nokia's international research projects have also gained in significance as a result of the company's global mode of operations.

2.1 Public funding of research and development

INTER-COUNTRY VARIATIONS IN R&D

In all industrialised countries, the public sector takes part in research and development activities, with R&D activity seen as a significant promoter of potential future economic growth. The role of the public sector in R&D activities varies by country (Figures 2.1 and 2.2).

Figure 2.1. Share of public finance of total R&D spending



Source: OECD: Main science and technology indicators

The results in Figure 2.1 show that during the past 15 years, the share of public finance has decreased in general but that the share of public funding of total R&D spending has varied considerably by country and region. In 2006, on average, almost 35 percent of R&D expenditures in the EU countries were financed by the public sector. This is slightly more than in the OECD area on average, where the respective figure for the same year was 28 percent. In Finland and in Sweden, the share of public finance is even less. According to the latest information available, the public sector funds less than a quarter of R&D in Finland and Sweden.

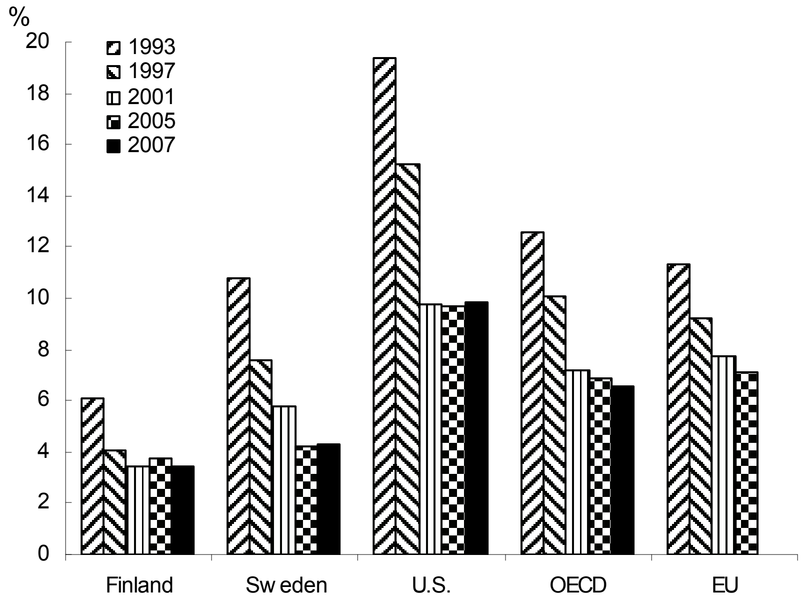
The public sector finances both its own R&D activity (e.g., at universities and government-owned research institutions) and the private sector research activity (Figure 2.2).

There are significant differences between countries and regions in their share of public funding of private sector R&D. The comparison is made more difficult by the fact that in some countries, the government funds a considerable portion of the private sector development of military technologies. However, in the course of time, the results of military technology development also spill over into the civil sector. For instance, the predecessor of the global Internet was ARPANET, developed by ARPA of the United States Department of Defense during the Cold War.

Contrary to what we see in the previous comparison in Figure 2.1, here the share of public finance (of private sector R&D) in the EU countries is less than the OECD average. On average, companies in the EU countries self-finance a larger share of their R&D than occurs in the rest of the OECD countries.

A second important observation concerns the role of the public sector in the United States. There, the public sector clearly finances more of the private sector R&D than occurs in the rest of the countries. This is partly due to the public financing of the development of military technology in the private sector. It may also be a signal that in the United States, companies are encouraged to invest in higher-risk R&D projects. However, the large share of public funding received by the private sector is potential threat. It is possible that public funding will begin crowd out private sector R&D funding. In fact, the empirical evidence based on statistical analyses with firm-level data gives support to the view that crowding-out problems are more severe in the U.S than in other countries (see the literature survey by David, Hall & Toole 2000).

Figure 2.2. Share of public finance of private sector R&D spending, %.



Source: OECD: Main science and technology indicators, Statistics Finland

In Finland and Sweden, the public sector finances a significantly smaller share of the private sector R&D than in the OECD and EU countries on average. In Finland, only 3.8 percent of the private sector R&D is financed by the public sector. If we exclude Nokia from the figures, in 2007 the share of public sector funding of total private R&D expenditure was roughly 6.5 percent[6].

Both of the above comparisons clearly show that the private sector has a more central role in research and development financing in Finland than in many other countries. On one hand, this can be seen as a strength of Finland's and a signal that companies are willing to invest in risky projects with their own financial resources.

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[6] The share was calculated as follows: (The aggregate amount of public R&D funding received by firms – Total amount of Tekes funding received by Nokia)/(The aggregate private sector R&D expenditure – Nokia's R&D expenditure in Finland)

On the other hand, one may ask whether private sector R&D projects are directed towards R&D investments that are too short-term. Projects financed by the public sector are often longer-term ventures that are aimed at research or technology development rather than incremental product development. The potential benefits from these projects are only reaped over a long period of time.

PUBLIC R&D FUNDING AND NOKIA

Tekes (the Finnish Funding Agency for Technology and Innovation) is an organisation under the Ministry of Employment and the Economy, through which the government supports and funds technology development in Finland. In the 1990s, Tekes increasingly directed its funding (grants and loans) towards companies in the industry of information and communication technology. In 2008, approximately 16% of the funding by Tekes was targeted at the electronics and electricity industry.

Nokia, too, has received public funding for its R&D activities. The amount of Tekes financing received by the company has varied considerably (Table 2.1). While in 1969 Nokia received EUR 34 000 (in current prices) from the Technology Office of the Ministry of Trade and Industry (Tekes's predecessor before its founding), in 1999 the figure was 18 million Euros in Tekes funding. In 2009, Nokia received Tekes funding worth 9.6 million Euros.

In the 1970s, the proportion of Nokia's total R&D expenditures addressed through funding from the MTI Technology Office (Tekes's predecessor) was 7 percent on average. In the first two years of the 1980s, funding from Tekes gained a significant position in the financing of Nokia's R&D. In 1980, over 25 percent of the company's total R&D was financed by Tekes, and in the following year, the share fell to 15 percent. After these exceptional peak years, the share of Tekes' funding of Nokia's total R&D spending decreased significantly.

During the recession in the beginning of the 1990s, the importance of Tekes's funding grew again. With the support of public funding, the Nokia Research Center managed to sustain the continuity of its research activities even through the most difficult years of the economic slump (Häikiö 2001, pg. 96). In the second half of the 1990s, the share of Tekes's financing of Nokia's total R&D expenditure was around 1.5 percent on average, while in the 2000s, the share decreased to 0.2-0.4 percent of Nokia's total R&D expenditure.

In the 1990s, most of the Tekes funding received by Nokia was directed towards Nokia Research Center projects. In the years 1993-2001, the share of the total Tekes financing for the whole Nokia group received by the Research Center was 55 percent on average (Häikiö 2001).

In summary, we can conclude that the amount of financing granted to Nokia by Tekes increased in nominal terms in the 1990s. In the 2000s, the nominal figures for Tekes funding stayed at the same level as in the 1990s, but the share of Nokia's total R&D expenditure drastically decreased. In 2009, the share of Tekes funding received by Nokia was 0.16% of company's total R&D expenditure (Table 2.1).

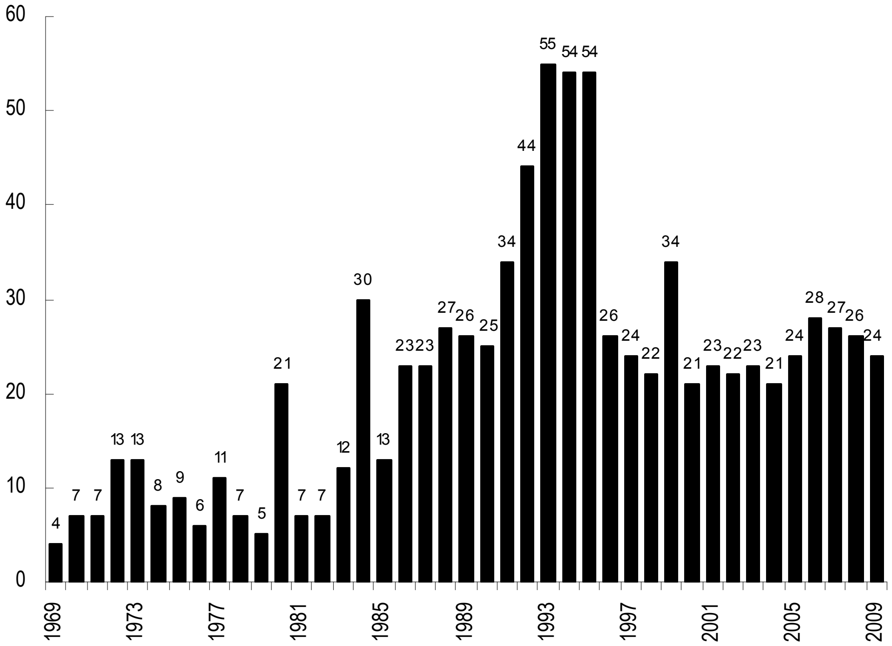
Table 2.1 Nokia's R&D activities and Tekes funding*

	Nokia's R&D exp., EUR mill.	Percent of total sales	Tekes funding, EUR. Mill.	Percent of Nokia's R&D exp.
1969	1.6	1.6%	0.03	2.1%
1970	1.9	1.6%	0.2	7.8%
1971	2.5	1.9%	0.1	5.3%
1972	3.4	2.3%	0.3	8.0%
1973	4.9	2.7%	0.4	8.5%
1974	6.3	2.3%	0.5	7.7%
1975	7.9	2.8%	0.4	5.1%
1976	9.2	3.1%	0.4	4.4%
1977	9.3	2.9%	0.8	9.0%
1978	9.9	2.3%	0.7	6.9%
1979	12.1	2.3%	0.7	5.6%
1980	16.0	2.1%	4.2	26.3%
1981	28.9	3.0%	4.2	14.5%
1982	35.7	3.3%	1.7	4.7%
1983	44.9	3.8%	2.9	6.4%
1984	59.7	3.8%	4.7	7.9%
1985	76.7	4.1%	1.3	1.8%
1986	90.7	4.5%	3.9	4.3%
1987	97.7	4.2%	4.4	4.5%
1988	133.7	3.6%	6.1	4.5%
1989	159.8	4.2%	3.0	1.9%
1990	195.8	5.3%	5.0	2.6%
1991	156.9	6.0%	7.9	5.0%
1992	187.2	6.1%	9.6	5.1%
1993	247.6	6.2%	12.3	5.0%
1994	319.6	6.3%	10.8	3.4%
1995	425.7	6.9%	10.9	2.6%
1996	591.0	8.9%	10.4	1.8%
1997	766.9	8.7%	12.4	1.6%
1998	1150.1	8.6%	13.3	1.2%
1999	1755.0	8.9%	18.2	1.0%
2000	2584.0	8.5%	7.9	0.3%
2001	2985.0	9.6%	11.8	0.4%
2002	3052.0	10.2%	10.3	0.3%
2003	3760.0	12.8%	14.1	0.4%
2004	3776.0	12.9%	12.7	0.3%
2005	3825.0	11.2%	13.0	0.3%
2006	3875.0	9.4%	14.8	0.4%
2007	5647.0	11.1%	12.8	0.2%
2008	5968.0	11.8%	12.8	0.2%
2009	5909.0	14.4%	9.6	0.16%

* Based on Tekes' funding decisions. The data before 1983 is from the Ministry of Trade and Industry Technology Office.
Author's own calculations (sources: Nokia's annual reports, Häikiö (2001), Tekes).

During the 1980s and 1990s, the nominal amount of Tekes funding for Nokia increased at the same time as the number of R&D projects increased (figure 2.3).

Figure 2.3. Number of Tekes projects at Nokia annually.



Source: Tekes, Häikiö (2001), updated by the author,
Note: Including NSN.

In the 1970s, Nokia received Tekes funding for an average of 9 projects annually. During the following decade, the number of projects receiving Tekes funding grew to nineteen on an annual basis. In the 1990s, the number of projects receiving Tekes funding continued to grow, but in the 2000s, this trend turned downward. During the 2000s on an annual basis, an average of 24 projects at Nokia received R&D funding from Tekes.

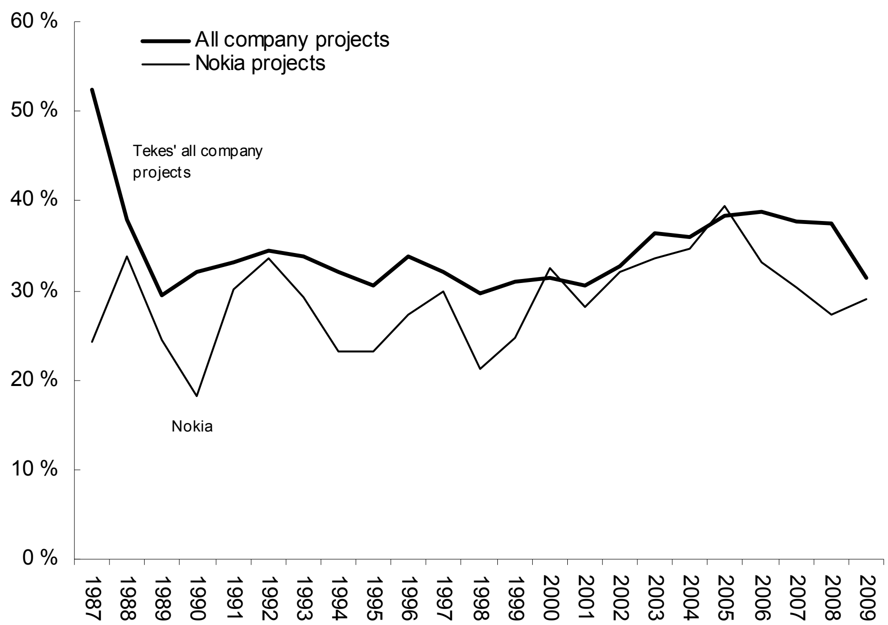
Taking inflation into account, the average size of Tekes' Nokia projects has not varied significantly. However, a number of extensive projects were initiated during the 1970s – for example, laying the foundation for GSM technology and developing IT systems. The second aberration in the size of projects emerged from the growth in size that took place at the end of the 1990s. This was partly the result of the TLX (Telecommunications – Creating a Global Village) and ETX

(Electronics for the Information Society) research programmes initiated by Tekes, in which Nokia had been involved. During the 2000s the average amount of Tekes funding per Nokia project was approximately EUR 0.5 million (in 2000 prices).

Tekes finances only a part of the cost of companies' research and development projects (the so-called company projects of Tekes). Usually, most of the costs of company projects are financed by the company or group of companies. Figure 2.4 examines the share of Tekes financing for all company projects and separately examines the share for Nokia projects.

Tekes's share of financing for company projects decreased during the 1990s, but in the 2000s, the share again climbed slightly. In the years 2000-2009, Tekes's financing share of all its company projects was 35 percent on average. Around 65 percent of the financing came from other sources, mainly the companies themselves.

Figure 2.4. Share of Tekes financing for all company projects and Nokia projects.



Data source: Tekes
Note: Including NSN.

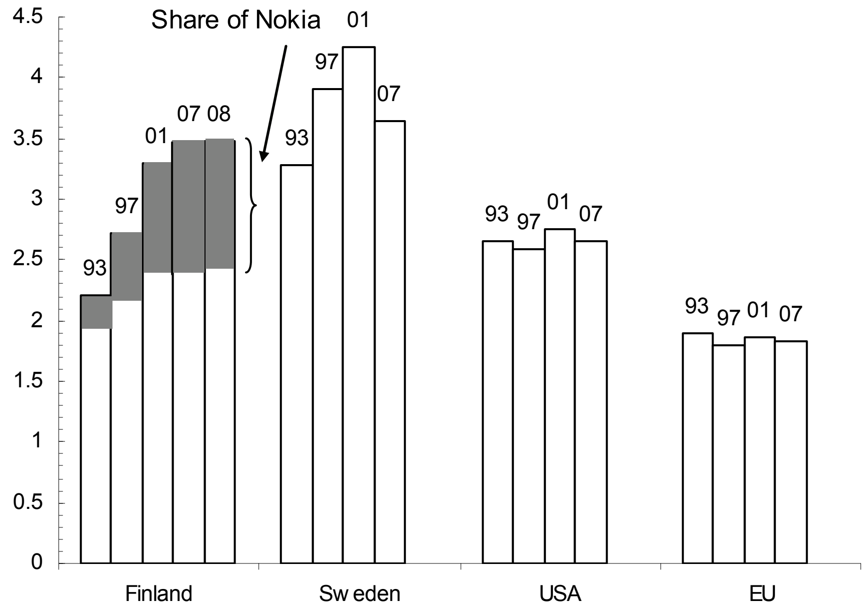
The share of Tekes financing for Nokia projects has been smaller than for company projects on average. In the 1990s Tekes financed 26 percent of Nokia projects on average, while the share of other financing, primarily Nokia's own share, comprised about three fourths of the project's total costs. In 2008 and 2009, Tekes's share of financing for Nokia projects was 27 and 29 percent, respectively. It should be noted that Tekes funds only a small minor of Nokia's R&D project portfolio; hence, the vast majority of R&D projects are funded internally.

