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Small and beautiful

The ICT success of Finland & Sweden

Eric Giertz, Annika Rickne & Petri Rouvinen

VINNOVA

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Preface

VINNOVA, the Swedish Innovation Agency, promotes research and innovation for sustainable growth in Sweden. Investments in research, development and innovation are of paramount importance for economic growth, job creation and for solving grand societal challenges. This report is a result of a joint research project by the Royal Institute of Technology and Etlatieto Oy. This study aims at providing understanding of the mechanisms that has taken Sweden and Finland to leading positions in ICT and digitalization. Such learning is of key importance in the continuous improvement of VINNOVA's strategies and activities.

In both Finland and Sweden, the ICT sector plays a predominant role as a source for economic growth, as a key employer and as a provider for solutions to societal challenges. This report is one of the most comprehensive comparisons between the ICT sectors in Sweden and Finland. The sectors have many similarities but also, as the report highlights, important differences.

In order to generate important policy learning it is essential to understand the role of policy and different policy mechanisms in relation to historical developments. The systemic, evolutionary and institutional approach taken in this thorough analysis of the development of ICT sectors in Finland and Sweden provides an ambitious and promising model for such policy learning studies. The study contributes substantially to policy learning on *how to think* around innovation and development processes, as well as around policy mechanisms. Such policy learning is of fundamental importance to policy making.

This research project is related to the impact analysis "Similar paths, different approaches" presented earlier this year. The impact analysis focused on Tekes' and VINNOVA's ICT programs. Many thanks to the research group at Royal Institute of Technology headed by Professor Eric Giertz and Professor Annika Rickne. Many thanks as well to the team at Etlatieto Oy, headed by Petri Rouvinen, CEO. A special thanks to all interviewees that have contributed to the analysis. Thanks also to Tekes, the Finnish innovation agency. Without the support from Tekes this research project would not have been possible.

VINNOVA in October 2015

Göran Marklund
Deputy Director General

Executive summary

From massive corporations to nimble startups

In year 2000, *Nokia* and *Ericsson* – and by extension Finland and Sweden – were riding high. *Nokia*'s direct share of Finnish GDP peaked at four per cent and it accounted for over forty per cent of the ICT sector value added in Finland. At the same time, *Ericsson*'s share of Swedish GDP was two per cent and it was directly, without its extensive partnering and sub-contracting, about thirty per cent of the ICT sector value added in Sweden. Since Sweden is twice the size of Finland as an economy, moneywise *Nokia*'s value added in Finland and *Ericsson*'s value added in Sweden were the *same* (to be exact, within 5% of each other in year 2000).

The two Nordic "national champions" loomed large in part because of intense public-private cooperation in nurturing Nordic NMT mobile telephony standard since the late 1970s and in particular thanks to the first European and then global GSM standard developed since the late 1980s. Indeed, as far as Finland and Sweden are concerned, the GSM may be considered the "first disruption", which provided the two countries a crucial break for entering the global scene as major providers of ICT.

Since year 2000, Finland and Sweden followed different paths. Global developments within the ICT sector – in this context in particular the advents of cloud computing, big data, and mobile internet as well as the convergence of previously distinguishable ICT sub-sectors – amounted to something that can justly be called the "second disruption". Due to national idiosyncrasies, however, the second disruption was initially felt quite differently in Finland and in Sweden. With *Nokia*'s lead, and with its increasing concentration to and global dominance in mobile handsets, the Finnish ICT sector continued to boom until 2008, after which it entered a period of extensive re-structuring, the most visible parts of which were *Nokia*'s massive lay-offs.

The end of the new economy boom in the late 1990s was felt more severely in Sweden, on top of which *Ericsson* ran into difficulties in the early 2000s. In year 2000, *Ericsson* had 101,553 employees globally (43,193 in Sweden). It was counting on winning large network equipment delivery contracts from telecommunications operators worldwide. But as the market tanked, *Ericsson* fell into trouble and its operating profit fell deeply into the negative territory in 2001–2003. In 2001, *Ericsson*'s mobile handset business was moved into a new *Sony-Ericsson* entity – completely subsumed by *Sony* in 2012 –, which had reasonable success up until the current smartphone era was initiated with the introduction of *Apple*'s *iPhone* in January 2007. By 2004, *Ericsson*'s global employment was down to 50,534 employees (21,296 in Sweden); in just four years, *Ericsson*'s global and Swedish employment fell to less than half of their previous levels. In Sweden, the ICT sector outside *Ericsson* was hit even harder. Via its external networking and partnering, *Ericsson* had employed tens of thousands workers in ICT-related development, consulting, maintenance, and research. In an attempt to return to profitability, *Ericsson* slashed this spending. With this multiplicative effect and *Ericsson*'s own layoffs, a huge volume of ICT-expertise had to be re-deployed.

The re-deployment of Swedish ICT labor coincided with important global developments, the afore-mentioned second disruption. Thanks to *Ericsson* and also *Telia*, Sweden had deep expertise in technologies underlying the second disruption as well as advanced and forward-looking customers with whom to experiment in providing new solutions. ICT consultancies sought engineering and other ICT-using companies as their new customers in developing embedded ICT systems and deploying ICT services. Startup activity was particularly intense in internet services and software. Early 2000s was a feverish period in Swedish ICT but in hindsight it can be said that the actors within the sector re-positioned themselves quite successfully thanks to accumulated expertise, advanced demand, and – despite the burst of the new economy bubble – still vibrant global market.

As compared to *Ericsson*, *Nokia* ran into difficulties much later – in a major way only in 2008. Within a few years, Nokia's troubles lead into a re-deployment of ICT expertise in Finland, which in relative terms was quite comparable to the Swedish turmoil a decade earlier. For Finland, however, several things were different: the second disruption was now in full bloom rather than in its infancy, global demand was less vibrant and competition was more intense, and the bulk of potential domestic customers were not investing into avant-garde ICT services and solutions.

In this report we analyze the ICT sectors of Sweden and Finland. When doing so we have to define what we include in the ICT sector. But since ICT are basically impregnating every single business and industry the delimitation of the ICT sector is by no means obvious. In most parts of this report we stick to the OECD definition of the ICT sector (see chapter 3.2), which means that we use a rather narrow definition of the ICT sector when comparing the development in Finland and Sweden. In chapter 7, which describes the Swedish ICT sector today, we use an even stricter definition of the ICT sector by excluding sales companies, wholesalers and retailers. In chapter 12 however we have broadened the definition of ICT consultancy companies, which means that we have identified twice as many ICT consultants as in chapter 7. Of course there are also many ICT experts working outside the defined ICT sector – in IT departments in various industries, in R&D departments, in operations in industries like banking and media, in universities and research institutes and in various public organizations. This is also reflected in chapter 13, ICT in other sectors, and in chapters 14 and 15. All this must be considered when reading the statistics from the ICT sector in itself. Even if for instance the share of ICT in total goods export is declining very fast in the statistics, the amount of embedded systems and software in products like cars, trucks and machinery, just to mention a few, is increasing very fast.

The Swedish ICT sector is more diverse and dynamic

After being on rather different trajectories in the course of the 2000s, today the Finnish and Swedish ICT sectors are quite similar in relative terms. In both countries, the ICT sector's is about 5-6% of GDP and 3-4% of total working hours. These shares are large for a single sector but, especially in Finland, nothing compared to the sector's heyday just a few years ago.

Currently, *Nokia* and *Ericsson* remain nationally important companies, but not overwhelmingly so. *Nokia* accounts for about half a per cent of Finnish GDP and about one-tenth of the sector's

value added in Finland. *Ericsson*'s corresponding shares in Sweden are comparable, albeit somewhat smaller. In terms of their corporate structures and market offerings, *Nokia* and *Ericsson* are more similar than ever before, even if considerable differences remain.

Since Sweden is a bigger economy than Finland, its ICT sector is also larger. The sector in Sweden has about twice as workers as in Finland and nearly six times as many companies. Nowadays software is the biggest ICT sub-sector in both countries in terms of employment. The most apparent difference between the two countries relates to ICT consulting, which in Sweden accounts for over one-fourth and in Finland under one-tenth of overall ICT employment.

Our comparison of the Finnish and Swedish ICT sub-sectors by firm age and size as well as our analysis of the sector's "creative destruction" – entries, exits, and differences in growth rates among continuing businesses – suggests that the Swedish ICT sector is more diverse and more dynamic than its Finnish counterpart.

Even though its economic importance is still limited, one of the ICT sub-sectors we look at is *electronic gaming* – a globally booming industry, in which both Finland and Sweden has a good foothold. In per capita terms, Finland and Sweden have some of the largest gaming industries worldwide, although South Korea is the leading national economy in this respect. South Korea is, however, quite orientated towards its domestic market. According to the metric we employ, Sweden and Finland have the two most export-oriented gaming industries in the world. If we concentrate on successful mobile gaming apps, we observe that Finland has somewhat larger but less diverse footprint than Sweden; the surrounding ecosystem is more vibrant in Sweden and it is more resilient to any one company's success or failure.

Discussion

Our analysis of the Finnish and Swedish ICT sectors suggest that *history matters***.** In both countries we trace some of the original reasons for successes back to the late 1800s, when the Nordics were already an advanced, large and – by the standards of that time – quite competitive telecommunications market. ICT developments in Sweden relate to the automotive and armaments sectors; in Finland, banking and forestry were important early breeding grounds; in both countries, industrial equipment and machinery were important. These historical links do not determine future outcomes, but they nevertheless influence national positions in new domains. The fact that history matters speaks to path dependency, but time and again it has also been important to break with the past and to re-deploy the accumulated assets in new domains, which both Finland and Sweden have done quite successfully on several occasions. The emerging internet of things, the interplay of path dependences and re-deployments of expertise will open new opportunities and influence commercial outcomes.

The second disruption was more difficult for the Finnish economy. Our analysis has showed that Sweden has had a form of *dynamics and resilience* to the necessary change process that Finland perhaps has not had to the same extent. Now in this disruptive phase this proves crucial. While the Swedish economy had its period of layoffs in ICT earlier, ICT actors and competence bases were also more prepared. The many ICT consultants in *Ericsson* and *Telia* could move to other companies and explore related technological opportunities. Their proficiency fit well with

the changes in the second disruption, and Swedish innovation processes could move forward and be matched with the needs of advanced customers. When *Nokia* had to restructure it became apparent that the Finnish case was different as the restructuring came at a later stage in the global cycle, with less demand and more competition.

A final observation about the dynamics in the ICT sectors is the crucial importance of *hotspots as environments conducive for innovation and growth*. Both countries are ranked high among the global leaders and seen as good innovation milieus. The question is how to further develop the countries – and the city hotspots within them – to not only retain but to strengthen their global competitiveness. A multitude and variety of actors need to be present, and competence in general and specialized areas, and both countries are well endowed.

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Editors

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1 Finland and Sweden – Small, knowledge intensive nations

Eric ***Giertz****, Annika* ***Rickne****, Petri* ***Rouvinen****, and Pekka* ***Ylä-Anttila***

In this chapter, we set the scene for comparing ICT provision and use in Finland and in Sweden. We observe many similarities but also considerable, and somewhat surprising, differences between the two countries. The Nordic countries have a great legacy both as leading ICT providers and as the world's foremost knowledge economies. While Finland and Sweden has been changed on both fronts, there are good reasons to believe that the Nordic success in ICT will continue in the future.

1.1 Beyond the "golden era" in Nordic ICT

In year 2000, two Nordic companies, *Ericsson* and *Nokia*, commanded together some forty per cent of the global mobile phone market, and were arguably even more dominant when it came to innovation in mobile telephony. Today, *Ericsson* and *Nokia* provide half of the world's wireless telecom infrastructure, and roughly the corresponding share of related innovations. And mobile telephony is just the tip of the Nordic Information and Communication Technology (ICT) iceberg. Both Finland and Sweden have strong ICT clusters and Nordic ICT success stories range from *Linux* to *Spotify*.

Any reasonable economic historian would say that having such a concentration of ICT in Finland and in Sweden is implausible. It is indeed rare in industrial history that global leaders in a major industry are hosted by small economies. Yet, it has happened in this case and there is every reason to believe that the two countries can continue to excel in the future.

In this report, we study how the Nordic success in ICT came about and what is the current status of the Finnish and Swedish ICT sectors. The report builds on earlier work at ETLA, Finland, and KTH, Sweden, which has been extended in this report with the kind support of VINNOVA.

Key questions for this report include the following:

- How have Nordic companies and industries adapted to the new competitive landscape and value capture logics?
- What kind of lessons can be learned from "golden era" of the Nordic ICT sector?
- Was the performance of the Nordic countries simply a result of exceptional and temporary advantages, bound to disappear over time?
- Or is there still something left of the small country advantage that seemed to make the Nordics so conducive to innovation in the early phase of ICT development?

Having a better sense of the answers to the above questions helps Nordic business and policymakers to make for informed decisions as regard to the future.

1.2 New competitive landscape in ICT

In the turn of the millennium, both Finland and Sweden were to be found on top of virtually all international comparisons ranging from competitiveness to human development, which reflected the two countries' stellar economic and social performance at that time. The Nordic socio-economic model combined industrial dynamics and innovation with social cohesion. Finland and Sweden were seen as globally leading knowledge economies with clear strengths in both providing and using ICT.[1]

In recent years, particularly Finland's economic performance has deteriorated – in considerable part due developments within ICT. In the past decade, there have been rather dramatic changes in the global ICT landscape and the Nordic countries are no longer seen as global hotspots nurturing new trends in ICT.

Convergence of previously separate industries – telecommunications, information technology, consumer electronics, and digital content provision – is approaching its completion. Boundaries between hardware, software, and services are fading away.

ICT-enabled services have taken the lead in the digital revolution and are becoming an integrated part of practically all industries, intelligence of industrial products is increasing, and traditional private and public services are being digitalized to a growing degree. As a consequence, the importance of ICT manufacturing, the backbone of Finland's and Sweden's ICT sectors, has diminished.

Developing *digital platforms* and the related ecosystems has become the core competitive edge of many businesses – also outside the ICT sector. Creating digital platforms is seen as an important means of escaping the "commodity trap" – decreasing relative prices and increased competition from low-cost producers.[2]

1.3 Past, present, and future of Nordic ICT

The core features of the Nordic socio-economic model – developed infrastructure, high educational level, social cohesion, ease of communication – partly explain Nordic success in ICT. There are also a number of historical and political factors that played a role.

In industrial policy, both Finland and Sweden were among early adopters of a systems approach, which was a useful vantage point in advancing ICT featuring relatively strong network effects and having several domains of application. Both Finnish and Swedish ICT business emerge from a long and fruitful history of public-private interaction.

The single most important landmark in a long history of public action was the *Nordisk Mobil Telefon* (NMT) standard in the 1970s, which started to provide analog mobile telephony services in the 1980s. NMT was a highly valuable outcome of the traditional cooperation of Nordic telecommunications administrators and industry. It aimed at creating a Nordic market for mobile telephony. The standard development project was open to third-country suppliers,

[1] See, for example: Castells and Himanen (2002), Dahlman et al. (2006), Ornston, D. (2012).
[2] Zysman and Kenney (2014).

which promoted competition in network equipment and handsets markets. In the 1980s, the Nordic countries formed the *largest* mobile communication *market worldwide* in terms of the number of subscribers. NMT served as a model in establishing *Groupe Spécial Mobile* (GSM) in 1988, which was a European-wide effort to establish a digital mobile telephony standard, which later became globally dominant. Both NMT and GSM played central roles in Finnish and Swedish ICT sagas.

Another important public policy aspect concerns telecom operators. Both Finland and Sweden had maintained aspects of competition among operators through history. The two countries were also several years "ahead of the curve" in worldwide telecommunication liberalization of the 1990s, which gave local operators and equipment providers time to adapt to the emerging new business environment. Global liberalization contributed to booming ICT demand.

By the turn of the millennium, Finland had become the most ICT specialized country in the world and Sweden was not far behind. The Swedish ICT sector ran into difficulties in early 2000s; at that point, the Finnish ICT sector was still quite strong. In 2008 Nokia, and the Finnish ICT sector more broadly, was caught by the worsening financial crisis, by global developments with the ICT sector, and also by internal mismanagement.

In the course of the still lingering financial crisis, the ICT industry developments in Finland and in Sweden have been quite different. In short, Sweden has fared better and its competences appear to be better aligned with future needs, whereas Finland is struggles in shaking old legacies and in finding new directions, even though necessary elements of future success are in place.

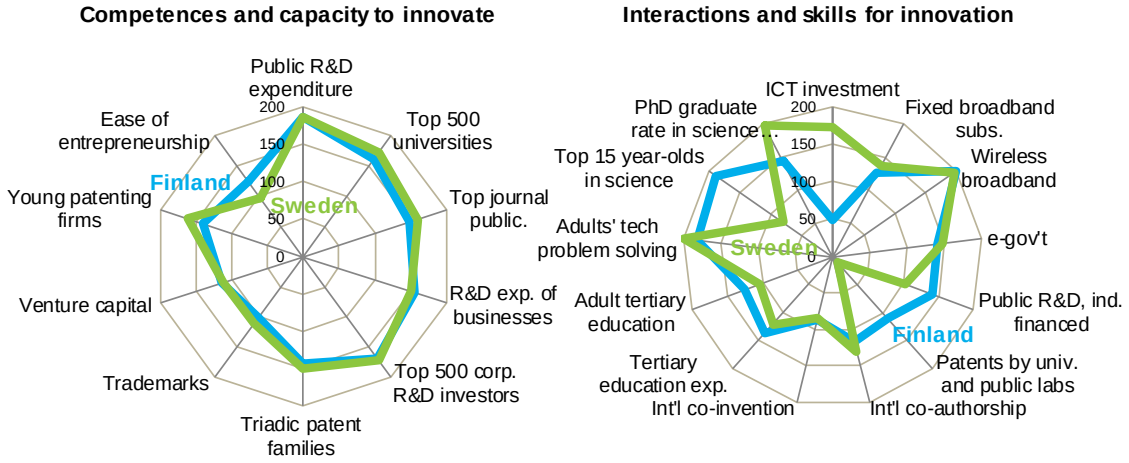
1.4 Finnish and Swedish national innovation systems

The ICT sector is knowledge-intensive in itself and what it provides is central to knowledge creation and exploitation in other sectors. In order to characterize Finnish and Swedish similarities and differences when it comes to knowledge, here we will briefly discuss some aspects of the two countries' national innovation systems.

Figure 1.1 provides a set of indicators the OECD commonly uses to benchmark national innovation systems. The indicators are normalized between 0 (the worst performance) and 200 (the best performance); one hundred corresponds to the median value among OECD countries.

As can be seen in Figure 1.1, both Finland and Sweden are typically far from the center, which suggests that in most dimensions their innovation systems compare favorably to the other OECD countries and that the systems are in reasonably good balance. Furthermore, the lines of the two countries tend to overlap, which suggests that they share relative strengths and weaknesses. Both Finland and Sweden are prominent in public R&D expenditure and in larger corporations R&D investment. Also the penetration of wireless mobile telephony is a shared strength. International co-invention is in fact the only indicator in which the two countries dip below the OECD median, which thus constitutes Finland's and Sweden's clearest shared weakness in this comparison.

Figure 1.1: Finland and Sweden in light of the OECD innovation system indicators



Source: OECD Science, Technology and Industry Outlook 2014.

Besides many similarities between Finland and Sweden, some differences can be observed in Figure 1.1. Finland excels in 15 year-olds' science performance, in university and public lab patenting, and in industry financed public R&D. Sweden excels in ICT investment intensity, doctoral graduate rate in science and engineering, and in having a relative abundance of young patenting firms.