FINLAND'S REPUTATION AS A HIGH-TECH COUNTRY

The share of research and development expenditure of the gross domestic product has grown significantly in Finland over the past decades. Since the beginning of the 1990s, relatively more research and development have been conducted in Finland than in the EU on average (figure 2.5).

In the latter half of the 1990s, Finland overtook the United States in R&D intensity. At the end of the decade, it share of research and development exceeded 3 percent of the gross domestic product, which equals the level of R&D in Japan. Relatively speaking, Sweden is most invested in research and development of all the countries in the study.

Figure 2.5. R&D expenditures relative to GDP, %

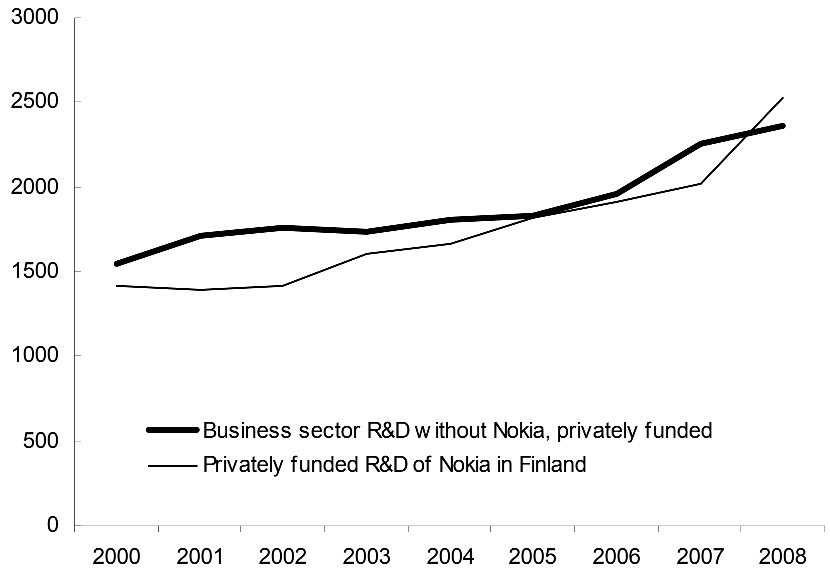


Author's calculations (Data sources: OECD – Main science and technology indicators, Nokia).

If Nokia's share were taken out of the figures, Finland's R&D spending in 2008 would be about 2.4 percent of GDP. However, even then, Finland's R&D intensity would be significantly above the average EU level.

To analyse this issue in more detail, we consider how privately funded R&D expenditures of firms have developed during the past few years (Figure 2.6).

Figure 2.6. Privately funded R&D expenditure performed by firms (Eur, mill.), in current prices.



Data sources: Statistics Finland, Tekes, Author

Figure 2.6 reveals that other firms than Nokia have also increased their R&D activity in Finland. In 2005-2007, Nokia's R&D expenditure (in Finland) grew at a slower pace than the R&D of the rest of the private sector. Nokia's R&D figures for the years 2007 and 2008 are not directly comparable; thus the growth, in that period is upward-biased in Figure 2.6.

To summarise, we can conclude that more research and development takes place in Finland than in the EU countries on average, independent of whether Nokia is taken into account or not.

Nokia's R&D spending has increased significantly since the beginning of the 1990s. Although the company has increased its research and development abroad, R&D expenditures have also grown rapidly in Finland. In 2008, the company's R&D conducted in Finland was approximately 49.5 percent of total business-sector R&D (BERD) and 37 percent of the total R&D expenditure (GERD) in Finland[7].

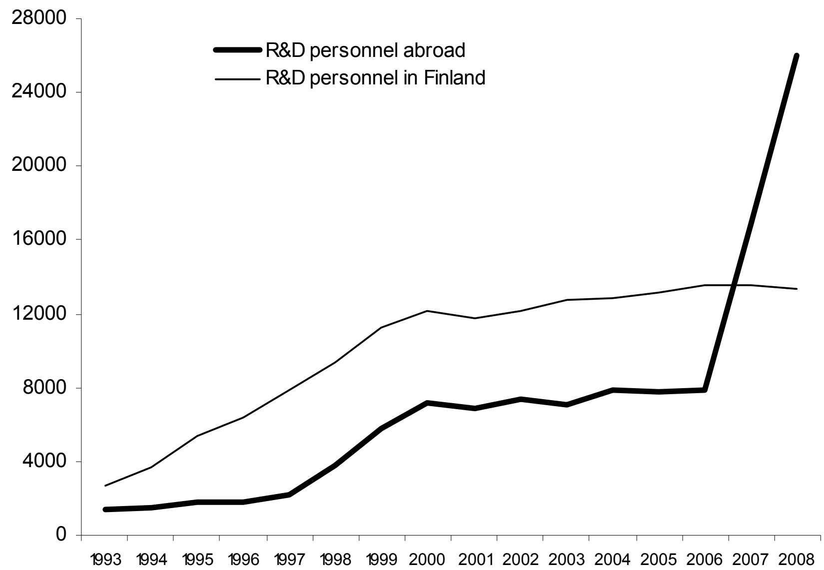
[7] GERD - Gross domestic expenditure on R&D, BERD - Business Enterprise Research and Development

The number of R&D personnel at Nokia has significantly increased during the past fifteen years (Figure 2.7). While in 1993, Nokia employed globally a total of 4,100 R&D employees, in 2008 the figure exceeded 39,300.

In 1997-2000 Nokia's R&D employment outside Finland increased rapidly when the company expanded its in-house R&D network via both greenfield investments and acquisitions.

After that, the pace slowed significantly for several years, but between 2007-2008, the number of non-Finnish R&D employees jumped to a new level as Nokia Networks and Siemens's network divisions merged. Naturally, the R&D personnel from Siemens's network divisions were located mostly in other countries than Finland; hence Nokia's R&D personnel abroad (including those of Nokia Siemens Networks) increased drastically.

Figure 2.7. The R&D personnel of Nokia in Finland and abroad



Note: Due to the merger of Nokia Networks and Siemens' network divisions, the number of R&D employees abroad increased significantly in 2007.
Data source: Nokia

Even though Nokia has established a global R&D site network presence in Europe, the Americas and Asia, Finland has remained an important R&D location for Nokia. Traditionally, a large share of Nokia's R&D employees have worked in Finland. In 2006 (before the merger of Nokia Networks and Siemens's network divisions), more than 60 percent of the total R&D workforce worked in Finland. This kind of home country concentration is not rare among telecommunications equipment manufacturers. For instance, 60 percent of Ericsson's R&D activities are located in Sweden (Tekniikka & Talous 2006), and 60 percent of Motorola's R&D workforce is in the U.S (UNCTAD 2005). This tendency also holds in Asia. Although the leading Chinese telecommunications equipment manufacturer, Huawei Technologies, has established R&D sites in India, Russia, France, US and Sweden, 85 percent of its R&D employees are still in China.

3 Summary and conclusions

There is no doubt that Nokia is the most important single company in the Finnish national economy. Since the early 1990s, the company has contributed significantly to GDP and GDP growth, but annual figures – particularly in terms of contribution to GDP growth – have greatly varied. While Nokia's direct impact on GDP growth reached 2.5 percentage points in 2000, it had turned clearly negative by 2008. Notwithstanding the drop, Nokia still accounted for 2.6 percent of Finnish GDP as of 2008.

Research and development expenditures in Finland relative to the gross domestic product are among the highest in the world. In 2008, R&D expenditures were 3.4 percent of GDP. Only in Sweden was the share higher (3.6%). The high R&D intensity in Finland is largely based on the private sector's research and development investments. Additionally, the public sector financing (R&D support) share of private sector research activity is clearly smaller than in the comparison countries. Nokia's impact on Finland's high R&D intensity is significant. When Nokia's R&D activity is deducted from the calculation, Finland's R&D expenditures relative to GDP are 2.4 percent for 2008. However, it must be noted that even this share is well above the EU average.

In the peak year, 2000, Nokia accounted for a full 4% of the Finnish GDP, whereas currently, it accounts for about half of that. It is unlikely that this share will be restored to its former level.

4 References

Ali-Yrkkö, J. (2001). *Nokia's Network – Gaining Competetiveness from Co-operation*. Helsinki, Taloustieto Oy (ETLA B 174).

Ali-Yrkkö, J. & Hermans, R. (2002). Nokia in the Finnish Innovation System. Discussion Papers No 811, ETLA - The Research Institute of the Finnish Economy, Helsinki.

Ali-Yrkkö, J., Paija, L., Reilly, C. & Ylä-Anttila, P. (1999). *Nokia – A Big Company in a Small Country*. Helsinki, Taloustieto Oy (ETLA B 162).

CNN (2009). Former Samsung chief handed suspended jail term, August 14, 2009.
http://www.cnn.com/2009/WORLD/asiapcf/08/14/korea.samsung/index.html, accessed in January 19, 2009.

David, P. A., Hall, B. H. & Toole, A. A. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. *Research Policy*, vol. 29(4-5), pp.497-529

Eliasson G., Carlsson, B., Deiaco, E., Lindberg, T. & Pousette, T. (1986). *Kunskap, information och tjänster. En studie av svenska industriföretag*. Industriens Utredningsinstitut, Stockholm, Sweden.

Eliasson G., Fölster, S., Lindberg, T., Pousette, T. & Taymaz, E. (1990). *The Knowledge Based Information Economy*. The Industrial Institute for Economic and Social Research, Stockholm, Sweden.

Hariharan, R. (2005). Managing Nokia's R&D in China. Slide show presented in "Global R&D in China - An International Forum", May 28-29, 2005, Nanjing China.

Häikiö, M. (2001). *Nokia OYJ:n historia*. Helsinki: Edita.

Häikiö, M. (1998). Alkuräjähdys. *Radiolinja ja Suomen matkapuhelintoiminta 1988-1998*. Helsinki: Edita.

Kaitila, V., Nevalainen, A., Maliranta, M. & Mankinen, R. (2008). Measuring Productivity - Finland in an International Comparison (in Finnish with an English abstract/summary). ETLA's Discussion Papers No 1143, The Research Institute of The Finnish Economy, Helsinki. Downloadable at: http://www.etla.fi/files/1943_Dp1123.pdf

Maliranta, M. (2009). In Search of an Ideal Method for Analyzing Micro-Level Dynamics of a Great Productivity Leap. Paper presented at the Comparative Analysis of Entreprise Data (CAED), Tokyo, Japan, 2-4.10.2009.

Paija, L. (ed.) (2001). *Finnish ICT-cluster in the Digital Economy*. Helsinki: Taloustieto Oy (ETLA B 176).

Tekniikka & Talous (2006). Ruotsi on halpa tutkimusmaa (in Finnish). The interview of CEO Carl-Henric Svenberg. Tekniikka & Talous 20.4.2006, Talentum.

TCN (2007). The Communications Network (TCN). http://www.tcn-uk.org/cb.aspx?page=D6763515-BCF4-4B86-816D-887E79B66089

UNCTAD (2005). World Investment Report 2005 – Transnational Corporations and the Internationalization of R&D. United Nations, Geneva.

Vodde B. & Yi, L. (2006). An Inspection Improvement Story: Hangzhou R&D. *Software Quality Management*, 8, 5-10.

Arnold, E., Luukkonen, T., Oksanen, J., Thuriaux, B. & Whitehouse, S. (2002). *Evaluation of Finnish R&D Programmes in the Field of Electronics and Telecommunications (ETX, TLX and Telectronics I)*. Helsinki: Tekes (Technology Programme Report 2/2002).

III. TRANSFORMATIONS OF NOKIA'S FINNISH SUPPLIER NETWORK FROM 2000 TO 2008

Timo Seppälä

1 Introduction

Yielding to the powers of a large player in an industry network can be either exhilarating or devastating. That is to say, an enterprise in a weak value chain position may enjoy the benefits of latching on to the enabling vehicle or be thrown off the tracks if it does not act smart and quickly enough. The stakes are raised when the game is not merely with a single enterprise but instead with an entire industry.

The phenomenon of unequal power distribution in industry networks and relevant supply chains is well documented in the business literature. For instance, there are global supplier networks formed around powerful hub companies controlling key value chain activities and resources (Achrol 1997). Similarly, there is business literature about concentrated buyer power, where one customer represents a major portion of industry revenues and growth. Even in well established and stable industries, the effect of an imbalance of power can cause major disturbances in a short period of time among the subordinate supply chain players. (Fine 1998, Porter 2007).

The usual result for the feeble suppliers in a fast-changing business environment is either that they are targeted for acquisition, lose their business, or slowly (and often painfully) undergo a transformation into a new market. The latter is often better served by entrepreneurial enterprises. (Mintzberg 1994, Mintzberg et al. 1998, pp 123-147, 302-347, Teece 1998).

Fine (1998) and Möller and Rajala (2007) point out that one way of managing a supply chain strategy is to control the entire supply chain and/or entire vertical demand-supply networks. This, however, cannot occur for those in weak positions, especially when a supply chain network relies on a single dominating enterprise for strategic and operative decision-making and execution.

Understanding the success or failure of the organisations in such an environment means considering the context of corporate decision-making associated with the industry change and respective organisations over a certain period of time (Whittington 2006). This pattern of supply chain strategy decision-making and execution can be observed from 2000 to 2008 in the Finnish electronics subcontracting network.

This particular industry experienced extraordinary growth at the dawn of the new millennium. With the explosion of the global mobile phone market (averaging 24 per cent growth year over year between 2000 and 2008[8]), the suppliers in the value chain inevitably encountered similar growth. This was especially the case for the electronics subcontracting network, which was responsible for industrialising and manufacturing electronic components, sub-assemblies and printed circuit boards. This subcontracting network closely aligned itself in strategy and geographic proximity to its main customers, the mobile phone companies.

Some recent papers have considered the industry, supplier chain networks, enterprise agglomeration (Baldwin 2009, see also Krugman 1980, 1991) and global transformations of industries from one country to another (Blinder 2006) from the perspective of both macroeconomic environment and strategic thinking and decision-making. Fine (1998) elaborates on the value chain and supply chain changes in a particular industry but does not go into detail regarding the relationship between industry globalisation, regional agglomeration, supply chain strategic thinking and strategic decision-making in different enterprises.

In this article, I extend the existing literature by analysing the strategic and operative behaviour of the Finnish electronics subcontracting network for technology and service enterprises under the influence of industry globalisation and regional agglomeration and under a strategically and operatively dominant player in the industry network.

Thus, I analyse the strategic and operative business behaviour of the Finnish electronics subcontracting industry based on the perspective of three transformations that took place during the extraordinary growth period of the mobile phone industry between 2000 and 2008.

In short, the first transformation is related to the globalisation of the predominantly Finnish electronics subcontracting industry. The second transformation (2004-2007) explains corporate strategic deci-

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[8] http://www.itu.int/newsroom/press_releases/2008/29.html

sion-making as part of the forced supplier clusters and regional agglomeration. Finally, the analysis of the third transformation scrutinises the status quo, providing insight into the next expected transformation.

The qualitative analysis is based on 47 interviews with industry experts, current or former representatives of the case enterprises. The interviews were conducted between November 2007 and November 2009.

The remainder of this paper continues as follows. The next section introduces the global phenomenon of the mobile phone industry from the customer business transformation perspective, paying particular attention to the customer-supplier relationship between Nokia Corporation and the Finnish electronics subcontracting industry. The three transformations of the global electronics subcontracting industry are then discussed in detail, with the implications of those behavioural patterns presented. The final section discusses the next possible transformation and includes concluding remarks.

2 Riding the wave into a mobile world: An overview of the global mobile phone phenomenon

2.1 Market changes and Nokia's supply chain strategy

The demand for the mobile phone surged from 2000 to 2008 as global penetration went from 12 to over 60 per cent in a short time period. The most important changes were new emerging market areas, higher product volumes, different product models, different product form factors, higher product customisation levels and lower average selling prices. Based on these changes, several mobile phone brands quickly started to change their supply chains, moving towards an original design and manufacturing business model. That transformation has continued to this day.

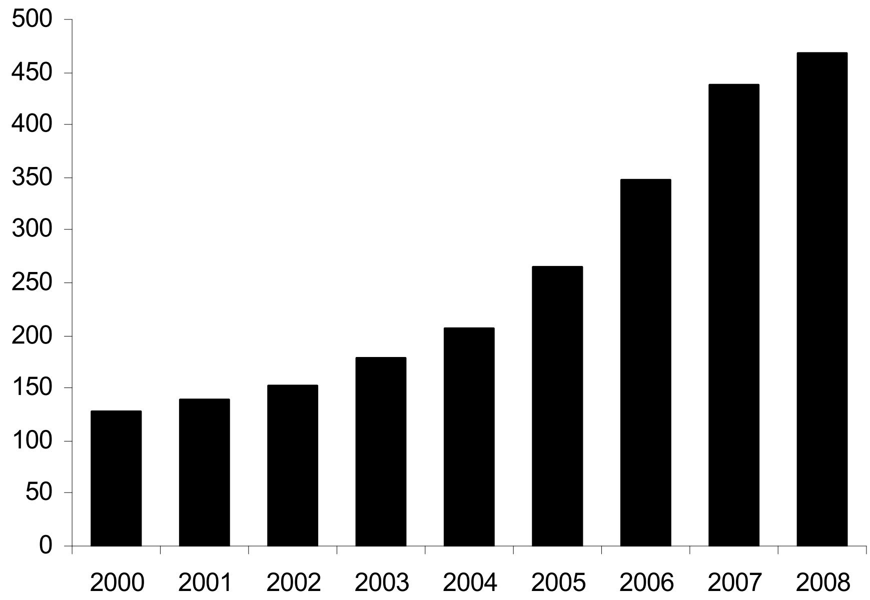
Most of the mobile phone brand owners decided to move ahead with a strategy that minimised their own investments in variable and fixed assets around 2002 – 2003. This caused a massive growth spurt in the Finnish and western supplier network, but even they could not keep up with the rising demand. By early 2003, the original supplier network in the mobile phone industry was running out of capacity and capital due to is own globalisation and customer portfolio management efforts. A new strategy and new players were needed.

In the dawn of the emerging markets, Asia answered the call. Partly due to a regional renewal network, Chinese and Taiwanese suppliers were able to grab hold of the supplier network, assisting with the revolutionary changes that were needed to minimise the technology and service costs.

NOKIA PRODUCT VOLUMES DURING 2000 – 2008

Nokia mobile phone sales were increasing year by year, especially in emerging market areas. New strategic transformations initiatives were needed. These strategic initiatives then helped Nokia to meet its increasing volume requirements and the product needs of the marketplace.

Figure 2.1 Nokia's handset volume in 2000-2008, millions of units



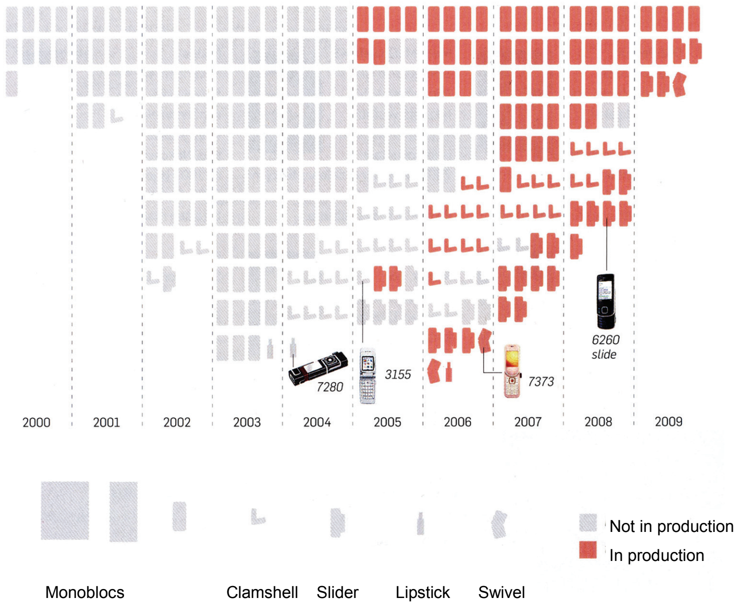
The rapid growth of Nokia's product volume as shown in the graph above meant a great deal of investment in plants, machinery, competence and knowledge not only for the Finnish supplier network but also for Nokia's other suppliers[9]. The Finnish supplier network could not have done it alone in the areas of technologies and services they provided. It would have been catastrophic from the perspective of Nokia volume production if Nokia had relied on just the Finnish supplier network. The Finnish supplier network would also have run out of capital.

[9] In the early 2000s, the Finnish supplier network represented less then 20% of Nokia's total subcontracting.

CHANGES IN NOKIA'S PRODUCT PORTFOLIO

Nokia's product portfolio changed considerably from 2000 to 2008 (Figure 2.2). The mobile phone evolved from a large and heavy mono block product portfolio to include clamshells, sliders and swivels as well. These changes in the product portfolio and product form factors influenced Nokia's decisions in collaborating with its suppliers between 2000 and 2004 and when implementing its supplier network strategy during 2004 – 2007; it also impacts the current situation.

Figure 2.2 Nokia's product portfolio changes (adapted from Kauppalehti Optio 1.10.2009)



Source: Adapted from Kauppalehti Optio 1.10.2009

The changes as described above are usually seen in the product portfolio two years after the actual decisions are made by Nokia executives. For example, the Nokia reaction to the lack of products in the product portfolio in 2000 resulted in an increase of almost 300% in the number of products in the product portfolio for 2002. Another example is the Nokia reaction to clamshell products in early 2003, which resulted in the introduction of ten new clamshell products for the 2004 Christmas market.

Even though there were only ten new clamshell products added to the Nokia product portfolio during 2004, with ten additional clamshell products and seven slider products added a year later, in 2005, the need for capacity in terms of both mechanics and assembly was almost four times greater than in 2003. Additionally, because Nokia did not want to invest in mechanics and assembly capacity, additional suppliers were needed to provide the capacity along with Finnish suppliers.

THE EVOLUTION OF NOKIA'S SUPPLY CHAIN STRATEGY

The major changes in terms of product volume and product portfolio resulted in a situation wherein the globalisation of Nokia's Finnish supplier base started to evolve at the same time as Nokia strengthened its local distribution networks due to increasing demand for its products in Europe, China, Asia Pacific and North America[10].

In the late 1990s, some Finnish suppliers decided to follow Nokia and internationalise their manufacturing operations. At the same time, Nokia began systematically increasing the number of Asian-based suppliers in their portfolio to include more suppliers in Taiwan, China and, later on, India; in this way, the company copied the trends, the integration model and the way forward almost exclusively from the computer and automotive industries and related value chain structures. Moreover, in the electronics industry the period after 2000 saw an intensification of the movements towards low-cost locations.

The breakdown of the company's evolution into three transformations is based on the Nokia business strategy and organisational changes that occurred in three distinct periods: pre-2004, during 2004-2007 and in the current context (Doz & Kosonen 2008). Because Nokia's supply chain strategy implementation in particular followed a similar pattern, this article conceptualises the transformations as taking place in these three periods as well (Figure 2.3).

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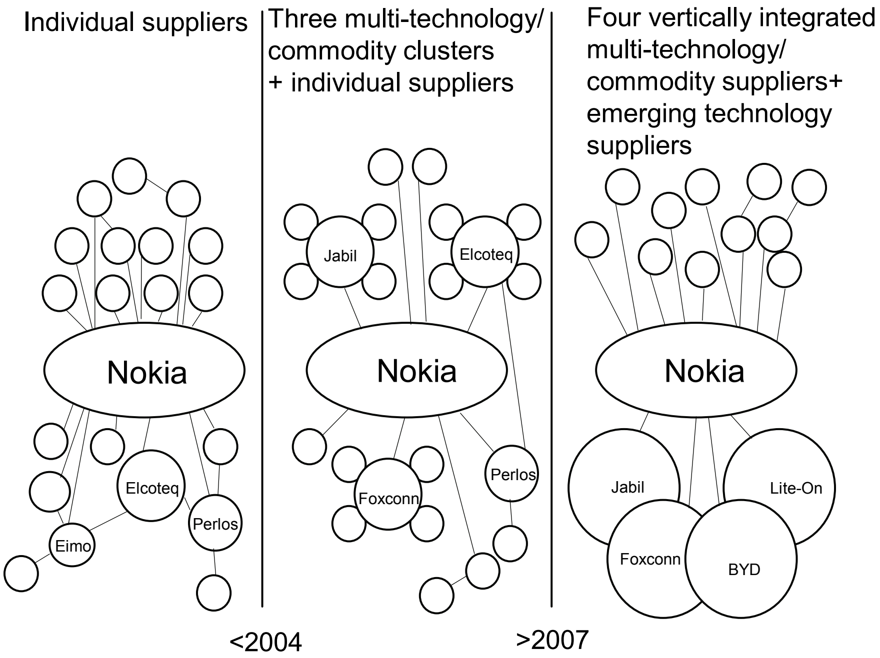
[10] Thus, Nokia had a number of non-Finnish subcontractors already in the late 1990s.

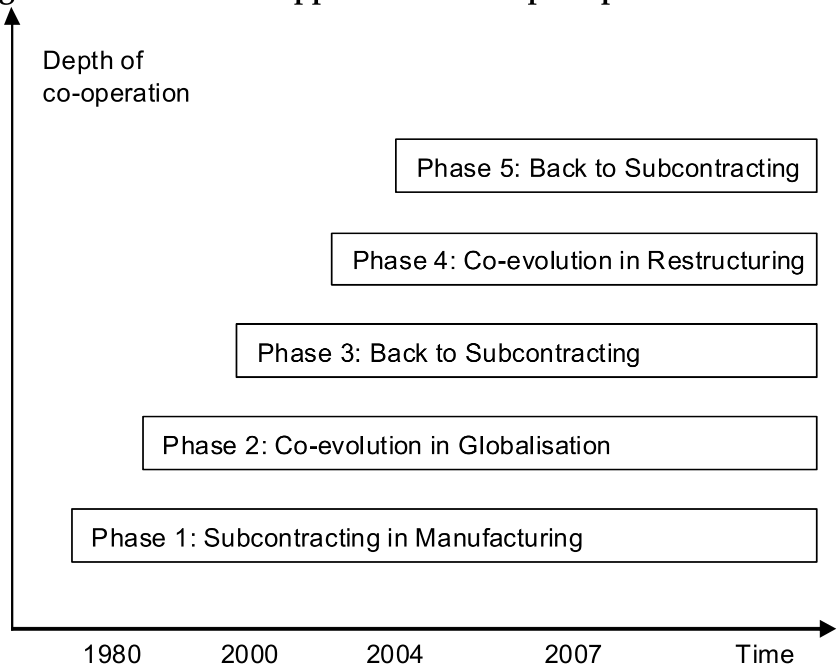
Figure 2.3. Three transformations and Nokia's supply chain strategy from the Finnish suppliers' perspective



2.2 Seduce and squeeze

Some customer-supplier relationships, where no intellectual property rights are involved, can be conceived of as a game of "seduce and squeeze". The seduction occurs when the customer seduces suppliers into investing in additional capacity or additional technologies, and the squeeze occurs after suppliers have expanded their capacity and learned new technologies, when the customer then tightens his belt in a bid for lower prices and more flexible terms of their agreement in practice (Figure 2.4).

Figure 2.4. Customer–supplier relationships in practice



Seduce and squeeze behaviour often emerges in customer-supplier relationships, and some Finnish and other Western suppliers feel that this has happened in their relationships with Nokia.

Indeed, this pattern is seen as having emerged within such a short interval that these suppliers were incapable of reacting successfully to it. This became one of the major obstacles for Finnish suppliers as they attempted to address global technology, service and manufacturing capacity and provide the flexibility necessary for managing that capacity.

2.3 The behavioural patterns of different supplier networks

Enterprises have reacted in different strategic and operative ways to customer business and supply chain strategies as well as to the changes in the marketplace and competition (Figure 2.5).

There are fundamental differences between Finnish suppliers and Asian competitors in their approaches to implementing customer business and supply chain strategies. In the market situation described, the Asian approach proved to be the most efficient.

Figure 2.5. The behavioural patterns of Finnish and Asian suppliers during the three transformations

Finnish suppliers	Growth through co-evolution, investing in global operations	Balancing the customer portfolio through acquiring customer operations	Divesting (customer) business operations
Asian suppliers	Proactive investing in global manufacturing network	Growth through technology and service aquisitions -> vertical integration	Balancing for the need

< 2004 **> 2007**

It seems that the Finnish networks lacked a proper understanding of the changing market needs. Due to changes in Nokia's supplier network strategy, changes in categorisation and changes driven by Asian and other competitors, the Finnish network could no longer predict Nokia's business strategy as easily as they once could. This led to uncertainty and difficulty in strategic and operative decision-making at all levels of the organisations.

3 Pre-2004 transformation

In 1999, Nokia appointed a new head of sourcing. He is currently a Senior Vice President of Sourcing and Procurement at Nokia. His background is in computers, where original design and manufacturing (complete vertical integration) companies were the tier-one suppliers in the value chain in most cases.

After the nomination of the new head of sourcing, Nokia quickly began to adopt new modes of thinking and complete vertical integration. To enable this change, Nokia evolved from a purchasing organisation to a sourcing organisation and further developed its new supply chain management concepts. During that same period, Nokia also began to add Asian suppliers to its supplier portfolio.

Nokia's Finnish suppliers started to globalise their supply chains and manufacturing operations, thus taking their first step towards becoming global players. This happened approximately two or three years later for the Finnish suppliers than for their American competitors because Asians were just entering the game.

> *"In 1999, Nokia took its first steps to internationalise their plastics and manufacturing supplier network and the first audit of Foxconn was made. Later on that same year Foxconn became an approved supplier."* (A former Nokia Sourcing Manager)

In 2000-2002, Foxconn entered the Nokia business in the Asia Pacific region through some mechanics[11] programmes. Foxconn also started manufacturing their first printed circuit board assemblies, and through their success in these areas, they challenged the Finnish suppliers and other suppliers in the Asia Pacific region.

Hon Hai's (later on, Foxconn's) superior casing and mass production capabilities were visible in Acer's newly launched Aspire RC900 and RC500 series PCs. Acer assigned Hon Hai to be the sole supplier

[11] Mechanics includes plastic (e.g. covers) and metal parts and their assembly.

in March 2004 when the SARS outbreak began. Due to travel restrictions, Acer and Hon Hai were forced to communicate concerning design and specification matters through video conference calls instead of personal meetings. Hon Hai still surprised Acer by taking only two months from tooling to volume production to launch these products in the early summer of the year (Lehman Brothers, 2003).

This swift action is why Nokia started using Foxconn increasingly in its programmes. The other reason was that Foxconn had the capital for the necessary technology, service and manufacturing investments.

3.1 Global services locally

While there was pressure to globalise manufacturing operations, some suppliers refused to do so. Protopaja Oy, a small company based in Naantali, Finland, is an excellent example.

> *"Nokia asked us to globalise our operations. First they asked us to come to Hungary and then to China. On both occasions we said no. We wanted to continue operating only in Naantali [a small town located in Western Finland]",* said one of the employees of Protopaja.

Protopaja decided to stay in Finland for very natural reasons. This was typical in the firm's technology segment due to the high capital costs of setting up new industrial and manufacturing operations. Another reason was Protopaja's ability to react immediately to customer needs, which would have been weakened in the multi-plant operation context

> *"As our company name says our strategy has been making prototypes. We were manufacturing component prototypes for Nokia 3310 and suddenly we were investing in mass manufacturing capabilities".* (Employee of Protopaja)

Nokia 3310 is still one of the best-selling Nokia products worldwide, with over 100 million units sold. This was how some Finnish suppliers, like many others, accidentally entered the mass volume business.

3.2 Local services globally

The behavioural pattern that most of the Finnish suppliers followed was that of internationalisation. These firms invested almost blindly in the globalisation of their own industrialisation and manufacturing operations.

From the customer perspective, the change could be described as follows: it was the transformation from regional and centralised research and development, product creation and supply chain networks to a centralised research and development network and a decentralised (global) product creation and supply chain network. In other words, in the late 1990s, most of Nokia's subcontracting decisions were made in Finland, close to Nokia's in-house research and development, product creation and manufacturing. Later on, Nokia started to expand research and development and product creation to other countries like China. Outsourcing was a means of managing flexibility. The technique was basically only used in Europe initially but was later expanded to Asia as well as to the Americas.

Usually when co-operation began between Nokia and its suppliers, Nokia's message to suppliers was very clear, at least from the outsourcing perspective: Nokia outsources manufacturing for risk management purposes and for the sake of cost efficiency and flexibility. Cost and flexibility were the most important in the beginning. In other words, Nokia's manufacturing strategy and its primary aim was first to run its own plant at full capacity, after which it would outsource what its own plants could not handle, and this meant demand fluctuations for suppliers. The strategy was the same throughout the years, and it was repeated in every possible context. Nokia was and is outsourcing just because of the flexibility.

Until the end of 2003, most sourcing decisions were made by Nokia's regional sourcing organisations, and programmes were allocated within particular geographical regions by the organisation in each region. Thus, Europe-related product design programme and manufacturing decisions were made in Finland, Asia-Pacific-related decisions in Hong Kong and America-related decisions in Dallas. As mentioned above, during the same period, Nokia introduced a more powerful global sourcing organisation, starting first as a supplier business development organisation and evolving into a real global sourcing organisation.

Nokia also introduced and started gaining cost benefits from the so-called Nokia XingWang logistics concept, which could be called the first-generation Nokia industrial park. Additionally, this period can be considered the time when Nokia started to implement its supply chain transformation, integrating global supply chain processes and tools into a way to manage the entire value chain.

In the early 2000s, the mechanics technology segment was very fragmented, and the business was divided among several different companies. Table 3.1 below shows the largest suppliers in this market segment per geographical region.

Table 3.1. Nokia's mechanics supplier network during 2000 – 2002

Asia	Americas	Europe	Brazil
Perlos	Perlos	Perlos	Perlos
Foxconn	Triple S	Nypro	Intesys-Metacal
Eimo	Nypro	Eimo	
		Nolato	
		Balda	

As can be seen from Table 3.1, Nokia's global mechanics supplier network was very fragmented, and there was room for improvement from a risk management, cost efficiency and flexibility perspective.