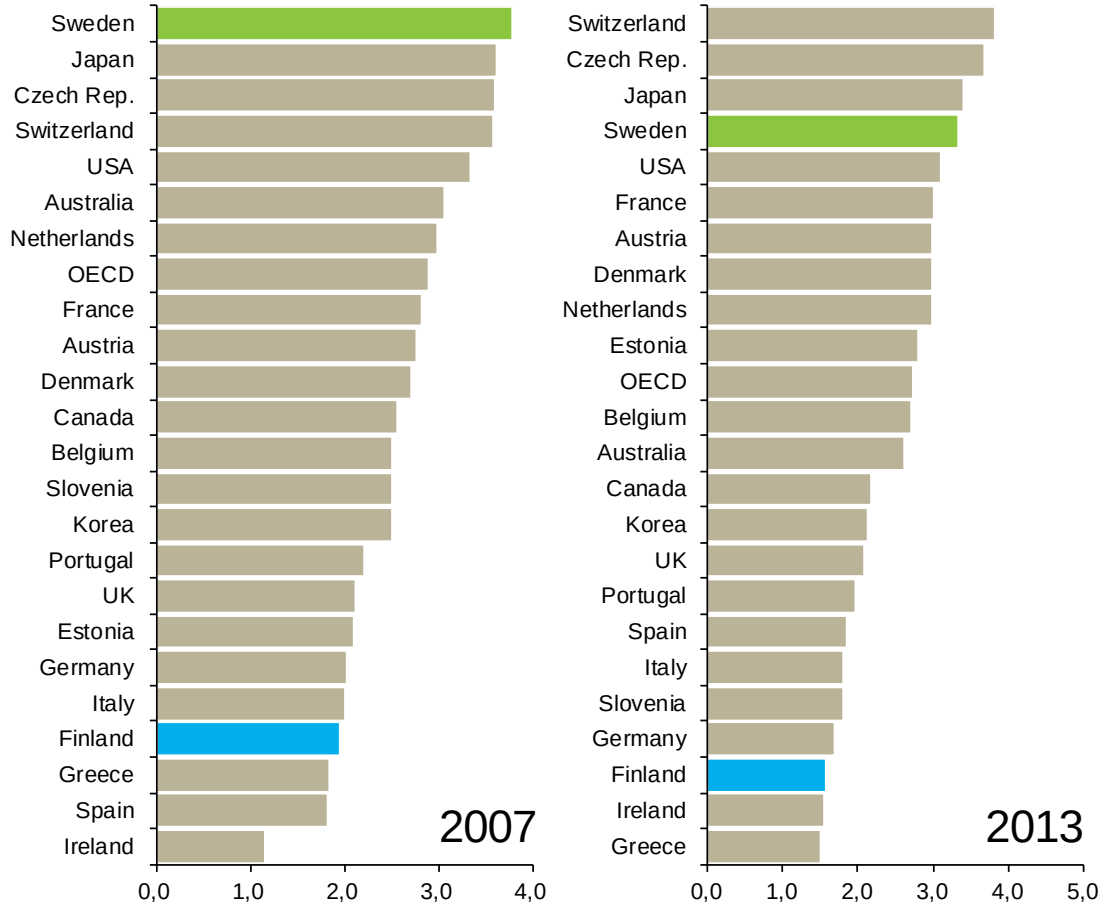
Besides considering the above-discussed indicators, the *OECD Science, Technology and Industry Outlook* summarizes aspects of national innovation policies along some basic dimensions (note: not shown in Figure 1.1):

- In universities *versus* public research institutes, both Finland and Sweden favor universities, although Sweden considerably more so.
- In terms of civil- *versus* defense-orientated research, Sweden has reduced its defense-orientated research in 2007–2012 to the extent that Finland and Sweden are now quite similar and clearly civil-orientated.
- Sweden has more generic and Finland more thematic research agenda, although the Finnish agenda is still quite close to the OECD median in the generic *versus* thematic dimension.

1.5 ICT in national innovation systems

As seen already in the indicator set above, ICT investment intensity is among strengths of the Swedish innovation system. Figure 1.2 provides further details of ICT investment dynamics across the OECD countries. As can be seen, Sweden is, and has been, quite dominant in this respect. It is quite striking that Finland is almost at the other end of the spectrum. Thus, whereas Sweden has consistently made sizable economy-wide investments in ICT, Finland has not.

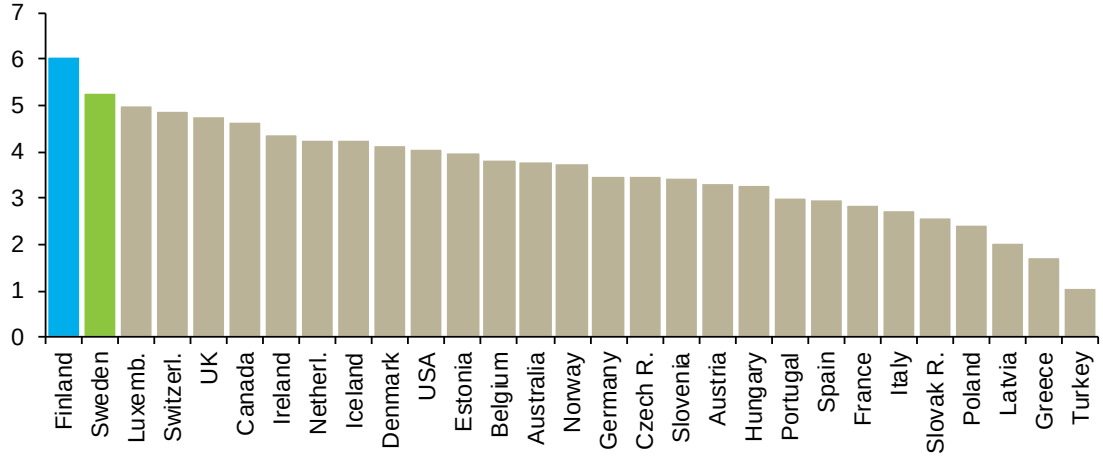
Figure 1.2: ICT investment as a percentage of GDP by country in 2007 (left) and in 2013 (right)



Source: OECD Digital Economy Outlook 2015.

This is even more striking in light of Figure 1.3, which shows the share of ICT specialists across the economy. Finland has the highest economy-wide human expertise in ICT, with a considerable margin to Sweden that takes the second place.

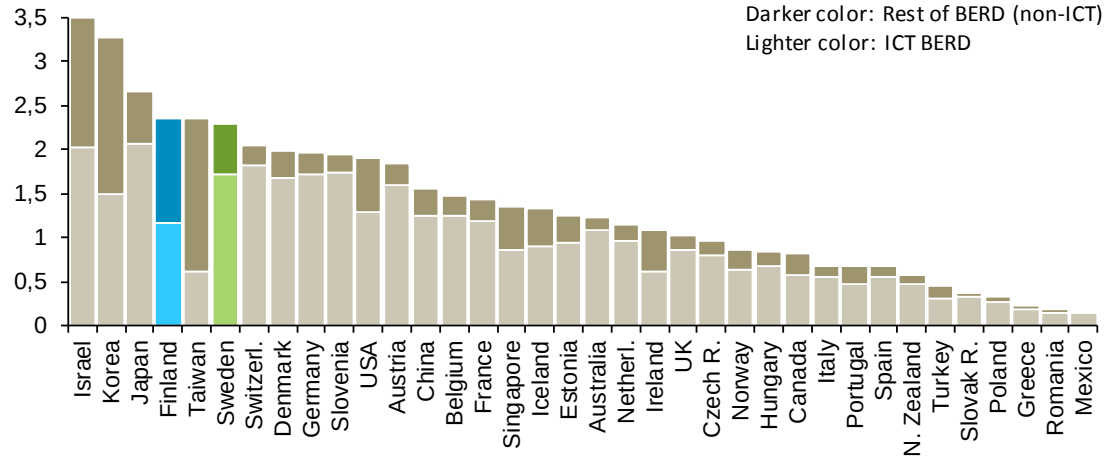
Figure 1.3: Employment of ICT specialists across the economy, as a share of total employment



Source: OECD Digital Economy Outlook 2015.

The high share of ICT specialists in Finland partly relates to Finland's R&D intensity in general and in ICT in particular. Figure 1.4 shows that – along with Israel, South Korea, and Taiwan – Finland and Sweden have the highest business enterprise R&D (BERD) intensities in the world. The share of ICT in overall BERD is the third highest in Finland (51%) after Taiwan (74%) and South Korea (54%).

Figure 1.4: ICT and non-ICT Business enterprise R&D as a percentage of GDP in 2013



Source: OECD Digital Economy Outlook 2015.

1.6 Nordic ICT at crossroads

In the postwar era, Finland and Sweden have simultaneously achieved good economic performance and social cohesion, which in considerable part can be attributed to developments within ICT.

In general terms, Finland and Sweden have many similarities. In ICT, often the developments in the two countries have been linked directly. The Nordic countries' influence in global ICT developments arguably peaked in early 2000s, after which the two countries have been in somewhat different trajectories.

Sweden had difficulties earlier but had fared quite well more recently despite the financial crisis and turmoil within ICT. Finland was riding high until 2008 but has since been caught by both the financial crisis and disruptions within ICT.

These developments set an interesting scene for our report. Finland and Sweden are at crossroads. Both countries have great legacies in ICT and abundance of accumulate human capital and other strengths. In the past, the two countries have succeeded in part because of their abilities to coordinate efforts at various levels.

In recent years, the scope of global ICT industries have expanded and at least the relative roles of Finland and Sweden have shrunk. Despite the ongoing struggles, the future nevertheless holds a lot of promise.

2 Dynamics of the global telecom sector – the telecom equipment supplier industry

*Sven **Lindmark***

In this chapter the development of the Swedish and Finnish telecom sector is placed into a global context. Starting the discussion with the situation in the telecom industry in the 1980s the chapter traces transformations of the global telecom equipment supplier industry from nationally oriented markets to the globally competitive industry of today. A number of pervasive trends and major events have affected the sector: (1) growth of markets in particular mobile and datacom (Internet), (2) technological progress, (3) digitalization, and the resulting (4) convergence, (5) the changing role of standardization, (6) the changing R&D regime, (7) liberalization, and the resulting (8) changing industrial structure. Very few of the leading players of the 1980s remains as independent entities (Ericsson being the major exception); many have disappeared, gone bankrupt, merged or been acquired (e.g. ITT, Nortel, Alcatel-Lucent, Siemens) while new ones have risen to become major players following the growth of mobile, datacom and globalization (e.g. Nokia, Cisco and Huawei).