The reason why Brazil is treated as a separate market area is that it has its own set of regulations favouring local manufacturing instead of imports. In that market, Intesys-Metacal was dominant in the mechanics technology segment in Manaus in early 2000 prior to Perlos's announcing its investments in 2002.

Table 3.2 describes the network providing printed circuit board assembly services to Nokia during 2000-2004.

Table 3.2. Nokia's outsourcing* supplier network during 2000 – 2002

Asia	Americas	Europe	Brazil
Elcoteq	Elcoteq	Elcoteq	In-house
GKI			
Foxconn			

* Firms that provide printed circuit board assembly services.

As can be seen from Table 3.2, Nokia was in a very different situation with regard to printed circuit board assembly service outsourcing than with its mechanics supplier networks. Later on, these networks changed significantly. To defend its market position in the Asia-Pacific region, Elcoteq acquired GKI from IBM. However, the competition tightened when Taiwanese Foxconn entered this business segment, after which Nokia used that firm as a price challenger in the Asia-Pacific region. In the Americas and as well in Europe, in 2002, Nokia introduced Jabil Circuit as a new supplier in all outsourcing areas.

> *"Jabil received its first orders from Nokia in the Americas Region in 2002 and began to become a global Nokia Supplier".* (A former Nokia Sourcing Manager)

Assembly, radio frequency card manufacturing and mobile phone engine manufacturing started to play a more important role after the Nokia volume increased and when Nokia did not increase its capacity in its own plants. Volume increased in every geographical region, and therefore, outsourced volumes became attractive to other players. Thus, price competition began in all geographical regions.

Eimo wanted to become the third global plastics supplier for Nokia alongside Perlos and Nypro. However, "*There were too many things happening at Eimo in 2000, and we lacked experience,*" said a former Eimo employee. In 2000, Eimo acquired facilities from another Finnish manufacturer, Ensto, and established manufacturing operations in Pecs (Hungary), near Elcoteq's operations. Later, that strategic decision was considered catastrophic (Seppälä, 2008, pp. 18-27). Eimo acquired competitor Triples S from the U.S. in the same year. Later on, Eimo faced great difficulties in the integration process with Triple S.

> *"For the Finnish supplier network, year 2000 was already too late to enter Asia. We should have done it a couple of years earlier".* (A former Eimo employee)

Eimo's competitor Perlos is basically the only Finnish supplier that built most of its plants from scratch. This means that all its plants around the world are similarly designed to support its core competencies and knowledge. In 2001, however, Perlos decided to expand its service and technology offerings by acquiring the Swedish-based antenna company Moteco AB. Moteco AB was considered an entry-point into the Ericsson Mobile Phone business, but unfortunately, when Flextronics took over Ericsson Mobile Phone in 2002, the Moteco AB investment became almost worthless, especially because Nokia decided not to approve Perlos as its antenna supplier.

> *"Yes, we were delivering antennas to Nokia, but not directly, but always through an approved antenna supplier of Nokia"* [later on, Perlos was approved as an antenna supplier]. (A former Perlos employee)

Another Finnish company, Savcor, succeeded better in its acquisitions. Savcor acquired two niche technology companies: LK-Engineering, a decorative etching company from Denmark, and a flexible circuit antenna manufacturer from Sweden named Swedecal. This helped Savcor to maximise its value added as a one-stop shop for its customers. As a result of the Swedecal acquisition, Savcor introduced antenna technologies to its mobile phone technology portfolio. Later on, Savcor relocated the manufacturing operations of these companies to China. In additions to these acquisitions, Savcor followed Nokia by expanding to the same locations where Nokia's in-house plants were located. For instance, Savcor invested heavily in greenfield operations by establishing units in Beijing, Fort Worth (the U.S.), Manaus (Brazil) and Komarom (Hungary).

> *"We invested heavily, but after a couple of years we noticed our technologies were replaced by other shielding*

technologies and we faced restructuring". (A former Savcor employee)

Unlike Perlos and Savcor, with their vertical technology strategy, Elcoteq decided to implement a horizontal service strategy.

"It was in 2002 when Elcoteq made a strategic decision to stay in the horizontal service model instead of the vertical service model". (A former Elcoteq employee)

At this point, it is clear that the firm's decision to maintain the horizontal model was unsuccessful. A potential reason for the decision was the peer group analysis by Elcoteq.

"Elcoteq compared itself with the wrong peer-group while deciding about its new strategy. They were following what Flextronics, Solectron, Sanmina etc. were doing, not what Foxconn and similar companies were doing". (An analyst monitoring telecommunications companies)

Based on the horizontal strategy, Elcoteq acquired most of its research and development personnel from Benefon and established the Elcoteq Design Center Oy in Salo.

"That was a wrong decision to start design operations in Finland. We should have started either in China and/or India". (A former Elcoteq Design Center employee)

3.3 Products globally

In 2003, Salcomp decided to close down its mobile phone charger manufacturing operations in Kemijärvi and relocate its industrialisation and manufacturing operations from Finland to China. However, it kept its platform design for mobile phone chargers in Finland.

To have a new technology platform designed in Western countries but industrialisation and manufacturing operations in lower-cost locations has become the norm for most of Western electronics companies that exist today.

4 2004 – 2007 transformation

The transformation from a centralised research and development network and regionalised supply chain network to a decentralised research and development (R&D) network and a decentralised (global) supply chain network meant that more and more R&D activities in the mechanics technology segment were moved from Nokia to three different technology and service clusters: Foxconn, Jabil and Elcoteq.

During the same time and earlier, Nokia started to realise the importance of customer variation and product customisation. The firm made the strategic decision to concentrate on assembling to order in its manufacturing sites, copying the Compal/Cisco supply chain and logistics model. Cisco's model was called “a customisation for one”, based on which Nokia's model could be called “mass customisation for one”.

To be able to support its selected customer variation and product customisation strategy, Nokia introduced a cluster strategy: that is, it would be capable of supporting various part technologies and deliveries and would be located close to Nokia’s manufacturing locations.

Also, after realising the above-mentioned changes, Nokia started planning and implementing changes to their XingWang industrial park supply chain and logistics model by introducing some second-tier suppliers to the industrial parks. Later on, these same changes were partly implemented at the Nokia Reynosa industry park in Mexico as well as in Chennai, India and Cluj-Naboca, Romania.

However, there was also another reason to change supplier networks. *“The behaviour among the Finnish suppliers, especially in geographical region Europe, was the main reason why vertical integration became so popular among Nokia Sourcing,”* said a former employee of Nokia. In other words, Europe became too expensive, and it was cheaper to manufacture and transport parts from the Asia-Pacific region to Europe.

At the beginning of 2005, Nokia announced that it would invest in an expansion of the Reynosa Plant, and this led to many changes in the Americas. This investment also meant a number of changes for

Nokia and for Nokia's supplier network in South Korea. Based on that same Nokia decision, a year later, Foxconn entered the Nokia supplier network in the Americas region by promising that it would build a plant to Reynosa, which led to Elcoteq's losing its Americas business in 2006.

Nokia implemented the new global supply chain model, the demand supply network strategy, by dividing its plant network into two basic categories, a low mix/high volume category (volume) and a high mix/low volume (value) category. Brazil and South Korea were treated differently. This new global supply chain model implementation resulted, as an example, in the closing down of Elcoteq's Nokia operations in Tallinn at the end of 2006.

On the other hand, the Nokia Chennai logistics model can be called a second-generation industrial park and demand supply chain management model. This new model meant that only vertically integrated companies like Foxconn, Jabil Cluster (including Perlos) and, later on, Chinese BYD were invited to join the Nokia Chennai Business Park because they had the right vertical technology and service portfolio to support the technologies required for the Nokia product portfolio. All clusters were included in Chennai, making it the high volume plant that it currently is. Before this change, the integrated mechanics and printed circuit board assembly market was divided as follows (see also Figure 2.3):

1. The Elcoteq cluster, later on the Nokia Cluster, including Nypro and BYD;
2. The Jabil Cluster, including Perlos; and
3. The Foxconn Cluster

BYD was under development and basically at the same stage as Foxconn had been at five years earlier. It was investing heavily in different technologies in hopes of becoming a genuinely vertically integrated company. Because BYD was under development, Nokia was forced to preserve some non-vertically integrated companies to support the BYD ramp-up.

Because of vertical integration, Jabil acquired Greenpoint in late 2006, leaving Elcoteq the only EMS (Electronics Manufacturing Services) company without vertical integration in mechanics and some other technologies and raising the question of whether a merger between Perlos and Elcoteq was a lost business opportunity.

Based on the changes in the marketplace and due to emerging vertical integration in the Nokia supplier base, Nokia decided preliminarily to ramp down its business with Elcoteq, one of the reasons being that Elcoteq showed no interest in investing in vertical integration.

4.1 Commodity technology and service clusters

Foxconn got Eimo, Jabil got Greenpoint and Elcoteq got nothing. Because not everything was not occurring as planned with Jabil and Elcoteq, Nokia wanted to create a competitor that would serve as an alternative to Foxconn.

> *"We had one target, we wanted to create a competitor for Foxconn, another Foxconn*", said a former Nokia Sourcing Manage*r*.

From the beginning of this new relationship, BYD started making significant investments in hopes of being able to serve Nokia in the area of mechanics technologies and deliveries worldwide. BYD also listed its operations on the Hong Kong Stock Exchange to obtain additional financing so that it could comply with Nokia's written and verbal supplier requirements.

Because of BYD's willingness to invest, Nokia introduced BYD as a second source for its product programmes, which were basically the Foxconn programs. However, once BYD started to comply with Nokia's supplier requirements, they improved their performance so much that they actually became the main source for some product programmes. Later, the cooperation expanded to other technology areas and deliveries.

This was also when the Elcoteq cluster was renamed Nokia Cluster because Nokia took over the management of the cluster from Elcoteq and all of the Elcoteq cluster members were returned to Nokia's normal supplier base.

> *"BYD became another Foxconn in the end, but it took a lot of effort"* said a former Nokia Sourcing Manager

> *"Too much effort, because we did not succeed with some technologies like mobile phone engine manufacturing*" he continued.

Perlos continued unhesitatingly to invest in its Nokia operations because that was the only way to slow down Foxconn's and BYD's success. The company continued to expand its manufacturing network, remaining close to Nokia's in-house manufacturing locations. At the same time as it continued to invest in Nokia as a customer, the firm struggled with acquiring new customers. Later on, this became one of the key obstacles to the firm's continuing alone.

> *"Perlos was in the brink of deciding to either restructure their customer portfolio and keep Nokia happy, and at the same time investing millions in new customer acquisitions, or finding the right partner to support their vertical integration process*." said a consultant in the telecommunications industry.

Later on, following Foxconn's acquisition of Eimo, Perlos was sold to the Taiwanese firm LiteOn, providing LiteOn with immediate access to Nokia's business and volume. Following the acquisition of Perlos, LiteOn became the fourth vertically integrated company (along with Foxconn, BYD and Jabil) supporting Nokia's sourcing strategies.

The main reason for the acquisition of Perlos, as stated by LiteOn, was Perlos's relationship with Nokia, which provided LiteOn with access to Nokia. Other reasons included Perlos's extensive knowledge of plastics.

For Elcoteq, this was the start of a significant decline in revenue, profitability and cash flow.

> *"Elcoteq's decline started when we at Nokia could not make Elcoteq move towards vertical integration and we then decided to take over the Elcoteq cluster*" said a former Sourcing Manager from Nokia.

> *"Because of our horizontal service strategy we started to lose our manufacturing business... Every time we lost a new project the feedback was the same: 'because you are not vertically integrated' "* said a former Elcoteq employee.

For the first time, the possibility of establishing manufacturing operations in Manaus also started to attract attention. A location in Manaus, Brazil became the verbal supplier requirement because Nokia wanted all clusters to have a presence in all locations. Thus, most of Nokia's first-tier suppliers invested in Manaus. However, Nokia later withdrew the location requirement. The firm realised that there was not enough business for every cluster.

Here is a list of some of the activities that took places in Manaus:

In 2004, Balda acquired Intesys-Metacal, together with Lumberg Brasil, by establishing a 50-50 joint venture. Later, in 2008, Balda acquired the entire stake in the joint venture company.

In 2004, Nypro decided to invest in Brazil because of the opportunity it had missed in not buying Intesys-Metacal. Later on, Nypro decided to withdraw from Manaus, and many other manufacturers made the same decision.

In 2004, Elcoteq began operations in Manaus. In 2006, Elcoteq tripled the size of its facilities.

4.2 Niche technology and service companies

Savcor's niche technology strategy, concentrating on coating technologies, drove that firm into a predicament wherein new technologies were replacing its old technologies. However, Savcor emerged as a winner with regard to the changing technologies and found new business areas, such as camera modules and cosmetics, for its coating technologies.

Building on its niche technology strategy in the mobile phone business, the firm introduced another technology niche: decorating technologies.

Some other companies were not as successful when changes were needed. Aspocomp (providing services for the design and manufacture of high-tech printed circuit boards), for instance, released a new strategy in which it tried to change its company focus, but it did not succeed.

> *"We warned them that their new strategy was very risky and aggressive, but it seems that they did not listen to us".*
> (A former Nokia Sourcing Manager)

The risks proved real, Aspocomp's profitability began to fall and the firm ran out of cash. This was one reason why the firm was forced to sell its manufacturing operations so that Meadville (from Hong Kong) acquired Aspocomp India, Aspocomp China and part of the Salo operations.

On the other hand, what Nokia did globally was identical to what Protopaja did locally in Naantali, Finland. Although Protopaja's business with Nokia was growing, the former started sharing the growth and risk with local suppliers because of the increasing mass volumes.

> *"They [Protopaja] had ten suppliers working for us under the same roof sharing all the fixed costs. That was one of the best decisions they made and in that way they continued to be competitive against the Asian competitors",* said a former Nokia Sourcing Manager.

5 Current status of the Finnish supplier network

Eimo and Perlos have been taken over. Aspocomp has sold the majority of its operations. Laukamo and Elcoteq were left with no business.

After the announcement that Foxconn was building a plant in Reynosa, Mexico, it became quite obvious to Elcoteq that sooner or later, it would lose its business in the Americas. Elcoteq did not change its strategy for reasons that were not made public and did not become vertically integrated – and it was apparent that there was no room in the Nokia supplier portfolio for a company that was just manufacturing mobile phone engines.

Protopaja, Salcomp and Savcor continue to be Nokia's suppliers. These three companies have demonstrated their capability to transform strategically and operationally during the last ten years. One might say that this is thanks to their entrepreneurial mindset at all levels of the organisation.

Protopaja is returning to its original strategy of making prototypes because there are only a couple of programmes still produced in mass quantities. Thanks to what they have learned as a Nokia supplier, they can also successfully attract new customers.

Salcomp invested in India and continues to be one of the market leaders in its technological domain. However, today, all of its manufacturing operations are in low-cost countries, and the majority of its R&D employees are located in China. Savcor continues to invest in three mobile phone technology niches: coatings, antennas and decoration technologies. However, its global manufacturing strategy for these technologies has changed. While earlier, the firm was close to its second-tier customers, it now basically offers one technology from each of one or two locations: antennas from Beijing, coatings from Guangzhou and Reynosa and decorations from Guangzhou and Komarum.

Savcor has succeeded in changing and has also found new business opportunities for its existing mobile phone technology portfolio.

6 Conclusions and discussion

In this paper, I have examined the integration between the industry market changes, how those changes are translated in supply chain strategies by a strategically and operationally dominant player in the industry network and how that dominant player has managed its electronics subcontracting network from 2000 to 2008.

Based on the study, there are three reasons why the Finnish electronics subcontracting network did not survive throughout these three transformations:

All Finnish enterprises ran their own agendas from start to finish in their business relationships with Nokia. They did not enter into real discussions about their collaboration, and there were no private investors interested in financing these enterprises together and integrating them.

In the end, none of the enterprises had enough financial capital on their own to move ahead in adding additional technologies, services/ products into their portfolio, adding production capacity or making the right kind of acquisitions.

None of the enterprises had a globally recognised brand to attract new customers. Most of the Finnish suppliers were unknown in the global marketplace. Additionally, having Nokia in their customer portfolio and playing such an important role was seen as a large risk.

6.1 Structural changes within the global value chain

On the one hand, scale economies push towards complete industry value chains or certain parts of a value chain in one location from whence intermediate and final products are shipped to customers. On the other hand, transportation costs and customer service commitments push towards locating value chains close to consumers. These opposing forces drive decision-making within the different value chains of different industries.

Industry value chain agglomeration or partial industry value chain agglomeration usually increases speed, salience and clarity, reinforcing and enabling firms and their supply chains in executing continual and pervasive incremental operational improvements more efficiently and in a more centralised fashion.

These two factors have operated as drivers behind the scenes when the Finnish (European)-based subcontracting networks have transformed into China-based subcontracting networks. This means that most of the value added contributing to the Finnish economy and most of the design, industrialisation, manufacturing and services provided by the Finnish electronics subcontracting network have been transferred to China and to the different electronics industrial parks in low-cost locations around the world.

6.2 Technology commoditisation

The idea that industries will become mature, business will become saturated, and technologies, services and products will become commodities is a logic that can be followed throughout history.

In the Finnish electronics industry, where everything was "high-tech" in the late 1990s and early 2000s, many of these items have become commodities. On the other hand, it can be said that Finnish suppliers have been unable to renew and restructure their businesses and that and their strategic and operative thinking has not kept up with market requirements.

6.3 Knowledge spillovers between industries, enterprises and individuals

If a firm is to strategically transform and change, attracting talent and experience from other industries and businesses is of the utmost importance. This has been one of the key drivers of success for various Finnish companies, including Nokia, Nokia Siemens Networks, UPM, Kone and Konecranes.

The mobility of top management between industry and business allows enterprises to transform and position themselves according to the requirements set by the other industries and competition. Thus, management mobility is an important channel of knowledge spillovers.

Offshoring and outsourcing phenomena encourage the migration of impersonal technology, service and manufacturing jobs to low-cost locations to minimise the cost of technology, service, and product ownership. However, jobs where personal or face-to-face contact is either imperative or highly desirable remain in locations close to customers and consumers. These opposing forces drive the decision-making in society and business concerning where to locate jobs today and in the future.

6.4 Discussion - Parting thoughts on Nokia's next transformation

In my opinion, this recession is a golden opportunity for Nokia to restructure its supply chain and reselect its outsourcing subcontractors as well as its overall supplier portfolio. I believe that Nokia will move further toward an exclusively ODM (Original Design Manufacturer) -oriented business model, meaning that some additional manufacturing assets and machinery may be sold to newly selected outsourcing partners.

7 References

Achrol, R. (1997). Changes in the Theory of Interorganizational Relations in Marketing: Toward a Network Paradigm. *Journal of the Academy of Marketing Science*. Vol. 25, No. 1, p. 56-71.

Baldwin, R. (2009). *Integration of the North American Economy and New-Paradigm Globalisation*. Center for Economic Policy Research, Discussion Paper No. 7523.

Blinder, A. (2006). *Preparing America's Workforce: Are We Looking in a Rear-View Mirror?* Princeton University. CEPS Working Paper No. 135.

Doz, Y. & Kosonen, M. (2008). The Dynamics of Strategic Agility: Nokia Rollercoaster Experience. *California Management Review*. Vol. 50, No. 3, p. 95-118

Fine, C., (1998). *Clockspeed, Winning Industry Control on the Age of Temporary Advantage*. Basic Books. Pages 6-13, 43-67, 89-104.

Krugman, P. (1980). Scale Economies, Product Differentiation, and the Pattern of *Trade. The American Economic Review,* Vol. 7, No. 5, p. 950-959.

Krugman, P. (1991). Increasing Returns and Economic Geography. *The Journal of Political Economy*, Vol. 99, No. 3, p. 483-499.

Lehman Brothers (2003). *Hon Hai Precision: Seasonal Uptick*. Lehman Brothers Equity Research.

Mintzberg H. (1994). The Fall and Rise of Strategic Planning. *Harvard Business Review*. January-February Issue, p. 107-114.

Mintzberg, H., Ahlstrand, B. & Lampel, J. (1998). *Strategy Safari, A Guided Tour Through the Wilds of Strategic Management.* Prentice Hall Europe.

Möller, K. & Rajala, A. (2007). Rise of Strategic Nets – New Modes of Value Creation. *Industrial Marketing Management*. Vol. 36, pages 895-908.

Saastamoinen, J. (2009). Sivuille katsomatta (in Finnish). *Kauppalehti Optio*. No. 15, p. 18-27.

Seppälä, R, (2009). *Jalo Paananen, yrittäjä*, (in Finnish). Kustannusosakeyhtiö Otava.

Porter, M., (2007). *The Five Competitive Forces That Shape Strategy*. Harvard Business School Publishing Corporation.

Teece, D, (1998). Capturing Value from Knowledge Assets: The new Economy, Markets for Know-how, and Intangible Assets. *California Management Review,* vol 40, No. 3, p. 55-79.

Whittington, R., (2006). Completing the Practice Turn in Strategy Research. *Organizational Studies* Vol. 27, No. 5, p. 613-634.

IV. IS THE INNOVATIVE DOMINANCE OF NOKIA IN FINLAND UNIQUE IN INTERNATIONAL COMPARISON?

Tuomo Nikulainen and Mika Pajarinen

1 Introduction

The emergence of a new, large-scale industry often has a significant impact on the technological landscape of a country. The impact increases over time as an industry develops and grows, and eventually, as the industry matures, its role in the national economy starts to diminish (Abernathy and Utterback 1978). Large-scale technological progress is usually driven by a select number of large multinational companies that have the resources and abilities to take advantage of technological advances. In smaller economies, there are often only a few such companies, or even just one, that may start to dominate the technological landscape of the country over time. Eventually, this dominance should diminish as the industry becomes more mature. One reason for this change may be higher levels of specialisation among the dominant innovators as markets become more defined and increasingly competitive.

This paper will focus on large companies' dominance in innovative activities in selected smaller European countries. This approach should illustrate whether Nokia's dominant role in Finland is unique among small, open economies[12]. In addition, this paper will discuss the changes in technological specialisation that occur over different stages of industry life cycles.

The dominant role of top R&D performers and their technological specialisation will be examined through looking at patents and patent statistics. These data provide a useful proxy for innovative output. As the use of patent statistics has certain limitations, a brief discussion of the uses and misuses of this type of data is included.

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[12] The basic unit of analysis in this article is patent applications but instead of all applications, only those patent applications from top R&D companies that were assigned to the company's home country were included in the study. As all companies included in the analysis are multinational corporations, our focus is their domestic activities and development trends.

The scope of the current research is limited to a small number of selected countries to provide an overview of the role of top R&D performers, or 'national champions', in a domestic context. While this scope can be seen as a limitation, it does allow for a more in-depth analysis of underlying changes in the role of these companies' in a national context.

The rest of the paper is structured as follows. Section 2 will briefly discuss the use of patents in measuring innovative activities. Section 3 will focus on the role of top R&D performers in selected countries, illustrating that the dominance of a single company is not a unique phenomenon. Section 4 addresses changes in technological specialisation in the selected countries and among the top R&D performers. Section 5 concludes with a brief discussion.

2 Patenting as a measure of innovative activities

Patent and associated intellectual property rights (IPRs) have become ever more important in the last decades in an increasing number of industries, not only because of their role in preventing imitation in the globalizing economy but also as bargaining chips in technology development through activities such as licensing and cross-licensing of patents (OECD 2009). In some industries, IPRs are also the basis for technological standards. Thus, the ownership of essential patents, upon which standards are built, is important (Palmberg and Martikainen 2004). Patents have a variety of different characteristics that relate to the efficiency of patent systems, such as the width and length of patent rights; but the key question for this paper is whether patent statistics, including both the number of patents as well as their technological classifications, provide a valid approximation of the innovative activities of companies.

Patent statistics should be seen as an intermediate output measure for innovative activities (Griliches 1990). R&D investments represent input to the innovative processes within companies, whereas innovations are products and processes successfully commercialised in markets. Patents lie somewhere in between. They are not direct inputs for the internal innovative processes of companies, nor are they innovations that have been commercialised, although they may be someday. Patents indicate a certain level of inventive activity within companies, which is a preliminary stage for actual commercialisation. In fact, only a small number of patents are commercially valuable and can be seen as innovations (Harhoff et al. 1999).

The advantage of using patent statistics as an intermediate innovation indicator is that they are readily available, with only a short lag from the actual innovative activities within companies (Griliches 1990). They are also fairly objective, as they are screened by external examiners in patent offices who determine whether or not the patent application is valid. The main drawback of using patent statistics is that they usually do not measure inventive activities related to process innovations but, instead, mostly relate to product innovations. The degree to which this is a problem depends on the industry in question. In industries where components and equipment are related end products (for example, electronics), patents play a key role in protecting intellectual property rights. In other industries, manufacturing processes are more important, and they are better protected by means other than patents, such as secrecy (Cohen et al. 2000). Another drawback of using patent statistics is that national patenting activity is partly a reflection of company's patenting strategy. As patent protection is national, patents for companies operating in global markets are filed in countries with biggest sales (both for company itself and its competitors) and also in countries, where the risk of patent litigation is the highest.

Even when taking into account the shortcomings of patent statistics, it is evident that they are and will continue to be used widely as indicators of innovative activity. Patents are used by policymakers, analysts and other parties, such as OECD, for measuring technological development and identifying national differences in technological specialisation.

3 The role of top innovators in selected European countries

The main focus of this paper is the role of top R&D performers in selected countries. Through a comparison of patenting activities of the top R&D performers, this paper aims to inquire whether it is typical for a single company to dominate innovative activities in individual countries. To shed light on this issue, a comparison of patenting activities in a sample of small, open economies in Europe is presented in the following figure 4.1.

The top R&D company for each country was identified from the 2008 EU Industrial R&D Investment Scoreboard (European Commission 2008), and patenting data were extracted from the OECD PATSTAT database based on EPO (European Patent Office) applications by filing date. The basic unit of analysis in this paper is patent applications, which were assigned to the country of interest if at least one patent applicant was from that country. This method means that only those patent applications from top R&D companies that were assigned to the company's home country (not all of the company's applications) were included in the study. As all companies included in the analysis are multinational corporations, this focus allows us to highlight their domestic activities and development trends.

The EPO patent application data are used instead of data from domestic patent offices (for example USPTO - United States Patent and Trademark Office) for two reasons: 1) application data allow for the identification of a wider range of activity than granted patents and are more readily available after 18 months from the filing of the application, thus providing a more detailed account of the recent activities of the top R&D companies; and 2) EPO patents may be more relevant for European countries, such as the ones analysed here, and, due to higher application costs, EPO patents may be of higher quality than domestic patents (Moed et al. 2004). The drawback in using EPO application data compared to, for example, U.S. patent data is that the U.S. patent system allows for the patenting of software and even business models, which would provide a wider range of patents (Hall and

MacGarvie 2006). In the EPO, only technological patents are allowed. At the same time, many scholars argue that the broad applicability of the U.S. system has also deteriorated the use of patent statistics because the quality of these non-technical patents is highly debatable (Hall et al. 2003). In addition, U.S. patent data does not provide a long time-series of application data since it is available only from 2000 onwards.

The countries selected for the study were Austria, Denmark, Finland, the Netherlands and Sweden, all of which possess somewhat similar economic characteristics (e.g., population size, level of GDP per capita, and welfare system) and industry structures (a mixture of traditional and high-tech industries, with a prevailing shift from manufacturing to services). As shown in Table 4.1 and Table 4.2 below, the companies and industries represented in the analysis are some-what diverse, ranging from medium-tech areas, such as steel, to high-tech areas, such as telecommunications.

Table 4.1. Top R&D performer by country

Country	Top R&D performer	Industry	Industry description
Austria	Voestalpine	Steel	Steel; special steel, and steel products for railway, cold-rolled tubes, automotive industries
Denmark	Novo	Pharmaceuticals	Pharmaceuticals related to diabetes care, haemostasis management, growth hormone therapy, hormone replacement therapy
Finland	Nokia	Telecommunications	Mobile phones, telecom networks
Netherlands	Philips	Electronics	Electronics related to healthcare, consumer lifestyle, lighting
Sweden	LM Ericsson	Telecommunications	Mobile phones, telecom networks

Notes: Novo (Denmark) includes Novo Nordisk and Novozymes and their predecessors; Philips (Netherlands) was selected instead of EADS because of stronger historical ties to the country; and LM Ericsson (Sweden) includes Sony-Ericsson. The source of company rankings: European Commission (2008). Industry descriptions were adapted from companies' annual reports.

Table 4.2. Some key figures for the top R&D performers (2008)

	Turn-over, bill. euro	Total employ-ment	Employ-ment in the home country	Global R&D expendi-ture, bill. euro	Global R&D expenditure, % of turnover
Nokia	50.7	125,829	23,320	5.97	11.8%
Ericsson	21.7	78,740	20,155	3.49	16.1%
Philips	26.4	121,398	n/a	1.60	6.1%
Novo Nordisk	6.1	27,068	13,050	1.05	17.2%
Voestalpine	11.6	41,216	n/a	0.12	1.1%

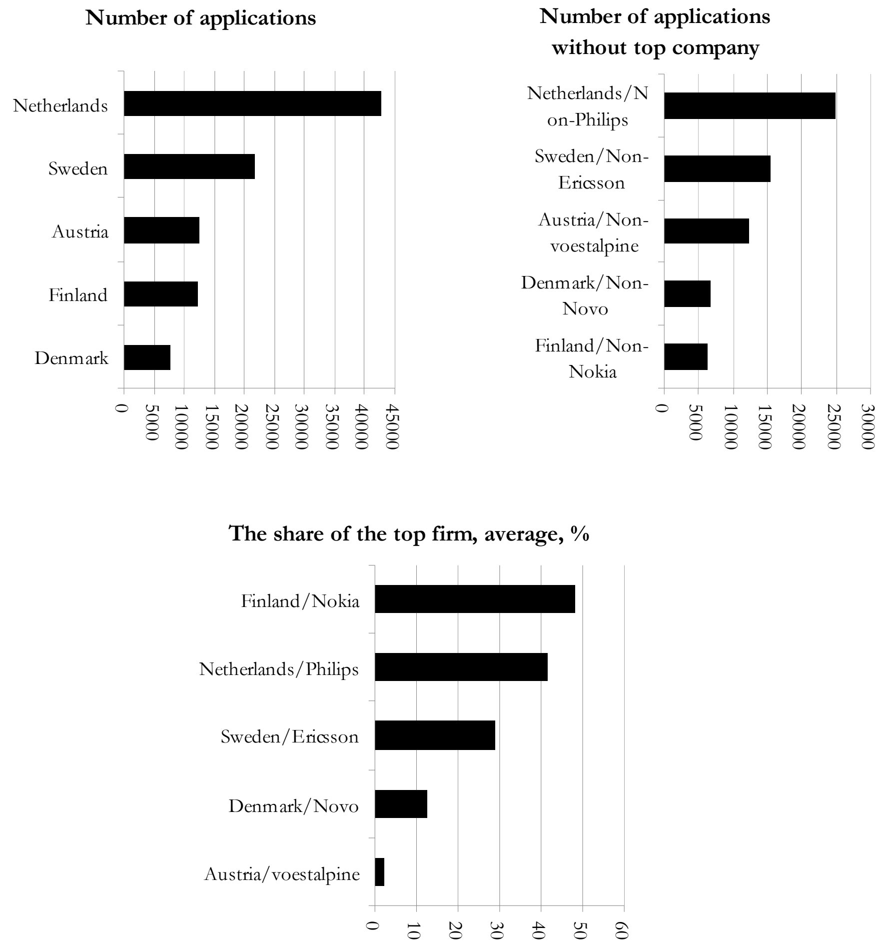
Notes: Ericsson's (Sweden) figures include a 50% share of Sony-Ericsson.

Source: Companies' annual reports

From Table 4.2, it is evident that Nokia is by far the largest company when measured through turnover, employment and R&D expenditures.

To illustrate the role of these companies in their home countries, Figure 4.1 provides summary statistics for the period 2000-2006. The top left figure indicates the total number of EPO applications for the respective countries for the period in question. The top right figure shows the number of patent applications without the top R&D company. The bottom figure provides the share of patents filed by the top R&D performers per country.

Figure 4.1. EPO applications - summary (2000-2006)

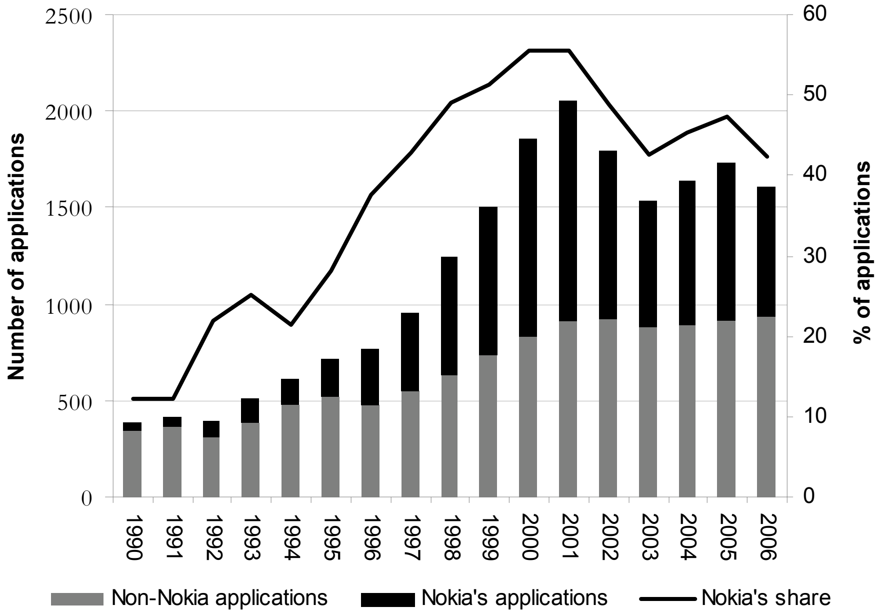


Data source: OECD PATSTAT database, calculations by the authors.