2.1 Introduction

The purpose of this chapter is to contextualize the development of the Swedish and Finnish telecom sectors, by giving an account the transformation of the global telecom equipment supplier industry; from nationally oriented markets of the 1980s to the globally competitive industry of today (2015).

The chapter is structured as follows. Section 2 describes the establishment and structure of what we here call the “PTT regime”, centered around national monopolies that provided telephony – system that had been in place for decades and that persisted, more or less, until the late 1980s. A number of pervasive trends and major events have affected the sectors since then. These are briefly described in Section 3. Against the backdrop of these trends and events, Section 4 accounts for the dynamics of the telecom supplier industry and the fates of its leading equipment suppliers. Focus is placed on infrastructure suppliers, but the terminal (handset) industry is also touched upon where relevant. Section 5 concludes the chapter.

2.2 Point of the departure: The telecom industry in the 1980s[3]

The structure of the telecom sector of the 1980s, here labeled the *PTT regime*, was established already early in the 20th century. This regime was characterized by national monopolies that provided telephony services (often in addition to postal and telegraphy service – hence PTT: Postal, Telegraph and Telephone) accompanied by primarily domestic suppliers. This system had it roots in how national telegraphy and postal services were organized in many countries, where the national postal providers eventually also obtained the rights to provide national telegraphy and later telephony, as well.[4]

Following Bell's invention of the telephone, in many countries, telephone services were initially provided by a number of competing operators (e.g. local Bell companies, private investors or telegraph companies), initially providing local, often incompatible, services. In most countries local competition eventually transformed into government-controlled national monopolies. One important exception was the Bell system in the US[5], which emerged as a *de facto* privately controlled monopoly consisting of local operating subsidiaries and a long-distance company – American Telephone and Telegraph (AT&T).

In the 1980s the PTT regime was still firmly in place in most countries, although there had been some tendencies of liberalization in a few places, notably in the US. Most PTTs were usually state-owned, but acting as fairly independent entities. Some of the PTTs were vertically integrated, i.e. they were engaged also in manufacturing (Table 2.1). [6]

Alongside the PTTs, a telecom equipment supplier industry co-emerged and co-evolved. During the first decades these suppliers could operate on a relatively small scale. As networks became increasingly automated, complex and resource consuming to develop, only larger companies could bear the costs of R&D, and the supplier industry became increasingly concentrated.

There were two main categories of *manufacturers* during the PTT era: (1) national champions and (2) internationally oriented ones. The national champions received large parts of national procurements and were also dependent on domestic sales. Examples include: Siemens in Germany; NTT's (Nippon Telegraph and Telephone Corporation) family of domestic suppliers in Japan (primarily NEC – Nippon Electric Company, Fujitsu, Hitachi and Oki); Alcatel/CGE (Compagnie Générale d'Electricité,) and Thomson in France; Italtel and Telettra in Italy; GEC (General Electric Company) and Plessey in the UK.

Internationally oriented ones were largely independent of their home markets, had development and production facilities in foreign countries, thus presenting themselves as a local rather than international company, often in countries that did not have any indigenous supply industry. The prime examples were ITT (International Telephone & Telegraph), Ericsson and to some extent GTE (General Telephone & Electric)[7] To illustrate the level of internationalization among some

[3] This section draws heavily on Lindmark et al. (2004) (sections 3.2-3.3, pp. 38-51) unless otherwise stated.
[4] See e.g. Bekkers (2001: 16-20) and Noam (1993:3-22).
[5] Finland was another exception.
[6] Lindmark et al (2004:46-47)
[7] See Lindmark et al. (2004:47)

suppliers: In 1987, Ericsson generated 91% of their (switching) revenues from outside their domestic market, Northern Telecom 67%, Alcatel 30%, AT&T/Western Electric 10% and Italtel 5%.[8]

As mentioned above, when networks grew increasingly complex, equipment R&D (especially in switching) grew increasingly costly. Consequently, the equipment supplier market became more dependent on scale, leading to a shakeout and internationalization. In the 1980s there was some 15 large equipment suppliers remaining, possessing the necessary technological competence and production facilities to stay in the market.[9]

Table 2.1: Equipment market in selected markets in the 1980s [1984]

Country	Equipment supplier market
West Germany	Two major suppliers: Siemens and Standard Elektrik Lorenz (SEL, an ITT company). The PTT, DPBT (Deutche Bundespost Telekom), procured according standard designs and fixed quotas.
France	The PTT system of procurement was strengthened during the 1970s and 1980s (see also below). Initially ITT and Ericsson subsidiaries were major suppliers. DGT (the PTT) had a policy of using multiple suppliers selected through bidding procedures. In practice, certain market shares were reserved for domestic suppliers. Two domestic suppliers, Alcatel/CGE and Thomson, were strengthened when ITT and Ericsson were forced to sell their French subsidiaries to Thompson. In the early 1980s, these firms were nationalized, and merged their telecommunications activities into Alcatel/CGE. The state-owned company bought the remaining part of ITT and became the second largest telecom supplier in the world. Meanwhile, Ericsson had bought the relatively small CGCT company.
UK	Three major British firms (GEC, STC [an ITT subsidiary] and Plessey) were strongly favored.
Italy	Very closed and partly vertically integrated market, through joint ownership of SIP (the PTT) and Italtel (supplier), which controlled about 40% of the market and had almost no exports. Telettra also had large market share.
Spain	Telefónica (PTT) was partly vertically integrated. It held interests in most Spanish manufacturers who in turn had a 90% share of the market.
Sweden	Partly vertically integrated. Televerket satisfied most of its equipment needs either through its manufacturing arm TELI or Ericsson. Less than 10-20% of orders went to international suppliers.
US	Vertical integration. AT&T procured from its manufacturing arm Western Electric. GTE also procured internally.
Japan	A system of “controlled competition” (see Fransman, 1995). Telecommunications equipment was developed jointly by NTT and a closed group of suppliers (NEC, Fujitsu, Hitachi and Oki). The structure was competitive in the sense that NTT punished and rewarded performance of the suppliers, by increasing and decreasing their market shares.

Sources: Lindmark et al (2004:49) compiled from Bekkers (2001:54) in turn based on Eward (1994:162-63, 116, 183), Meurling and Jeans (1994:122-124) and Noam (1992:83,181,207,255); and Fransman (1995)

Market concentration was typically high in each country – the four largest suppliers in a country typically held more than 90% of the market. As a rule, the PTTs purchased equipment from

[8] OECD (1991:23)
[9] Lindmark et al. (2004:47)

national supplier, and sometimes subsidized its R&D.[10] Cartels were common and the procurement practices of the PTTS further favored the local industries (long-term commitments, preferential standard-setting and certification policies gave the PTTs the power to determine which suppliers could participate in the lucrative national telecom market.[11]

The locus of innovation in the PTT regime was in the R&D labs of the PTTs.[12] Although some R&D (with an emphasis on D) was performed by the manufacturers, their R&D expenses was to a large extent financed by the PTTs, sometimes directly paid for by the PTT or the government, sometimes subsidized through artificially high prices that allowed manufacturers to recoup R&D investments and dump prices on the international market. Thus, the R&D financing functioned in effect as subsidy for the export activities of the national champions.[13]

In addition to owning and controlling the PTTs, governments had other policy roles to play. These were actions aimed at either strengthening certain actors or limiting their powers, the latter being of particular importance in the US. As mentioned, through the PTTs, governments often favored national suppliers or foreign suppliers with domestic manufacturing facilities or collaboration with domestic firms. Governments supported their exports by granting export credits and (as mentioned) also supported R&D in the national industries. Compensation orders were also important, or if large foreign orders were placed, governments often made sure that components were supplied by the national industries to the highest degree possible.[14]

On a supra-national level, the European Community/Union (EC/EU) started to play an increasingly important role for telecommunications in the 1980s (e.g. through supporting R&D, regulation, standardization). International standardization was mainly handled by ITU and CEPT. Telecommunications related policies were also influenced by the work conducted in the OECD. Telecom issues also spilled over to GATT. In general, it could be said that the inter-national governance regime mostly dealt with some global commons such as frequency spectrum and satellite orbits, and the technical standardization required for providing universal service. The PTT system functioned instead much like an international cartel, leading to for instances a substantial over-pricing of international calls.[15] [16]

[10] Noam (1992:24)
[11] Lindmark et al. (2004:48), based on Noam (1992:319)
[12] Fransman 2003
[13] Lindmark et al. (2004:49-50) referring to Bekkers (2001:66-70)
[14] Ibid.
[15] See Lindmark et al. (2004:50-51)
[16] It could also be worthwhile mentioning that in the 1980s, Sweden stands out as an advanced market, for instance in terms of main line penetration that was almost doubled the average penetration of OECD countries (63 % vs. 33%). The Swedish telecom equipment exports (1980-87) were also very high trailing only those of Japan and Germany. This can be confirmed by telecommunications equipment exports specialisation indices, such as those calculated by the OECD (1991:33). According to those, in 1985 Sweden stood out with an index of 429% followed by a by far distanced Japan at 164%. Other countries above 100% included Canada and Finland (the latter country rapidly rising from only 38% in 1978 to 200% in 1987, a fact which suggests that these period was important for Finland becoming a major player in this industry).