Note: Only those patent applications from top firms that were filed within the country in question have been included in that firm's and country's data.

The most enlightening figure in Figure 4.1 is the bottom one, which indicates that Nokia is very dominant in Finland's patenting activities. In the Netherlands, Philips has almost as dominant a role, but it should be noted that Philips operates in a broader set of technological areas, whereas Nokia focuses mostly on a single technology area: telecommunications (see Table 4.1). In Sweden, Ericsson has a lesser role, with only a 28% share of all Swedish EPO applications. While it is a notable share, the technological landscape is broader in Sweden (for example, in pharmaceuticals), as will be shown in following sections of this paper. In Denmark, the top R&D performer - Novo group - has a 12% share of applications. In Austria, Voestalpine has a small share, with only 3% of all applications. The figures presented in Figure 4.1 are for the period 2000-2006. The following figures (Figures 4.2-4.6) display the developments over time, and trends in each of the selected countries are analysed to highlight the evolution of patenting activities and the role of the top R&D performers.

Figure 4.2. Nokia's share of EPO patent applications in Finland

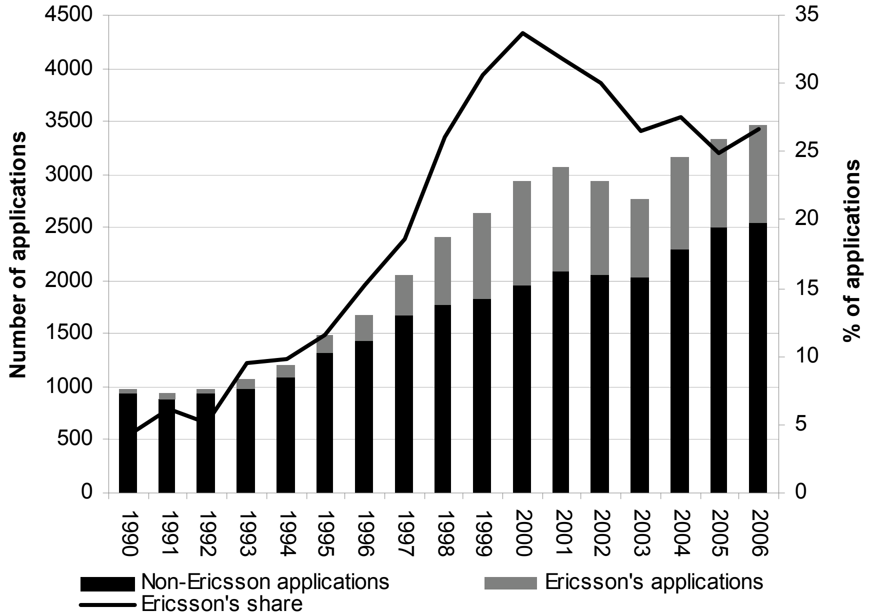


Note: including NSN.
Data source: OECD PATSTAT database, calculations by the authors.

As shown in Figure 4.2, the overall trend in Finnish patent applications peaked in the year 2001 after a period of rapid growth. The number of applications rose more than fourfold from 1990 to 2001. Since the peak, there has been a slowdown in patenting activities. This is partially explained by the decrease of patenting by Nokia. Nokia's share of all Finnish patent applications rose from about 12% in 1990 to 55% in 2001, indicating a strong dominance in the domestic technological landscape.

In the last several years, that share has dropped to around 45%. Interestingly, non-Nokia patenting has remained fairly stable since the peak year of 2001, and the overall downward trend is largely due to Nokia's decreasing activity. The reason for this downward movement in recent years may involve several factors, such as reorientation to services at the expense of technology development, more active licensing from external sources, patenting activity becoming less domestic or technological specialisation occurring due to maturing industry structures.

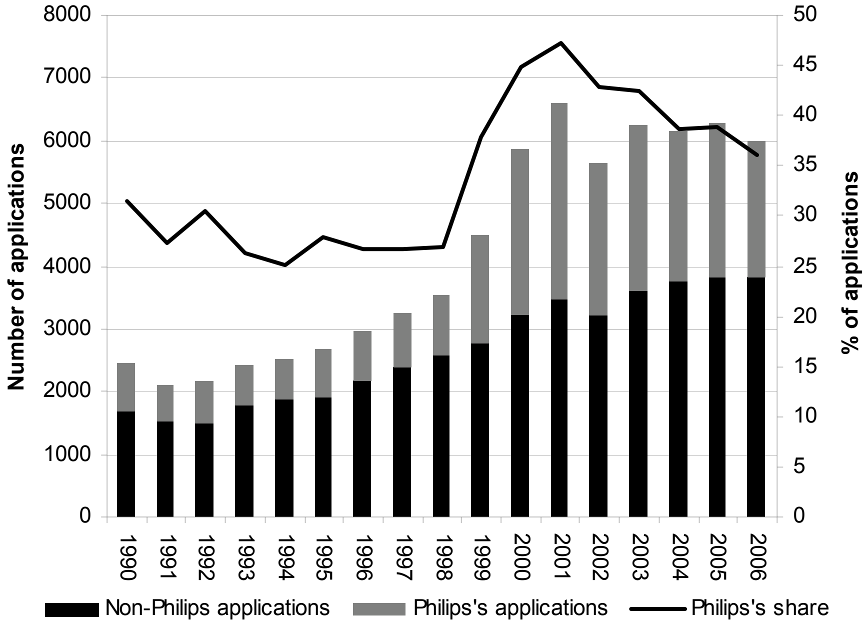
Figure 4.3. Ericsson's share of EPO patent applications in Sweden



Data source: OECD PATSTAT database, calculations by the authors.

Figure 4.3, above, indicates that patenting activity in Sweden has a somewhat more steady growth trend than Finland, which may be partially explained by Sweden's more diversified technology landscape. For Ericsson, 2000 is the peak year for its share of all Swedish patent applications, during which it accounted for 34% of all activity. The share grew very rapidly from 1990 to 2000, after which it has decreased slowly. Ericsson's volume in patenting is fairly similar to Nokia's role in Finland, but it has always accounted for a smaller share of applications than Nokia in Finland. Looking at the non-Ericsson applications, it is also evident that Swedish patenting activity has grown steadily regardless of developments in telecommunications.

Figure 4.4. Philips's share of EPO patent applications in the Netherlands

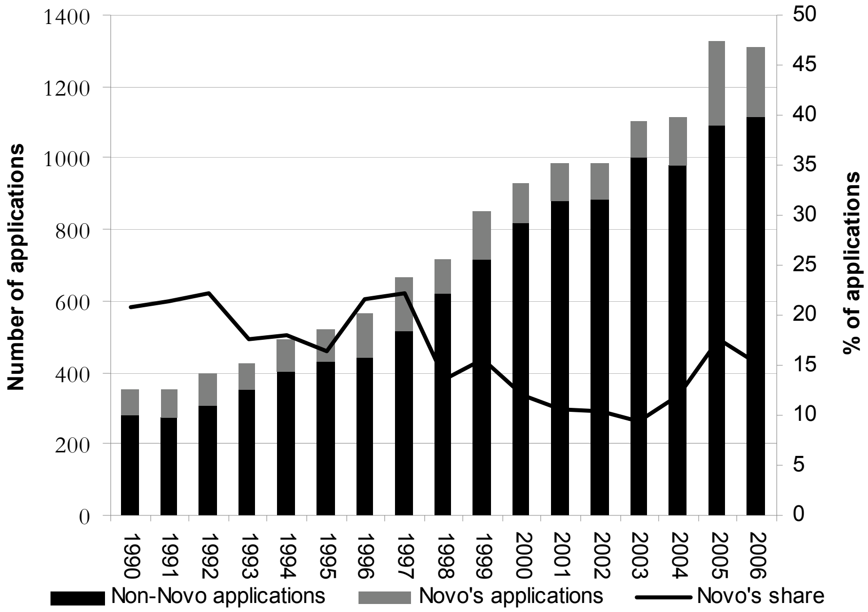


Data source: OECD PATSTAT database, calculations by the authors.

From Figure 4.2, one can see that the role of Philips in the Netherlands follows a fairly similar path to Nokia in Finland and Ericsson in Sweden. The peak year for Philips's share of applications was 2001, which was preceded by a steady share for most of the 1990s and then rapid growth in the late 1990s. Philips's share then went into a slow decline after 2001.

As in Finland, overall patenting activity in the Netherlands has slowed down after the peak of 2001. Non-Philips patenting has remained steady, and Philips's share has declined. The reasons for this development may be similar to those of Nokia in Finland.

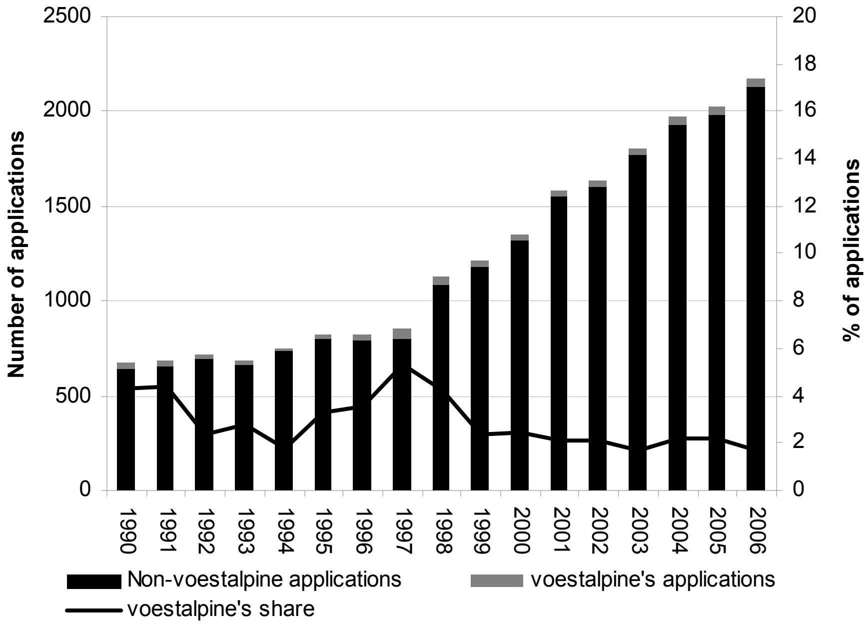
Figure 4.5. Novo's share of EPO patent applications in Denmark



Data source: OECD PATSTAT database, calculations by the authors.

Figure 4.5 illustrates the role of Novo in Danish patenting. Novo's share has been lower than in the countries discussed earlier and has been within the range of 10-20% of all Danish patent applications. Overall, patenting activity in Denmark seems to be fairly independent of Novo's role. This may relate to the industry in question, as the previously discussed companies represent industries where patenting plays a more significant role than in pharmaceuticals. That being said, patents are important in pharmaceuticals but do not play the critical role in standard-settings and cross-licensing there that they do in the telecommunications and electronics industries.

Figure 4.6. Voestalpine's share of EPO patent applications in Austria



Data source: OECD PATSTAT database, calculations by the authors.

Figure 4.6 shows that in Austria, top R&D performer Voestalpine only accounts for a marginal share of the country's patenting activity. One of the main reasons for this situation may be that the steel industry is very process-orientated. Thus, IPRs are protected by other means, as discussed earlier in this paper.

One of the key insights from the figures above is that peak patenting activity in Finland, the Netherlands and Sweden occurred in the years 2000 and 2001. Each country's peak year is followed by a slow decline in the number of applications, which, interestingly, coincides with the decline of the shares of the top R&D performers. In Denmark and Austria, the patenting trend has been increasing steadily, and the share of the top R&D performers seems to be fairly stable over the years.

These different trends may reflect differences in the industries to which the companies belong. In electronics (Philips) and telecommunications (Nokia and Ericsson), changes in the division of labour among different parts of the value chain may have had an impact on patenting activity. It may be that the companies have become more technologically focused and have begun leaving some parts of technology development to their suppliers instead of developing all relevant technologies in-house. This change would lead to higher specialisation in the top R&D performers in these industries, where IPR developed by other parties is accessed through licensing and cross-licensing. In pharmaceutical (Novo) and steel (Voestalpine) industries, such a breakdown of the value chain may not have happened, and thus, the level of patenting activity is more stable and technological specialisation has remained similar over time. To shed more light on the issue of technological specialisation, the next section will focus on changes in the technological specialisation of the selected countries and companies.

4 Technological specialisation

To assess technological specialisation, the same patent application data is used in greater detail. Patent publications include a variety of useful information. In the context of technology specialisation, the most valuable information is the technological classification of the patent. This information allows us to follow patenting trends in specific technologies.

The following analysis of technological specialisation focuses not on the volume of activity in specific technological classes but on the overall portfolios of the countries and the companies and the development of these portfolios over time. For this reason, the analysis uses an index that provides information on the concentration level of patent application portfolios. The Herfindahl index is more commonly used in the context of estimating market concentration as competition authorities to estimate the impact of mergers and acquisitions on market dynamics. In this paper, the index is applied in a different context, in which it does provide information on the technological concentration of companies (i.e. technological specialisation) similar to that which it provides on market concentration. The Herfindahl index is as follows:

$$H = \sum_{i=1}^{N} s_i^2 \quad ,$$

where s is the number of patents in technology area i divided by the total number of patents for each year. These are then summed up to provide the technological specialisation index H. In the following section, the level of technological specialisation is discussed on a fairly detailed level, where applications are categorised into 30 different classes (for more details on the classifications and categories see Appendix I). The technological specialisation index ranges from 0 to 1, where a value of 0 indicates absolute non-specialisation and a value of 1 indicates absolute specialisation in a single technology. This index number has been multiplied by 100 to make the differences between various countries and companies more clear. To give an example, a country or a company that is specialised in one technology with some patents in other technologies will have a high value in the index, and a country or a company with patents evenly distributed across different technologies will have a low value in the index (Table 4.3).

Table 4.3. Technology specialisation indexes for 1991-1999 and 2000-2006

Country	Period	Index - country (average)	Index – top company (average)	Index – country without top company (average)
Finland	1991-1999	12.90	65.06	5.89
	2000-2006	17.12	50.21	5.77
Sweden	1991-1999	6.44	51.71	5.40
	2000-2006	9.88	58.60	5.76
Netherlands	1991-1999	4.79	13.80	5.10
	2000-2006	5.71	14.83	5.13
Denmark	1991-1999	5.83	25.18	5.17
	2000-2006	5.99	20.87	5.38
Austria	1991-1999	5.68	27.36	5.82
	2000-2006	6.04	27.10	6.16

Data source: OECD PATSTAT database, calculations by the authors.

Looking first at the technological specialisation index on the country level, it is obvious that Finland is almost twice as specialised as Sweden and almost three times more specialised than the other countries. All countries exhibit a growing trend towards more specialised patent profiles. The higher degree of specialisation in Finland is largely explained by Nokia's dominance, as shown by the last column in Table 4.2, where the specialisation index without the top company is presented. The results are strikingly similar across countries, suggesting that without the countries' top companies, their levels of specialisation are practically even.

In the second column of Table 4.3, a comparison of the technological specialisation of the top R&D performers reveals that the companies have very different levels of specialisation. Nokia and Ericsson are clearly more specialised compared to the other companies. This is mostly explained by the characteristics of the industry, as the telecommunications industry is not only very IPR-orientated but also highly focused on specific technological areas, such as telecommunications, information technology and control and measurement technology. The other companies represent a more diversified set of industries: electronics, pharmaceuticals and steel. For this reason, comparing them to telecommunications is difficult. Philips operates, to some extent, in the same areas as the two companies that specialise in telecommunications, but it is active in a broader set of technologies, as it manufactures a wider range of electrical equipment. This diversification explains its low level of technological specialisation. Novo and Voestalpine have moderate levels of specialisation, which can be seen as typical for industries in which patenting plays a less significant role when compared to the high-tech industries.

The trends in the technological specialisation of companies provide further details. In the 2000s, Nokia began to diversify its technological portfolio. This trend may be explained by its extensive standard-setting activities in the 1990s and its shift in 2000s from pure technology provider towards offering integrated services that are built heavily on software in addition to hardware. Ericsson seems to have a somewhat different specialisation profile than Nokia, which has led to higher specialisation in the 2000s. All the other companies have a fairly stable level of specialisation, which may relate to the overall low levels of specialisation in their industries.

One aspect that the technological specialisation index does not capture is the role of individual technologies. For this reason, Table 4.4 presents countries' share of the top technology based on the total number of patent applications in each class (for the top three technologies, see Appendix II).