2.3 Trends affecting the sector

From the 1980s, a number of interrelated pervasive trends affected the sector.[17]

- *Market growth:* Telecommunications has grown faster than the economy as a whole throughout most of the investigated time period (i.e. until 2003-2004), providing ample growth opportunities for the equipment suppliers. Meanwhile the character of demand has changed. Plain Old Telephony Services (POTS) matured started to decline (in terms of revenues and number of users). Instead there were two pervasive growth trends in telecommunications: (1) increasing mobility enabled by cellular radio communications and (2) the increasing share of Internet based data communications induced by developments in computing, creating two new growth markets. The combination of those two growing segments into mobile Internet is a third growth area.
- *Technological change* in telecommunications has been dramatic throughout the time period, with rapidly increasing functionality, performance improvements and cost reductions, opening up markets for new services and products. Equipment has become increasingly complex and software accounted for an ever-increasing share of value and R&D.[18].[19]
- In particular, *digitalization* has played an important role for the transformation of the telecommunications industry. Digitization started in the core of the networks (interoffice transmission links, digital switches) in the 1960s to expand towards the periphery (terminals) in a stepwise manner, at an accelerating rate in the 1980s and early 1990s. The initial driving force was to improve performance and efficiency of networks. More importantly, digitalization provides a platform for introducing computer software capabilities into the network, generating new types of services.
- As a result digitalization has driven a process of *convergence* of telecommunications, computing and other information industries. Now the effects cannot only be seen in the ICT sector itself, but the whole information economy (including media and content industries), a range of other industries (manufacturing, transportation, utilities, tourism to mention a few), and also the public sector and day-to-day life, in fact most parts of the modern economy. Possibilities have opened up for a wide range of new services, technologies, allowing new actors to enter in new layers of increasingly complex and interdependent value chains. Recently, new entrants (e.g. Skype, WhatsApp) have started to provide communication services over-the-top (OTT), competing with the core business of operators (telephony and messaging).
- The importance and complexity of *standardization* processes have increased since the 1980s, while its character and locus changed. Ex-post standardization has given way for anticipatory standardization. The processes of liberalization and internationalization in the sector have made standards more international and open, while at the same time competing standards have clashed on the market. Rapid technological change and convergence necessitated formal standardization bodies to become more and more complemented with more flexible ad-hoc consortia.
- The *R&D and innovation* regimes have also changed greatly since the 1980s. The R&D intensity has increased (at least until the 2000 crisis), spurred by higher incentives to innovate and new generations of technology being more costly to develop. Gradually

[17] These trends draw on and updates the trends identified in Lindmark et al. (2004:52-90), which covers the time period 1970-2003
[18] Ericsson and Telia (1997)
[19] Olsson (2000:5)

equipment suppliers became more capable of R&D that they could leverage to a larger customer base because of liberalization. The character of R&D further changed with the emergence of the Internet regime, creating new layers of actors with lower barriers to entry and to innovation, open standards, higher incentives to innovate[20] and presumably more emphasis on services innovation and innovation in start-ups. Patents became, during the 1980s and 1990s, more of a competitive tool than before.[21] Meanwhile, governments have been spending more on targeted research programs, instead of financing R&D through the PTTs.

- One of the most important changes in the telecommunication sector in recent decades was the break-up of the PTT system and introduction of competition, i.e. the processes of *deregulation and liberalization***.** The transition of the PTT regime started in the 1960s in the US domestic market, where AT&T's monopoly was challenged by MCI. In 1984 AT&T was broken up into a long-distance operator and seven regional operating companies. Early deregulation followed in Japan and the UK in the early and mid-1980s, while continental Europe followed a cautious path to reform, mainly pushed by the European Commission, the introduction of GSM being a major opportunity to start the process. The process went into full swing in the 1990s. By the early 2000, most high-income countries were more or less deregulated. Having liberalized the market, the governments had to redesign regulatory frameworks in order to sustain and stimulate competition, lower barriers to entry and hinder dominant operators from abusing their market power. A number of complementary reforms (e.g. interconnection, carrier pre-selection, number portability) were introduced since then for these purposes. More recently, the establishment of a pervasive and almost ubiquitous Internet has generated a range new pressing regulatory issues to solve include, including net neutrality, regulation of OTT providers, privacy and security issues, adapting frameworks to online goods, adaptations of copyright frameworks, regulation of platforms and new intermediaries and combatting illegal content[22].
- Coinciding with the digitalization of the telephone network and deregulation, the telecom operators' *market structure* started to break up in the 1980s. Telecom operators encountered competition on their home markets and began to internationalize, especially in mobile telephony. Large numbers of new entries, mergers and acquisitions have taken place since then. This process accelerated in the 1990s, when the market was further fragmented following the diffusion of the Internet. The equipment supplier naturally co-evolved with the operators market, and is investigated further below. There was also a trend towards operators outsourcing increasingly the services related to the operations of their networks, and corresponding increase in the increase of the share of services as part of the revenues of the leading equipment suppliers.
- The evolution of telecom sector should also be seen in the face of two major *crisis events*: the Internet bubble in the late 1990s and its burst in 2000, and the financial crisis around 2009. The burst of the Internet bubble was very specific to the ICT sector, in particular telecoms and web services, and is further described and analyzed below, while the financial crisis and its aftermath (Eurozone crisis, etc.) was economy wide in scope. Both affected the telecom equipment supply industry and were followed by waves of consolidation.

Finally, it should be mentioned that these trends are by no means exhaustive. For instance, the industry can be characterized by increasing platformization where thriving ecosystems of internal and external complementary innovations and innovators evolve around a few platforms

[20] See e.g. Fransman 2003, 2014),
[21] See Granstrand (1999); Bekkers (2001) and Lindmark (2002)
[22] See e.g. European Commission (2015)

and platform leaders notably IBM, Intel, Microsoft, Cisco, NTT DoCoMo and later Apple, Amazon, Google and Facebook. For the purposes of this chapter, the above trends should suffice to contextualize and situate the changing telecom equipment supplier industry structure.

2.4 Dynamics of telecom equipment suppliers industry (1980s-2015)

This section will analyze the dynamics of the telecom supplier industry. The starting point is the major players of 1980 remained as a major independent player – Ericsson.[25] Many have disappeared (e.g. ITT and Nortel), some entered but did not manage to survive as independent significant players (e.g. Motorola), while others merged or were acquired (Alcatel-Lucent, Siemens) and some new entrants have risen to global leadership (e.g. Huawei from China and Cisco from the US). In the following we try to distil some of the key dynamics in this process as well as give short accounts of what happened to some of the companies involved.[26]

Table 2.2: Ranking of infrastructure suppliers (in terms of revenues)

Size / Rank	1980 n.a.	1990 n.a.	2000 n.a.	2006 Ca €100 Bn	2013 Ca €150 Bn
1	Lucent (AT&T)	Lucent (AT&T)	Lucent	Cisco	**Datacom:**
2	ITT	Alcatel	Nortel	Ericsson	
3	Siemens	Siemens	Ericsson	Alcatel-Lucent	1. Cisco
4	Ericsson	NEC	Nokia	Nokia Siemens	2. Huawei
5	GTE	Nortel	Alcatel	Nortel	3. Alcatel-Lucent
6	Nortel	Ericsson	Motorola	NEC	4. Juniper
7	NEC	Bosch	Siemens	Motorola	5. ZTE
8	Thomson	Motorola	Cisco	Huawei	6. n.a.
9	Philips	Fujitsu	NEC	Avaya	
10	Alcatel	GPT	Marconi	Siemens Enterpr.	**Mobile:**
11	GEC	Philips	Fujitsu	Fujitsu	
12	Plessey	Italtel	Hughes	ZTE	1. Ericsson
13	Italtel	Ascom	IBM	Juniper	2. Nokia Siemens
14	Fujitsu	Nokia	Samsung		3. Huawei
15	Hitachi	Matra	PTIC (China)		4. Alcatel-Lucent
16		GTE (?)	Matsushita		5. ZTE (?)

Sources: Adapted from Bekkers (2001:48), OECD (1993:33) and IDATE (2003), IBM (2007) and for 2013 data from infogenics. Note that, the diversity of sources limits the possibilities to compare between the years.

Digital switches and a first wave of consolidation

A first shift took place in the 1980s following the introduction of digital (electronic stored program control) switches, which were both costly and time-consuming to develop, while at same time necessary to stay competitive. Only a handful of companies were successful in

[23] Although the Japanese companies (NEC, Fujitsu and Hitachi) have managed to maintain a foothold in the market.
[24] It should be mentioned that this history involves many rather complex processes of acquisitions, mergers, joint ventures, and other business deals, which are difficult to fully map out. Such a complete mapping is anyway beyond the scope of this chapter.
[25] Although the Japanese companies (NEC, Fujitsu and Hitachi) have managed to maintain a foothold in the market.
[26] It should be mentioned that this history involves many rather complex processes of acquisitions, mergers, joint ventures, and other business deals, which are difficult to fully map out. Such a complete mapping is anyway beyond the scope of this chapter.

developing such switches. Nortel (at that time Northern Telecom) and Ericsson were two of the firms that strengthened their positions in this process. Nortel's DMS-100 was one of the first commercialized digital switches and lay the foundation for Nortel growing into a major telecom supplier, in North America, Europe and Asia and in both fixed and mobile communications. Similarly, Ericsson's AXE (jointly developed with Televerket) also allowed for Ericsson to strengthen its competitive position, and the use of AXE in cellular networks proved critical to Ericsson's success in the field.