Table 4.4. Share of patent applications for the top technology

Country	Period	Country		Top company		Without top company	
		(average)	Technology	(average)	Technology	(average)	
Finland	1991-1999	29%	Telecommunications	76%	Telecommunications	12%	Thermal processes
	2000-2006	37%	Telecommunications	67%	Telecommunications	11%	Thermal processes
Sweden	1991-1999	14%	Telecommunications	70%	Telecommunications	10%	Medical technology
	2000-2006	25%	Telecommunications	75%	Telecommunications	12%	Pharma and cosmetics
Netherlands	1991-1999	10%	Telecommunications	27%	Telecommunications	8%	Chemical engineering
	2000-2006	13%	Telecommunications	25%	Telecommunications	9%	Pharma and cosmetics
Denmark	1991-1999	11%	Biotechnology	38%	Biotechnology	8%	Civil engineering
	2000-2006	13%	Pharma and cosmetics	28%	Pharma and cosmetics	11%	Pharma and cosmetics
Austria	1991-1999	11%	Civil engineering	36%	Materials and metallurgy	11%	Civil engineering
	2000-2006	14%	Pharma and cosmetics	42%	Materials and metallurgy	14%	Pharma and cosmetics

Data source: OECD PATSTAT database, calculations by the authors.

Table 4.4 provides further insights into the technological specialisation of the countries and the top-performing R&D companies. On the country level, telecommunications technologies play a dominant role in Finland, Sweden and the Netherlands, whereas in Denmark, biotechnology and related pharmaceuticals play an important role, and in Austria, civil engineering-related patenting is most prevalent. These results are, naturally, quite similar to those of the top R&D companies.

Nokia's most important technology class, telecommunications, accounts for around 70% of all its patent applications. For Ericsson, the situation is fairly similar for the same technology (around 72%). Philips operates in a broader set of technologies, which is apparent in its share of the most important class (around 26%). As discussed earlier, Novo and Voestalpine exhibit moderate levels of specialisation, which is also evident from their moderate shares of their countries' main technologies.

The last column of Table 4.4 provides us with details on countries' leading technologies without the top company. This shows that the technological landscape of each country would be very different without its top company. In Finland, thermal process-related patents would be most important, relating mostly to the machinery industry in Finland. In Sweden, medical technologies and pharmaceuticals would be the main technologies. In the Netherlands, chemical engineering and pharmaceuticals would prevail. In Denmark and Austria, civil engineering and pharmaceuticals would be the most dominant technologies.

5 Concluding discussion

The answer to the main research question of this article, "*Is the innovative dominance of Nokia in Finland unique in international comparison?*", is less straightforward than one could assume a priori.

Looking at Nokia's share of EPO patent applications, it is evident that the company has played a very significant role in the technological landscape of Finland, particularly since the mid-1990s. While that share has declined in recent years, there is no doubt that Nokia will continue to dominate patent statistics in the near future. In Sweden, Ericsson has been less dominant, but this can be partially explained by the broader technology base in Sweden. Philips has a level of dominance in the Netherlands similar to that which Nokia has in Finland, but since Philips is active in a broader set of technologies, its dominance may be due to its multi-technology approach (compared to Nokia's fairly focused technological portfolio). In Denmark and Austria, the top R&D performers seem to be far less dominant, which is partially explained by the industries they represent (pharmaceuticals and steel).

To provide more insight into companies' innovative dominance in their respective countries, technological specialisation of the selected countries and the top R&D companies were examined. The results clearly show that Finland is the most specialised country of the selected sample, largely due to Nokia's dominant role. The individual company results indicate that Nokia and Ericsson are highly specialised, whereas Philips is less specialised due to its broad technological base. When comparing the share of patenting activity to the technological specialisation, interesting results emerge. Whereas Philips is dominant in its national context, it represents a broad set of technologies. Ericsson, on the other hand, is less dominant in Sweden, but it is more focused on a limited set of technologies. Nokia, by contrast, is very dominant in Finland and quite specialised in a limited number of technologies. This indicates that the technological landscape of Finland is quite skewed.

The findings from the analysis do not suggest that Nokia should diversify its patent portfolio or its technological profile. In fact, Nokia has actively diversified its activities towards services and software, neither of which is captured by patent statistics. For policymakers, the results of the analysis could be seen as somewhat alarming. For future development and economic prosperity, it is necessary for a country to have more the one stronghold. For this reason, policymakers should actively pursue and facilitate the broadening of Finland's technological landscape. Especially when taking into account the recent downward developments in the traditional strongholds of the Finnish export industry, such as paper and pulp, this conclusion appears stronger still.

This article provides insight into the role of top R&D companies in selected European countries. In future research, taking into account the global activities of the top R&D performers, not only to highlight the degree of internationalisation but also to identify the technological areas in which the internationalisation is most prevalent, would be a useful and complementary approach. These developments may have significant consequences for the future development of Finnish industries.

6 References

Abernathy, W. & Utterback, J. (1978). Patterns of Innovation in Industry. Technology Review, 80(7), 40-47.

European Commission (2008). The 2008 EU Industrial R&D Investment Scoreboard. , Retrieved 31.4.2009 (http://iri.jrc.ec.europa.eu/research/scoreboard_2008.htm)

Griliches, Z. (1990). Patent Statistics as Economic Indicators: A Survey. *Journal of Economic Literature*, Vol. 28:4, 1661-1707.

Hall, B., Graham, S. & Harhoff, D. (2003). Prospects for Improving U.S. Patent Quality via Post-grant Opposition. NBER Working Papers no. 9731.

Hall, B. & MacGarvie, M. (2006). The Private Value of Software Patents. NBER Working Papers no. 12195.

Harhoff, D., Narin, F., Scherer, F.M. & Vopel, K. (1999). Citation Frequency and the Value of Patented Innovation. *Review of Economics and statistics*, 81 (3), 511-515.

Cohen, W., Nelson, R. & Walsh, J. (2000). Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not). NBER working paper no. 7552.

Moed H., Glanzel W. & Schmoch U. (2005). *Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems*. Kluwer Academic Publishers.

Nikulainen, T., Pajarinen, M. & Palmberg, C. (2005). Patents and Technological Change – A Review with Focus on the FEPOCI Database. ETLA Discussion Papers no. 984.

OECD (2009). OECD Patent Statistics Manual. OECD, Paris, France.

Palmberg, C. & Martikainen, O. (2004). The Finnish Telecom Sector Facing Next Generation Standards - Indigenous Capabilities Versus R&D Alliances. ETLA Discussion Papers no. 949.

V. THE VALUE CREATION OF MOBILE PHONES – THE CASE OF NOKIA N95

Jyrki Ali-Yrkkö

1 Introduction

During the past few decades, industry value chains have expanded and globalised. Products and services typically require a number of value-creating activities and phases, performed by different companies and located in different regions and countries. The manufacturing process of final products typically consists of a number of phases, including component manufacturing, sub-assemblies and final assembly. These phases or steps have been dispersed to different companies and regions. Diversification is not limited to manufacturing operations but also includes R&D (research and development) activity and distribution channels.

Because GDP (Gross Domestic Product) can be measured as the sum of the values added by all organisations in a national economy, it is important to know where value added – gross output minus intermediate consumption – is created.

In this article, we concretise the operations of global value chains by taking a detailed look at a single product. We choose the Nokia N95 handset as our case example. The N95 was launched in September 2006 and can be described as Nokia's flagship device with a number of technological innovations. The N95 started shipping in the first quarter of 2007, and by February 2008, more than 7 million units were sold (Nokia press release, February 11, 2008). Therefore, the N95 can be considered an example of a commercially successful model with a number of novel technological features. In 2007, the retail price of the N95 without sales tax was $749 (EUR 546.5) in the U.S[13]. This price is the total value added of the product, which has been created in different phases by a number of companies located in various countries. This sales price equals the sum of all phases of production, from the processing plants of raw materials to mobile phone retail shops that create value added to the N95.

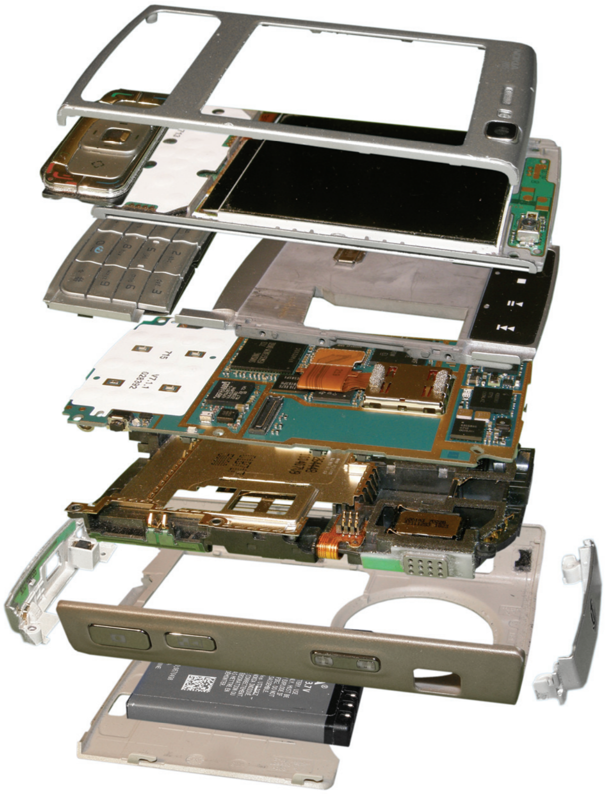
Our main research question here is very simple: to whom do these dollars ($749) go? In other words, the aim of this article is to analyse the vertical value-creating phases of this product, from component manufac-

[13] To convert U.S. dollars to Euros, we have used the yearly (in 2007) average USD/EUR exchange rate 1.3706.

turers to brand owner and from brand owner finally to retail. Our aim is to provide answers to the following questions: *First*, how is the value of the N95 distributed across organisations and participants? *Second,* how does the total value added of the N95 spread to different countries/regions, and how much of it is created domestically? We strictly adhere to the value added analysis of a single device without taking into account additional services or applications that Nokia can sell to the owners of this device. Moreover, we do not analyse the potential value that has been created when Nokia's other device models has included software and other technologies originally developed for the N95.

The phone model N95 consists of approximately 600 physical components, and its mechanical structure is quite complex, including its innovative double-slider design (Figure 1.1).

Figure 1.1 The mechanical structure of the Nokia N95



1.1 Data and methods

Companies themselves do not provide information about pricing of components or manufacturing costs, and the same holds for distributors and retailers. As this practice also applies to Nokia and the entire value chain of mobile handsets, we use three different information sources to estimate the distribution of value added created by different participants and regions.

As a starting point, we use the 'teardown' report published by Portelligent Inc. (Portelligent 2007) to analyse the component composition of the Nokia N95[14]. This teardown report includes a detailed list of components, their factory prices and suppliers.

To cross-examine and complete the teardown data, we use qualitative and quantitative data based on interviews of 10 industry experts working (currently or previously) in different parts of the handset's value chain. Due to the sensitivity of our topic, we had to assure anonymity to our interviewees. The interviews were conducted between January 2009 and October 2009.

Our third information source is financial reports and press releases published by companies.

2 The global value chain of the N95

2.1 Value capturing by participants

A value chain consists of a chain of activities where each activity gives the product or service more value added. The sum of the value added of all activities equals the final price of the product or service. These activities and their value added are typically distributed to different companies located in different regions and national economies. At every step, the

[14] The teardown report of Portelligent was acquired in September 2008.

producer of the activity buys inputs, adds value, and sells outputs (or intermediate products) to the next producer.

The journey from raw material mines to the final consumer electronics product that is delivered to the consumer is very long. There are typically at least four to eight supplier layers between Nokia and mining activities (Nokia 2009a). This stylised chain concerning the N95 is illustrated in Figure 2.1.

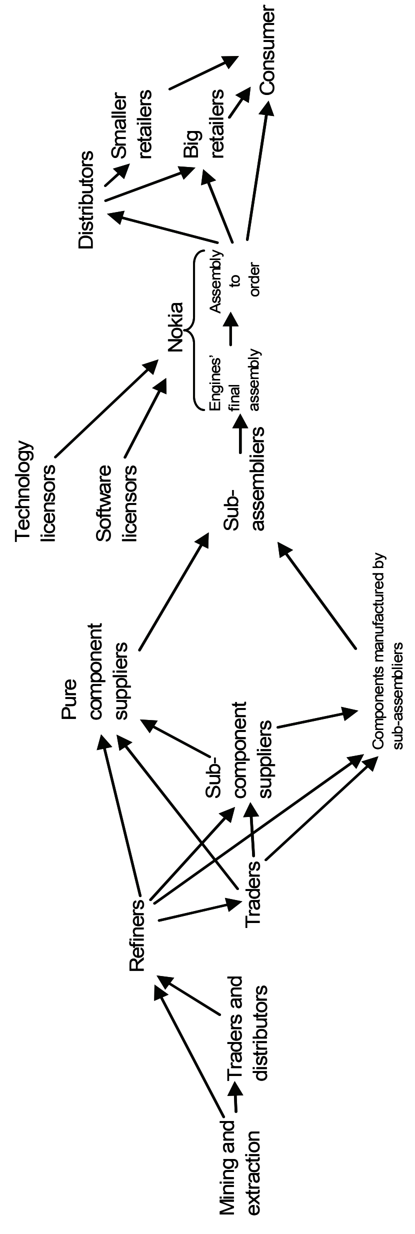


Figure 2.1. The value chain of Nokia N95 mobile phone

This kind of vertical supply chain is quite common in the consumer electronics industry (see e.g., Linden, Kraemer and Dedrick 2007).

According to Portelligent Inc. (Portelligent 2007), the Nokia N95 phone consists of almost 600 components. The most important material used in Nokia phone components is plastics (45%), with a further 35% percent made from metals, 10% glass and ceramics, 9% battery electrodes (graphite, lithium and cobalt) and 1% other materials (Nokia 2009b). Component suppliers deliver components mainly to sub-assembler companies, but some components are delivered directly to Nokia. Moreover, nowadays Nokia's first-tier sub-assemblers such as Foxconn, BYD and Jabil are no longer pure EMS (Electronic Manufacturing Services) companies but also manufacture components (see Chapter III of this book).

In the N95 case, sub-assemblers deliver intermediate products to Nokia's manufacturing plants where in the first stage, Nokia itself undertakes final assembly of the N95's engine[15]. Mobile phone engines include both hardware and software that perform core functions, but engines lack everything that varies from customer to customer. In the second stage (assembly-to-order), the engines are given the final software and outward appearance based on customers' orders. In addition to appearance, software also varies between customers, with different languages, features and menus. Nokia has introduced this two-step manufacturing process in response to customers' willingness to differentiate themselves from their competitors. Hence, phones they offer have customised software and features built into the handset. A single phone model, such as the N95 or the N96, can represent as many as 170 handset variations and 250 different sales packages (Putkiranta 2008).

Nokia sells completed phones to distributors (for example Brightpoint Inc.) and also sells directly to large customers such as operators (for example, China Mobile). Distributors, in turn, sell handsets to both smaller wholesalers and retailers. Depending on the country and region, operators are often important mobile phone retailers. In the U.S., the mobile

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[15] To our knowledge, Nokia has not outsourced the engine's final assembly for the N95 to other companies. In 2007, Nokia outsourced 20% of its total manufacturing volume (including all models) of mobile device engines (Nokia 20-F report, 2007, p.36).

phone retail sector is dominated by operators while, for instance, in China the operator's role is lower.

To analyse the breakdown of value added for the N95, we proceed systematically by using several data sources. To analyse the hardware cost structure of the N95, we use the teardown report by Portelligent as a starting point. Based on interviews, we modify and update some of these original figures.

We start our analysis by considering the N95's bill of materials (BOM). As mentioned before, lists of components, their factory prices and supplier companies are included in the teardown report. In Table 2.1 we consider these components as entities, without taking into account that many of those components include parts and materials that have been bought from other companies.

Table 2.1. The bill of materials (BOM) of the Nokia N95 (in 2007)

Description	**Eur**	**% of Total BOM**
Integrated circuits	80.3	40.4 %
Display	21.6	10.9 %
5MP camera module	16.5	8.3 %
Mechanics	18.7	9.4 %
All other hardware inputs including supporting material	40.8	20.5 %
Bill of materials excluding license fees	**177.9**	**89.6 %**
WCDMA license fees	13.5	6.8 %
Symbian OS	3.0	1.5 %
Other license fees	4.2	2.1 %
Bill of materials (software and other immaterial inputs)	**20.7**	**10.4 %**
Total Bill of Materials (BOM)	**198.6**	**100.0 %**

Source: Author's calculations
Data source: ETLA's database

As Table 2.1 shows, the bill of materials covering all hardware components and accessories is approximately EUR 178 (in 2007). Integrated circuits such as memories and processors form the most costly component category, which has an estimated cost of EUR 80. In addition, a display module and high-resolution (5 MP) camera are expensive inputs. It should be noted, however, that the above-mentioned suppliers do not generate the entire value of the components they provide by themselves. Many components, such as the 5-MP camera module, consist of a number of sub-components — e.g., module socket, interconnect flex, lens and electronic components — and not all of these components are manufactured by the camera module supplier itself. For example, according to Portelligent (2007), EEPROM camera memory is manufactured by the Japanese company Seiko, while the U.S. company Micron has produced CMOS image sensors for the camera module[16]. In any case, the value added of these components and sub-components are not generated by Nokia.

In addition to components and other physical parts, mobile phones include software that can be said to be the brain of the phone. Moreover, telecommunications technology is tightly protected by patents and other intellectual property rights. Therefore, notwithstanding the fact that Nokia itself invests heavily in software and other technology development related to handsets, it has to pay significant license fees to other companies. The N95 runs the Symbian operating system and based on press releases and financial statements by Symbian, the average royalty per phone was roughly EUR 3 in 2007[17]. We use this amount to estimate the Symbian OS license fee for each phone.