For other companies, although managing to develop switches, their situation became problematic. ITT developed the quite advanced System 12, which was launched to the market in 1982. However, the company - by that time an international conglomerate having acquired hundreds of companies - suffered from low profitability and allegations of having been involved in involvement several unethical affairs, sold its telecom businesses to Alcatel in 1986/87.[27]

Most British, Italian and Dutch manufacturers were acquired by international competitors in the 1980s and 1990s, while French and German ones managed stay independent longer. The British supplier industry, sometimes dubbed the 'Ring', was a cartel-like structure of three major British firms (GEC, STC [an ITT subsidiary] and Plessey). British Telecom tasked two of the companies, GEC and Plessey, to develop and supply the System X digital switching technology. In 1987 the companies merged into GPT (GEC-Plessey Telecommunications).[28] In 1989, Siemens acquired a major stake in the company, which eventually split into two parts: (1) one part evolving into Siemens GEC Communications Systems (1997), eventually becoming Siemens Enterprise Communications in 2008 and (2) the other part evolved, through series of mergers and reconstructions, into Marconi Communications, which in turn was eventually acquired by Ericsson in 2005. The third company, STC was also actually involved in developing System X at an early stage but withdrew, was acquired by Nortel in 1991. [29]

Italian Italtel and Telettra also jointly developed a digital switch. However, due to the inward looking and protective nature of the Italian market, neither of these companies managed to build a strong international presence before the 1990s.[30] Eventually Alcatel acquired Telettra (from FIAT) in 1991, while Italtel, after a range of ownership changes, was sold to a US investment fund in 2000.[31] Philip's telecommunications activities were taken over by AT&T; via a joint venture in 1984, AT&T eventually completely acquired Philip's telecom business in 1990. [32]

As mentioned in Table 2.1, by the early 1980s the French equipment supply industry had consolidated and been nationalized into Alcatel. Through the acquisition of ITT, it became a major international player. Alcatel, that already had developed their own switch (E10), thus inherited System 12 from ITT and had two product lines for a while. The 1980s German market was dominated Siemens and SEL (Standard Elektrik Lorenz, an ITT company). While SEL was

[27] See Chapuis & Joel (1990), chapter on "The ITT (now Alcatel) System 12, and a range of web sources e.g. http://www.referenceforbusiness.com/history2/96/International-Telephone-and-Telegraph-Corporation.html
[28] Bekkers (2001: 57)
[29] See Bekkers (2001:52-55) and a range of other sources.
[30] Bekkers (2001:58)
[31] See http://www.italtel.com/en/about-italtel-eng, http://www.italtel.com/images/BILANCI/Italtel%20GroupItaltel%20Annual%20Report%202013.pdf
[32] http://en.wikipedia.org/wiki/Alcatel-Lucent

acquired by Alcatel in 1988, Siemens developed their own EWDS switch, and also started expanding internationally through acquisitions e.g. of a part of GEC-Plessey (see above).

On the other side of the Atlantic, the US market was deregulated early on. In 1984, the Bell system (the biggest corporation in the US) broke up into: (1) seven regional (Bell) operating companies (the so called RBOCs or Baby Bells) and (2) AT&T, which retained control of the long-distance operations, Bell Labs and the manufacturing arm – Western Electric, the latter renamed to AT&T Technologies. Without its guaranteed captive market, the new company struggled for profitability. AT&T announced in 1995 that the company would split a second time, this time into three companies: a (1) computer company (NCR), a (2) services company (AT&T) and a (3) telecom manufacturer and R&D company (Lucent). Lucent was spun off and introduced to the stock market in 1996. The smaller US competitor, GTE, underwent a several changes in the 1980s and 1990s, to many to account for completely here. However, the company seems to have divested most of its telecom equipment supplier business in the late 1980s to Siemens and to Fujitsu. Eventually, in 1984, the GTE merged with Bell Atlantic to form Verizon (the new company being focused operations – not equipment supply).[33]

Finally, the Japanese suppliers used a system of "controlled competition", in which telecommunications equipment was developed jointly by the powerful operator NTT and a closed group of suppliers (NEC, Fujitsu, Hitachi and Oki).[34] Typically these companies were active not only in telecom equipment supply, but also in computing, and microelectronics,[35] and thanks to its large domestic market; they also managed to stay present as independent suppliers throughout the time period, albeit not as leading players.

Mobile communications: renews growth and new entrants

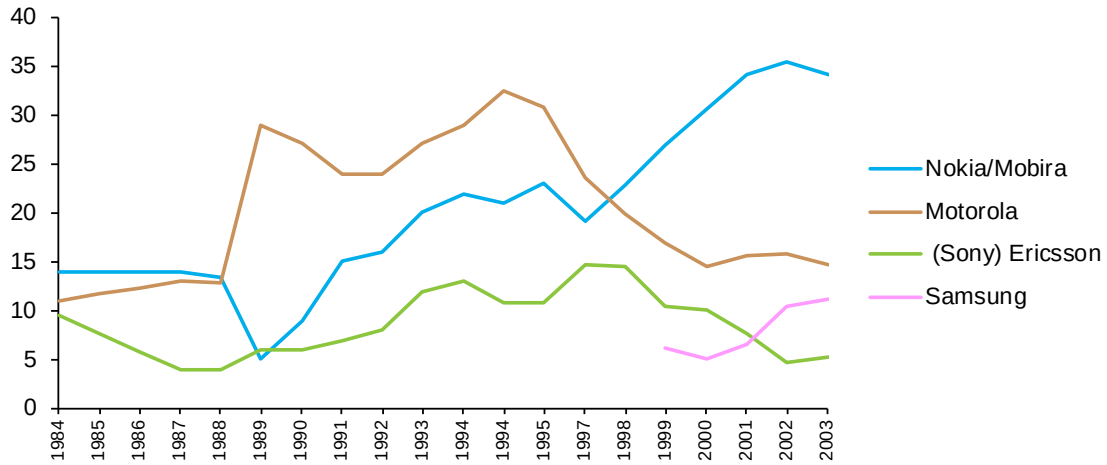
One may say that it was the introduction of the first generation cellular systems (1G) in the early 1980s, which marked the birth of global mobile communications industry.[36] It was the Nordic countries that launched the first commercially successful cellular systems. In doing so, the Nordic supply industry could use early mover advantages to secure leading positions in this growing market also outside (Ericsson mainly on the system side and Nokia/Mobira mainly for terminals). Still Motorola (the leading US radio supplier) managed to enter with a strong foothold the industry, becoming one of the leading suppliers for terminals and radio base stations. Other companies with an early presence in cellular infrastructure were: AT&T/Lucent, Nortel and NEC. In addition to those, local standards implemented in e.g. Germany, France, Italy and Japan, tended to favor local suppliers (e.g. Siemens, Thomson, Italtel and Telettra), while those companies were less successful in on the international market, with the exception of Japanese handset manufacturers.

In the much larger 2G cellular systems market, European (especially Nokia and Ericsson) suppliers could benefit from early move advantages of the GSM standard (developed in the

[33] See e.g. http://en.wikipedia.org/wiki/GTE and http://www.fundinguniverse.com/company-histories/gte-corporation-history/
[34] See Fransman 1995
[35] Fransman (1995)
[36] This section draws on Lindmark et al (2004: Ch7 & 8) unless stated otherwise.

1980s and commercialized in the 1990s). The introduction of GSM also marked an opening up and expansion of the market, partly because of cheaper and better services and products and partly because it was accompanied by introduction of competition, thereby expanding demand for infrastructure even more. Few suppliers had the capability to supply switching equipment to these systems, initially only Ericsson, Alcatel, Nokia and Siemens, later followed by Lucent and Nortel, while the radio base station market was more competitive (including more suppliers, notably Motorola). Initially, on the handset market, Motorola, Nokia and Ericsson all managed substantially improve their market shares, although the positions of Ericsson and Motorola would soon erode (Figure 2.1). The companies that were strong in GSM managed leverage their position the US IS-136 standard, which was based on a similar radio access technology.

Figure 2.1: Market shares for selected terminal suppliers (1984-2003)



Source: Lindmark et al. (2004: 251)

Along this trajectory of standards "wars" Ericsson managed to push successfully for its preferred technologies in 3G standard setting (WCDMA/UMTS in the late 90s) and in 4G (LTE in the late 2000s), which helped company to cement its position as the leading mobile infrastructure supplier.

The rise of the Internet and data communications suppliers

A second major growth market was data communication/Internet. While Europeans were largely developing solutions within the pre-dominant telecom paradigm (e.g. circuit-switched data, Videotex, ISDN, ATM), it was instead developments in the US that formed the basis for modern data communications. These early developments include: (1) datacom over telephone networks using modems in 1960s, (2) the birth of ARPANET in 1969 and its choice to use packet data, (3) the emergence of online services such as Compuserve in 1979 (eventually overtaken by AOL as leading provider in the 1990s) and (4) the emergence of LANs, notably Ethernet in the 1970s.[37]

[37] Lindmark et al. (2004:381-383)

These early development of networking technologies and services in the US gave the country a head-start in developing equipment. The fast-growing use of computer networks allowed both small start-ups and large computing firms to innovate in the networking area. During the 1970s and 1980s, established computer firms such as IBM and DEC developed communication equipment and proprietary computer communication protocols that diffused widely. However, the firms that eventually came to dominate the computer networking industry were companies that were started in the 1980s and 1990s to exploit the opportunities of open standards, notably TCP/IP and Ethernet, taking advantage unique access to venture capital, and other advantages of (mostly) being located in Silicon Valley. Between them, Cisco, 3Com (eventually acquired by HP) and Bay Networks (acquired by Nortel, and eventually sold to Avaya when Nortel went bankrupt, see below) for long held rather a strong grip on the market for computer communications equipment. The large domestic market in the US provided a stable ground for these US firms to propel into world computer networking market leadership, a development similar to how US packaged software firms leveraged the US domestic PC market in the 1980s. While today's market shares are difficult to assess, clearly Cisco is the dominant player, followed by Alcatel-Lucent, Huawei, ZTE and Juniper (another start-up from late 1990s). [38]

The telecom manufacturing industry on the other hand, largely missed this train, with failed investments in e.g. broadband telecommunications switches able to handle voice, video and data. These failed efforts spurred an acquisition frenzy of mainly US-based datacom suppliers in the late 1990s.

The telecom boom and bust

The evolution of telecom sector should also been seen in the face the Internet bubble and its burst in 2000. The collapse of the telecommunications industry around the millennium shift can be understood by first explaining the boom of the late 1990s. This boom was partly driven by unrealistic expectations of market growth and an overheated financial market, a maturing mobile market in need for renewed growth, and fueled by an unfortunate 3G licensing regime. This led to overinvestment, in particular in 3G licenses, but also in network capacity and in acquisitions raising debt to levels that could not be sustained, leading to write-downs, divestments, bankruptcies and halted investments. Faced with cost structures adapted to false market expectations, equipment suppliers' profits were rapidly turned into huge losses.[39] Downsizing among suppliers has enabled some to regain profitability, while others disappeared.

The effects of the bubble are well illustrated by the evolution of revenues and profits for four of the main equipment suppliers at that time, Alcatel, Ericsson, Lucent and Nortel[40], who, as general pattern, show very rapid revenue growth up until the year 2000 with drastic falls in revenues in 2000-2002 and concomitant huge losses. These losses were especially severe for the North American suppliers Lucent and Nortel, who were the most aggressive suppliers in terms of acquisitions, vendor financing, and engaged in dubious accounting practices. It also puts the

[38] This paragraph draws mainly on Lindmark et al. (2004:196-197)
[39] See Fransman (2003) and Lindmark et al. (2004: 91-93
[40] As shown by Lazonick and March (2010:2)

crisis of Ericsson into perspective, since of these four; it is the company that, by far, came out best of the crisis. We briefly elaborate on the other three below.

Lucent was perhaps the supplier that benefitted most from the boom, but was also first hit by the bust. During the late 1990s Lucent's focus shifted to broadband and optical networking, using risky vendor financing schemes to secure contracts. The company also made a large number of acquisitions of young IP-based technology companies; typically using its stock as payment (it acquired 36 companies for USD 47 billion between1997-2000). [41] Starting in 2001, Lucent's sales imploded from more than USD 40 bn to less than 10 bn in just three years, making tens of billions of dollars of losses in the process. In a restructuring program, the company laid off many employees, closed down manufacturing facilities and saved itself from bankruptcy by selling its stock at 1-2 % of its previous value. It also divested a number of business units: (1) Consumer products already in 1997; (2) enterprise networks in 2000 as Avaya in 2000 and (3) microelectronics in 2001 as Agere. It sold its power systems to Tyco International in 2000 and its optical fiber solutions business to Furukawa electronic in 2002. While the company was saved and could return to profitability in 2004, it was substantially smaller and weakened and did not anymore have the capability respond to growth mobile communications due to a weakness in the leading 3G standard UMTS. In 2006 Lucent became part of Alcatel. [42]

Similar to Lucent, Nortel expanded heavily in later parts of the 1990s. Between 1997 and 2000, it acquired companies for USD 30 billion, notably Bay Networks for USD 9.1 billion. Following the implosion of the market, the company made even bigger losses than Lucent in 2001. The company conducted a dramatic restructuring, laying off around two-thirds of its workforce, conducted huge write-offs, and returned to black figures in 2003. However, Nortel suffered also from accounting scandals and financial mismanagement. Entering into to the financial crisis in in 2009, it filed for bankruptcy. In this process, Ericsson acquired Nortel' assets in mobile communications, Avaya its business enterprise networking assets, with Ciena, Genband and Hitachi acquiring other parts. Its 6000 patents were sold a consortium including among others Apple and Ericsson.[43]

Alcatel went through a similar but somewhat less dramatic boom and bust. Still, the company (with strong positions in optical communication and ADSL), had problems returning to acceptable levels of profitability when market turned up again. In 2006, the by then much larger Alcatel merged with Lucent to form Alcatel-Lucent.

Among other major suppliers, it could be mentioned that Cisco (see further below) and especially Nokia was less affected by the crisis. Cisco will be discussed below and Nokia elsewhere in this report. It could be noted Cisco's strength was in the enterprise market and Nokia's in mobile phones, thus both companies were less dependent on operators market than Lucent, Ericsson, Alcatel and Ericsson, and therefore less affected by the bust.

[41] Lazonick and March (2010)
[42] ibid.
[43] See e.g. Lazonick and March (2010) and http://en.wikipedia.org/wiki/Nortel

Meanwhile, Siemens had pursued an international growth strategy since the late 1980s, early on acquiring companies like British GEC and Plessey (see above), Rolm Systems (a PBX supplier) from IBM, followed by acquisitions of US-based Stromberg-Carlsson (1990) and the PABX business of UK-based Mercury Communications (1996). In 1998, Siemens formed an ICT division (Siemens COM) as part of a major restructuring of the company's telecom businesses. Similar to the other major players, the company acquired several US data networking companies in the late 1990s and the company suffered from the burst of the bubble in the early 2000s. Later in 2006, Siemens telecom activities were divided into two companies (1) Siemens Enterprise Communications and (2) Siemens Networks in preparation for pursuing strategic alliances and divestments. Siemens Enterprise Communications formed a joint venture with the American private equity company Gores Group, the venture eventually in 2013, being rebranded to Unify. Siemens Networks was merged with Nokia in 2007, into Nokia Siemens Networks, with operations residing with Nokia. Eventually, when all Siemens shares had been acquired, the company was renamed Nokia Networks. [44]

At this writing, Nokia (network, for it handset business see below) is in the process of merging with Alcatel-Lucent. In April 2015, Nokia announced that it had agreed to purchase Alcatel-Lucent for €15.6 billion in an all-stock deal, where Nokia shareholders will hold 2/3 of the combined company, which will be branded Nokia. The acquisition is expected to be completed in early 2016, subject to regulatory approval. [45]

Motorola had also begun feeling the pressure of the crisis and competition in the telecom industry. Once the leading supplier, the market share of its mobile phones started to decline sharply in the mid-1990s, in 1998 the company was overtaken by Nokia a market leader (Figure 1). It continued to struggle with declining market shares, poor profitability and an inability to capitalize on growing emerging markets. It divested its semiconductor business to Freescale Semiconductors in 2003 and sold its mobile infrastructure business to Nokia Siemens in 2010, for a mere USD 1.2 billion. The remaining parts if the company were divided into two companies in 2011: (1) Motorola Mobility (handsets) and (2) Motorola Solutions (enterprise mobility and public safety radio solutions). Google acquired the handset division in 2012 (for $ 12.5 bn) in a pursuit to enter the mobile phone business and acquire intellectual property, only to later sell to Lenovo for a much lower price (still retaining control of the patents). Meanwhile, in 2014, Motorola Solutions sold its enterprise division to Zebra technologies (a leader in Barcodes and RFID). Hence, what remains in 2015 of this once global leader in radio communications is a company with focusing on public safety mobility solutions ($ 6 billion in revenues and 14.000 employees).

Smartphones and the rise of mobile Internet: new players enter and old ones disappear

The combination of the two above mentioned growth trends, i.e. (1) mobile and (2) Internet based data communications, fuelled another major growth segment – Mobile Internet. Several parallel developments drove this growth: (a) increasingly data capable mobile networks (2G,

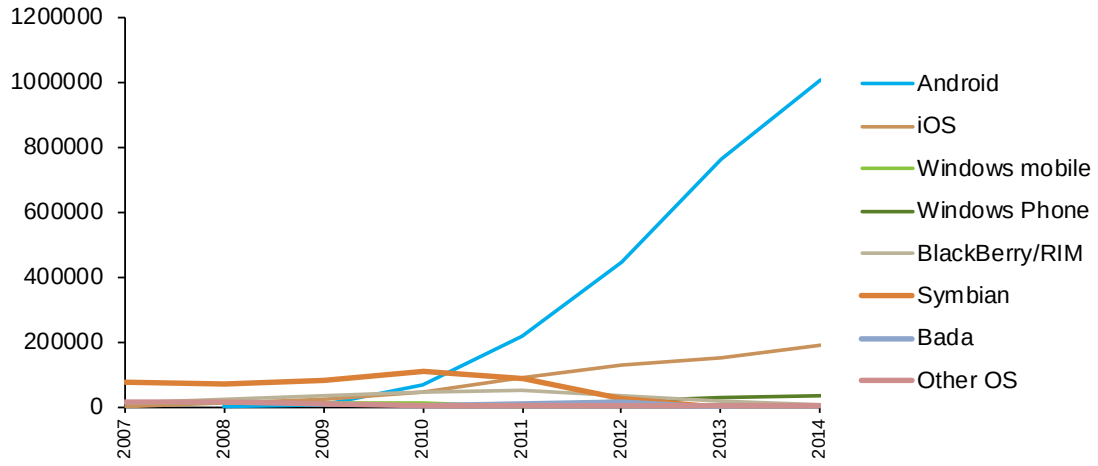
[44] The development of Nokia's network business up to this point is treated elsewhere in this report.
[45] https://en.wikipedia.org/wiki/Nokia#2014_to_present

3G, 4G and WiFi), (b) new protocols and middleware (e.g. WAP) and (c) smarter and more capable terminals (PDAs, later smart phones, tablets etc.).

Expectations of the Mobile Internet were high, but growth was disappointing for a long time. A first breakthrough came in the early 2000s with NTT DoCoMo's i-mode service in Japan, a success that was mainly due to its unique business model and ability of DoCoMo to control the crucial parts of the value network, with i-mode as platform on top of which a vibrant ecosystem of content and application providers thrived. European and US actors failed to emulate this success in spite of numerous efforts and initiatives (WAP, introducing i-mode in Europe, etc.), and still by the mid-2000s most of the revenues of operators came from voice and sms.[46] In the mid-2000s, smartphones were rare still outside Japan, although BlackBerrys and phones based on Microsoft Windows became quite popular among business users in the US. In Europe, Nokia and other handset manufacturers pushed smartphones based on the Symbian operating system, with limited success.

The major break-through came instead from outside the traditional mobile telephone industry, in 2007, when Apple introduced the iPhone, followed in 2008 with the first Android (an operating system based on Linux initiated by Google) phones were introduced, and rapidly came to systems was that they acted as platforms (just like i-mode) on top of which of third party applications (now called apps) could reach ever increasing user bases.

Figure 2.2: Worldwide smartphone sales per operating system (2007-2003; thousands of units)



Source: http://en.wikipedia.org/wiki/Mobile_operating_system (accessed 26 May 2015).