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[16] Because labour costs are an essential part of the calculation, value added cannot easily be calculated for companies from the U.S. and other countries using U.S. GAAP, because they are not at present required to reveal labour costs in their accounts.

[17] Source: Symbian Press Release, February 12, 2008. However, in 2007, Nokia was also the major owner of Symbian Ltd., owning as much as 48% of shares (Nokia 20-F 2007, p. F-64). However, later on Nokia acquired full ownership if Symbian Ltd and established the Symbian Foundation.

Moreover, Nokia has paid significant royalty payments to other companies in connection with WCDMA technology[18]. According to Nokia, it has paid less than 3% aggregate license fees on WCDMA handset sales (press release, April 12, 2007). This share is calculated from Nokia's sales price. Based on our interviews, we estimate that Nokia has paid 2.9% in WCDMA license fees on each WCDMA phone. Nokia's sales price of the N95 is approximately EUR 467; thus, Nokia has paid roughly EUR 13.5 in WCDMA license fees per phone to Qualcomm and other WCDMA patent owners.

In addition to WCDMA technology, Nokia also pays license fees relating to other technologies and applications. Based on our interviews, we estimate that these other license fees are approximately 0.9% of Nokia's sales price. Altogether, the purchase price of all software and other immaterial inputs totals EUR 21.

Thus, the suppliers of material and immaterial inputs, including their upstream vendors, generate a total value of EUR 199 for each phone. The question arises as to how much value added Nokia and the distribution channel generate for the N95?

To answer this question, we use a backwards calculation method, starting from the retail price. By definition, the retail sector only resells products. Thus, the sales margin and value added margin (value added divided by net sales) have to be almost equal. Based on interviews, retailers' sales margins are clearly lower for mobile phones than for other electronics products. Typically, sales margins for high-end mobile phones are only 10-12% of the final prices[19]. We use this share (11%), leading to an estimate of EUR 60.1 value added generated by the retail sector. By subtracting this amount from the retail price, we obtain EUR 486, which is the retailers' purchase price of the N95.

Independent retailers and retail chains purchase handsets from distributors or wholesalers. According to our interviews, distributors' sales margins are typically 3.3−4.5%. By assuming that in the N95 case the

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[18] Wideband Code Division Multiple Access.

[19] However, sales margins vary, and in some cases retailers sell some models without margins or even at a loss. In these cases, handsets are typically bundled with services such as subscriber connection.

distributors' share is 3.9% and that the sales margin equals the value added margin, the value captured by distributors is about EUR 19.1. When we subtract this amount from the retailers' purchase price (EUR 486), we obtain the estimated purchase price of distributors: EUR 467 Because distributors buy phones directly from manufacturers, this amount is also Nokia's estimated sales price of the N95.

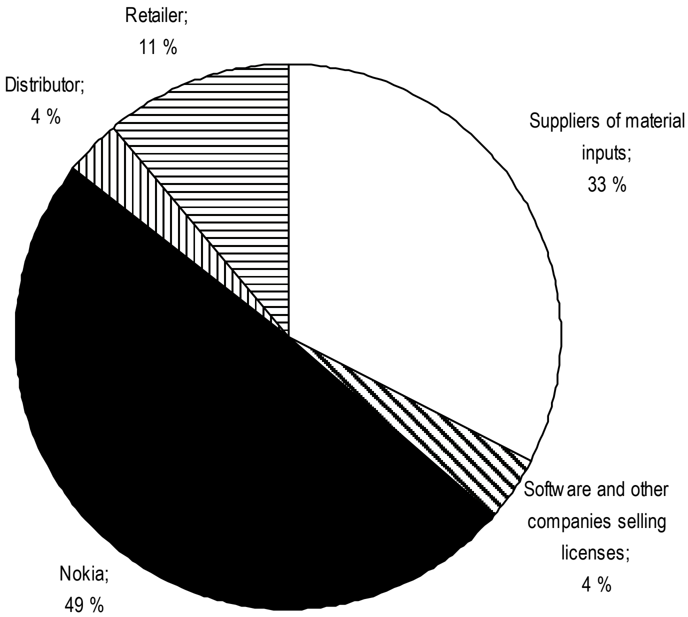
Finally, we are able to estimate Nokia's value added per N95 mobile phone. Value added is the difference between the cost of all inputs purchased by Nokia for each N95 and the price for which it sells the phone.

Hence, by subtracting all material input costs (EUR 178) and immaterial input costs (EUR 21) from Nokia's sales price (EUR 467), we obtain our estimate for Nokia's value added (EUR 269). This amount represents the value of work related to the N95 undertaken by Nokia in its own organisation. Value added is used to pay in-house labour costs (such as manufacturing, R&D, marketing and sales), depreciation of assets and operating profit. Based on our interviews, the manufacturing cost of the N95 is about EUR 11.5, accounting for only 2% of the consumer price and 4% of Nokia's value added[20]. Therefore, despite manufacturing's function as an essential part of the industrial value chain, its share of this product's value added remains surprisingly low.

Figure 2.1 summarises the value breakdown by the value chain participants.

[20] It should be noted that the design of the N95 is rather complex; hence, its manufacturing costs are clearly higher than corresponding costs of basic phone models.

Figure 2.1. The value added breakdown by the participants in the N95 value chain



Source: Author's calculations
Data source: ETLA's database

Out of the retail price of EUR 547 (without sales or value added tax), Nokia accounts for 49%, hardware suppliers 32.5%, software and other immaterial suppliers 4%, distributor 3.5% and retail approximately 11%. Therefore, Nokia generates by far the largest share of the total value. It should be noted, however, that this value added is not the same as profit.

2.2 Value capture by countries and regions

Our next step is to analyse the geographical breakdown of the N95's value added. It should be noted that companies themselves do not usually provide product-level information on the location of manufacturing and other operations. On that account, we follow Linden, Kraemer & Dedrick (2007) and use the headquarters location as the criteria for location. Thus, 100% of value added created by each participant in the value chain is attributed to the country or region where the headquarters of that company is located. For instance, the media processor of the N95 is produced by Texas Instruments (headquartered in Dallas), and we attribute the entire value of the processor to the U.S.

However, Portelligent's report does not provide any data relating to WCDMA and other license fees paid by Nokia. Therefore, we have used different sources to estimate these fees and their geographical distribution.

As discussed earlier, according to Nokia, it pays approximately 2.9% royalty fees for each WCDMA handset. In the N95 case, this means that Nokia pays EUR 13.5 WCDMA license fees per phone. Based on our expert interviews, we estimate that 40% of these fees are paid to Qualcomm (U.S.). To approximate the geographical distribution of the residual 60%, we use several studies focusing on the patenting of WCDMA technology (Goodman & Myers 2005, Martin & De Meyer 2006, Bekkers & West 2009). Analysis of the above-mentioned studies leads us to the following results: excluding Nokia and Qualcomm as receivers of license fees, approximately 50% of WCDMA license fees are paid to European (EU-15 countries) companies, 22% to U.S. companies, 3% to Korean companies, 12% to Japanese companies and 0.8% to companies headquartered in other Asian countries (see Appendix for details)[21]. We use these shares (and the share of Qualcomm) to geographically apportion WCDMA license fees paid by Nokia. This means that out of EUR 13.5 for WCDMA license fees, Nokia pays EUR 4.05 to European companies, EUR 7.16 to U.S. companies, EUR 0.33 to Korean companies, EUR 0.94 to Japanese companies and EUR 0.06 to Chinese (including Taiwanese) companies[22].

In 2007, the headquarters of Symbian Ltd. was located in the UK, and thus we attribute the entire Symbian license fee to the UK.

In addition to Symbian and WCDMA fees, the N95 includes a multiplicity of patented technologies by other companies, and as discussed earlier, we estimated that these license fees paid by Nokia total approxi-

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[21] These shares do not total 100% because 13% of license owners were unknown.

[22] Due to the lack of data, the residual amount of EUR 1.05 cannot be attributed to a specific company or country.

mately EUR 4.2[23]. According to our interviewees, most of these fees are paid to U.S. and Japanese companies, and we account 35% (EUR 1.5) each for both U.S. and Japan and 30% for Europe (EUR 1.2).

Based on headquarters location, the N95's total value added, including material and non-material inputs, Nokia's value added, distributor and retail, is distributed geographically as follows:

Table 2.2. The geographical breakdown of N95 total value added[24]

	(a) EUR	(b) %
Finland	270.8	49.7 %
Other Europe	29.1	5.4 %
The U.S.	69.8	12.1 %
Japan	40.2	6.5 %
Other Asia	40.6	4.6 %
Unknown	16.8	7.2 %
Country of final sales	79.2	14.5 %
Total	546.5	100 %

Note: Based on headquarters location.

Table 2.2 shows that out of the total value added, half has been generated in Finland, 5.4% in other European countries and 12% in the U.S., while Asian countries account for only 11%. However, the share of unaccounted inputs is 7%, and a large portion of these hundreds of low-value inputs is probably made and designed in Asia. Even then, approximately two-thirds of the total value added is created in Europe and the U.S.

Until now, we have considered the breakdown of value added based on the location of companies' headquarters. However, particularly large companies increasingly operate on a multinational basis, with affiliates in a number of countries. This development is emphasised in the electron-

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23 Based on our interviews, Nokia does not pay GSM licence fees to other companies. However, handset companies that do not hold a strong GSM patent portfolio have to pay GSM licence fees to patent holders.

24 We have not separated the value added generated by the upstream activities of vendors. Hence, the entire factory price of each component is attributed to the country where the headquarters of the vendor is located.

ics industry, where manufacturing operations in particular have agglomerated in China and other low-cost countries.

To estimate the Finnish share more accurately, we proceed by analysing Nokia's Finnish activities in more detail. First, we consider the geographical distribution of Nokia's Multimedia business unit, which was responsible for the product creation of the N95. In 2007, out of the total number of Multimedia employees, roughly 75% were located in Finland. Second, about 80% of Multimedia's top management worked in sites located in Finland. Third, the majority of N95 devices were manufactured in Finland, but Nokia's site in Beijing manufactured some of them as well.

Based on the above-mentioned three facts, we estimate that Finland accounts for roughly 70% of the valued added generated by Nokia. Using this share, approximately 35% of the total value added is created domestically if the country of final sale is abroad. If the handset is sold in Finland (and the value added in distribution and retail is attributed to Finland), then 50% of the total value is created domestically.

3 Conclusions

In this article, we have studied the global value chain of consumer electronics by using a single mobile phone model (Nokia N95) as a case example. Our analysis provided us with three main findings.

First, our results show that in the N95 case, the brand owner Nokia generates the largest share of the total value added. Out of the total value added, Nokia accounts for 49%, component suppliers 32.5%, software and other immaterial suppliers 4%, distributor 3.5%, and retail approximately 11%.

Second, the pure production or manufacturing function contributes only a minor share of the entire value of a high-tech product such as a mobile phone. In the N95 case, the final assembly of the phone costs approximately EUR 11.5, accounting for only 2.1% of the total value added and 4.3% of the value added generated by Nokia. This implicates that the production of a high-tech electronics product is in fact very low tech because manufacturing generates only a small amount of value added. One can buy electronic manufacturing services from a number of companies located in either developed or developing countries. Hence, much of the manufacturing know-how related to high-tech electronic products has become commoditised.

Third, the value added of the N95 is dispersed to a number of countries and continents. The geographical distribution also depends on the country of final sale, as retailers and distributors account for almost 15% of the total value. Notwithstanding the fact that virtually all physical components of the N95 are manufactured outside Finland, approximately 35% of the total value added is created domestically if the country of final sale is abroad. If the handset is sold in Finland (the value added of distributor and retail are attributed to Finland), then 50% of the total value is created domestically. We will consider the geographical breakdown of value added more carefully in our ongoing study that will be published in 2010.

4 References

Bekkers, R., Verspagen, B. and Smits, J. (2002). Intellectual Property Rights and Standardization: The Case of GSM. *Telecommunications Policy, 26,* 171-188.

Bekkers, R. and West, J. (2009). Standards, Patents and Mobile Phones: Lessons from ETSI's Handling of UMTS. *International Journal of IT Standards and Standardization Research,* vol 7, issue 1, 13-34.

Goodman, D. and Myers, R. (2005). 3G Cellular Standards and Patents. Paper presented in IEEE WirelessCom 2005, June 13.

Linden,G. Kraemer, K.L and Dedrick, J. (2007). *Who Captures Value in e Global Innovation System? The case of Apple's iPod. Communications of the* ACM, v. 52/3, 141-144.

Martin, D.L. and De Meyer, C. (2006). Patent Counting, a Misleading Index of Patent Value: A Critique of Goodman & Myers and its Uses. Working Paper Series. Downloadable at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=949439

Nokia (2009a). http://www.nokia.com/corporate-responsibility/supply-chain/overview

Nokia (2009b). http://www.nokia.com/environment/we-create/materials-and-substances. (accessed Oct. 26, 2009).

Portelligent Inc. (2007). Nokia N95. Report #11807-070416-TMf. Austin, Texas, Portelligent Inc.

Putkiranta, J. (2008). *Demand Supply Network Management*. Presentation, Capital markets day, December 4th, 2008.

Reller, A., Bublies, T., Staudinger, T., Oswald,I., Meißner, S. and Allen, M. (2009). The Mobile Phone: Powerful Communicator and Potential Metal Dissipator. *GAIA,* 18/2 (2009): 127–135.

5 Appendix

Appendix 1. The Geographical Breakdown of WCDMA License fees

Several studies have focused on patent ownership issues in third-generation cellular technology. Goodman & Myers (2005) identified 732 patent families issued prior to 2004 for WCDMA (Figure 1 in Goodman & Myers 2005). We excluded Nokia (94 patents) and Qualcomm (279 patents) from the total count and consider the owners of the remaining 359 patents. Our geographical breakdown is based on the headquarters location of these patent owners and is presented in Row 1 (Table A1).

Goodman & Myers also evaluated which patents are actually essential to the WCDMA standard, distinguishing them from those that are claimed to be potentially essential. Based on this evaluation, only 157 of 732 patents were judged to be essential (Figure 5 in Goodman & Myers 2005). Again, we exclude Nokia (40 patents) and Qualcomm (30 patents) and consider the remaining 87 patents. The geographical breakdown of this residual number is presented in Row 2 (Table A1).

Martin & De Myers (2006) criticised the approach and patent evaluation method of Goodman & Myers (2005) and suggested an alternative approach, based on patent citations. Martin & De Myers analysed the citations of 725 UMTS patents and found that they received a total of 14211 citations by others (Table 1 in Martin & De Myers 2006). We excluded the citations of Nokia's and Qualcomm's patents and consider the patent owners of the residual 7630 citations. The geographical breakdown of this residual is presented in Row 3 (Table A1).

The more recent analysis of WCDMA patents covered a total of 1,227 patents that were claimed to be essential (Bekkers & West 2009, Table 3). After excluding Nokia (248 patents) and Qualcomm (228 patents), we considered the geographical breakdown of the remaining 751 patents (see Row 4 in Table A1).

Table A1. The geographical distribution of WCDMA patents (Nokia and Qualcomm excluded)

	Other EU-15	U.S. excluding Qualcomm	South Korea	Japan	China (incl. Tw)	Unknown
3gpp (Goodman & Myers, Fig. 1)	46.2%	13.6%	0.0%	20.9%	0.0%	19.2%
IP judged essential 3gpp (Goodman & Myers, Fig. 5)	58.6%	17.2%	0.0%	17.2%	0.0%	6.9%
Citations (Martin & De Myers, Table 1)	49.2%	33.4%	0.0%	6.0%	0.0%	11.5%
ETSI notified essential patents (Bekkers & West, Table 3)	46.2%	22.4%	11.5%	2.4%	3.1%	14.5%
Average	**50.1%**	**21.7%**	**2.9%**	**11.6%**	**0.8%**	**13.0%**

Notes: Martin & De Meyer (2006) argue that rather than patent counts, patent citations are a better proxy for the value of intellectual property of WCDMA patent holders.

Sources: Goodman & Myers (2005), Martin & De Myer (2006), Bekkers & West (2009)

To approximate the geographical distribution of WCDMA license fees paid by Nokia (excluding fees paid to Qualcomm), we have used the average share of each region (the last row of Table A.1) based on the above-mentioned studies.

In the 1990s, Nokia became a leader in the global cell phone market. The stellar growth of Nokia contributed significantly to the Finnish national economy, especially to GDP growth, exports and the R&D system.

The first years of the 21st century have witnessed a massive relocation of electronics manufacturing from Europe and the U.S. to Asia and other low-cost regions via the emergence of global supply chains. The Finnish ICT cluster and the national economy as a whole have been influenced by this transformation in many ways.

This book offers four complementary perspectives on the global ICT transformation and the role of Nokia in the Finnish economy:

- What is Nokia's contribution to the growth and restructuring of the Finnish economy?
- How have the manufacturing supplier networks of Nokia changed during the 2000s?
- Is the innovative dominance of Nokia in Finland a unique phenomenon in international comparison?
- Where is the value added of high-tech products such as mobile phones created, and who captures the value?

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