Supporting the right platform became crucial for handset manufacturers, since there seemed to be room for only two or possibly three of those. Nokia, initially backing the Symbian platform, then switching to Windows phone, failed to successfully make the transition to smart phones. Also other traditional European, US and Japanese handset manufacturers fared less well and/or disappeared (Sony-Ericsson, Motorola, Alcatel, Siemens). Samsung has been an exception, increasing its market shares to become the leading smartphone supplier alongside Apple. The Smartphone market leaders (in addition to Apple and Samsung) are instead a new breed a

[46] Lindmark et al. 2004b.

suppliers, including HTC, Google, LG and Microsoft, as well as several Chinese ones (e.g. Lenovo, Huawei, Xiaomi, Coolpad, ZTE and TCL). The Chinese companies have a particularly strong position in the home market, where they benefit, not only from low labor costs, but also from favorable IP-regulation. [47]

Just as many of the telecom equipment suppliers consolidated and spun-off their enterprise businesses (Lucent to Avaya, Alcatel-Lucent to China Huaxin, Siemens to Unify, Ericsson to Aastra/Mitel, and Nortel to Avaya), many also divested their handset businesses:

- Ericsson and Sony created the Sony-Ericsson joint venture in 2001, where Sony acquired Ericsson's share in 2012.
- Alcatel created Alcatel Mobile Phones in 2004 – a joint venture with Chinese TCL. TCL later acquired Alcatel shares.
- Taiwanese BenQ acquired Siemens Mobile in 2005.
- Motorola sold its handset business to Google in 2012 (acquired by Lenovo in 2014).
- Nokia sold its handset business to Microsoft in 2014

The rise of Asian suppliers

A final important development described here is the emergence of a number of new players from South-East Asia (Japan, Korea, Taiwan and China). At the beginning of the investigated time-period, Japanese suppliers were already well established in the market. At this writing, we have not been able to fully trace the history of the Japanese suppliers, up until now. It seems however that some of them are still present in the market, possibly partly as a result of the quite protected Japanese market. As a rule they also stayed quite diversified offering a broad range of ICT related products and services. NEC, a conglomerate present in a wide range of product areas, reports revenues of around € 5 Bn, in its Telecom Carrier Business area business area.[48] Also Fujitsu, a strong global player in IT services and servers, appears to still be present, in particular in the handset market, where it holds a runner-up position the domestic market after Apple. [49] Hitachi is even more diversified, but also still have a presence in the telecommunications equipment market.[50] The same goes for the smaller and less diversified, OKI.[51]

The Japanese companies aside, initially, the Asian new entrants came from South Korea (Samsung, LG). Their entry was aided by strong government policy and betting on specific technologies (e.g. CDMA). While this strategy proved to be successful in semiconductors, displays, consumer electronics, and mobile phones, in telecoms equipment supply Korean companies are not particularly strong (with some exceptions, e.g. Samsung's wireless broadband products). Neither are Taiwanese companies, which instead established prominent positions in semiconductors, computers, computer peripherals and consumer electronics. [52]

[47] http://www.computerworld.com/article/2859707/the-rise-of-chinas-smartphone-makers.html
[48] http://www.nec.com/en/global/ir/pdf/annual/2014/ar2014-e.pdf
[49] See http://www.fujitsu.com/downloads/IR/library/databook/pdf/15.pdf and http://www.fujitsu.com/global/Images/annualreport2014-pdf-all_tcm100-1103711.pdf
[50] See http://www.hitachi.com/IR-e/library/annual/2014/ar2014e.pdf
[51] https://www.oki.com/en/ir/finance/library/ar2014pdf/ar2014.pdf
[52] See e.g. Fransman (2014)

Instead it was China been that bred a number internationally successful telecom suppliers, most notably Huawei. Huawei was founded in 1987, taking advantage of the Chinese government's program to modernize the country's telecommunications infrastructure. The company was initially focused on supplying PBXs, and has since diversified into telecom networks, enterprise products, enterprise services and communications consumer devices. Instead of forming joint ventures with foreign suppliers (a common practice at that time in China), Huawei focused on internal development of its products. By 1993, it had developed its first SPC switch and managed to sell it successfully in China.. In 1996, the Chinese government decided to explicitly support domestic suppliers, promoting Huawei as a national champion. Huawei's international expansion commenced the same year, when it also entered the GSM market. Internationally, it initially focused on other developing markets (e.g. Russia, Thailand, Brazil, South Africa and other African countries) where competition was less intense and where low price was a key selling point. By 2000, it started to establish R&D centers abroad, first in Stockholm, followed by centers the US. By then, the company was also increasingly targeting advanced markets, and made its first major sales in Europe in 2001. It entered the 3G market in 2004, and in 2005 its international sales started to exceed its domestic ones. By this time Huawei also entered the Internet data communications market, which up until then had been dominated by Cisco (also in China). At this writing Huawei has become a global leader with a strong presence in all major segments (switching, datacom, wireless, enterprise systems and also handsets), with more 110.000 employees, two thirds of its revenues from international markets, a strong R&D and patent portfolio, and active contribution to standardization (e.g. LTE) [53]

The Chinese government also fostered other telecommunications equipment companies, notably ZTE (Zhongxing Telecommunications Equipment Group) and Julong (Great Dragon) and.[54]

2.5 Conclusions

This chapter analyzed the transformation of the global telecom equipment supplier industry; from nationally oriented markets of the 1980s to the globally competitive industry of today (2015). It started with the establishment of "PTT regime", dominated by national monopolies for telephony service provision supplemented by primarily domestic suppliers – a system that persisted, more or less, until the late 1980s.

A number of pervasive trends and major events have affected the sector since then: (1) growth of markets in particular mobile and datacoms, (2) technological progress, (3) digitalization, and the resulting (4) convergence, (5) the changing role of standardization, (6) the changing R&D regime, (7) liberalization, and the resulting (8) changing industrial structure.

Against the backdrop of these trends and events, the chapter accounted for the dynamics of the telecom supplier industry and the fates of its leading equipment suppliers. Clearly todays global Internet and mobile ecosystem of which telecom suppliers are parts, is very different from the

[53] See http://csis.org/files/publication/130215_competitiveness_Huawei_casestudy_Web.pdf and also http://en.wikipedia.org/wiki/Huawei

[54] See further http://www.digitaltrends.com/ces/gauging-the-rise-of-the-chinese-tech-brands/ and discuss ZTE see e.g. http://en.wikipedia.org/wiki/ZTE#History

closed national PTT regime of the 1980s. In this process of turbulent change, only one of leading players in the 1980s remains as an independent entity – Ericsson (possibly with the exception of Japanese suppliers). Ericsson's traditional competitors have been acquired, merged, or gone bankrupt. Many companies have disappeared (e.g. ITT and Nortel). The rise of mobile allowed some companies to enter and establish leading positions (Nokia, Motorola), but did not manage to survive as major players (e.g. Motorola), while others merged or were acquired (Alcatel-Lucent, Siemens). Following from the widespread diffusion of the Internet and globalization, some new entrants have risen to global leadership (e.g. Huawei from China and Cisco from the US).

3 A comparison of the Finnish and the Swedish ICT sector

*Jyrki **Ali-Yrkkö**, Juri **Mattila**, Mika **Pajarinen** and Petri **Rouvinen***

In both Finland and Sweden, the ICT sector accounts for 5–6% of GDP and 3–4% of total working hours. Since Sweden is a bigger economy than Finland, its ICT sector has about twice as workers. Software is the biggest ICT sub-sector in both countries. The most apparent structural difference relates to ICT consulting, which in Sweden is over one-fourth and in Finland under one-tenth of ICT employment. The Swedish ICT sector appears more diverse and more dynamic than its Finnish counterpart.

3.1 A global view on ICT provision and use

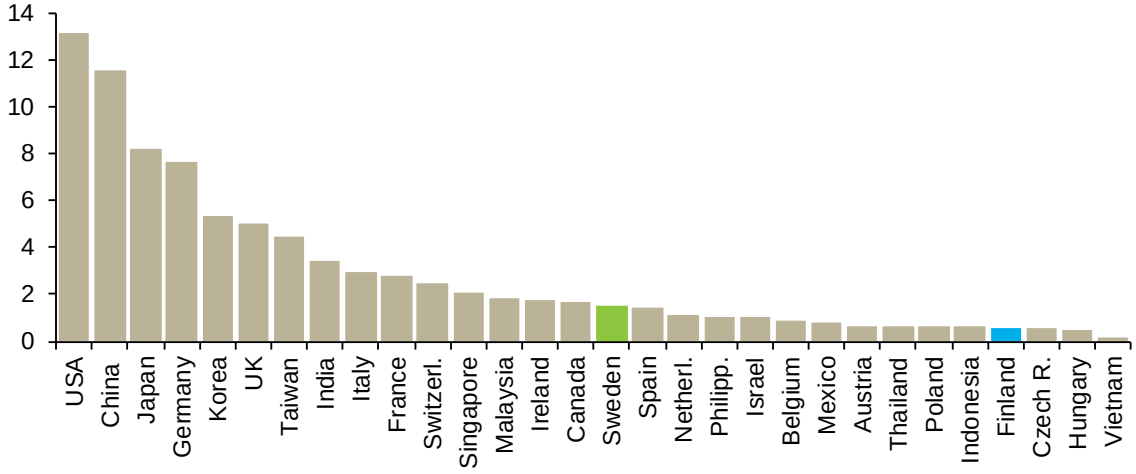
As shown in Chapter 1, Finland and Sweden have the highest economy-wide intensity of ICT specialists among the OECD countries – a metric measures the economy-wide intensity of ICT provision *and* use.

Dozens of composite indices, including the EU's *Digital Economy and Society*, ITU's *ICT Development*, and Tufts University's *Digital Evolution Index*, have been developed for measuring how countries fare in ICT *use*. While all of these indices have their idiosyncrasies, they almost invariably have one feature in common: Finland and Sweden are among top countries.

For example, *World Economic Forum* (WEF), best-known for its annual Davos meetings gathering the world's political and business elite to a Swiss ski resort, publishes *The Networked Readiness Index* (NRI) as a part of its annual *Global Information Technology Report*. Singapore, Finland, and Sweden are the top three among the 143 countries ranked in the 2015 edition of NRI. Among the ten sub-indices of NRI, Sweden ranks the highest in "individual usage" and "economic impacts". Finland gets its best marks in "skills" and "economic impacts". In international comparison, Finland and Sweden are undeniably among the most intense and advanced ICT-*using* countries in the world.

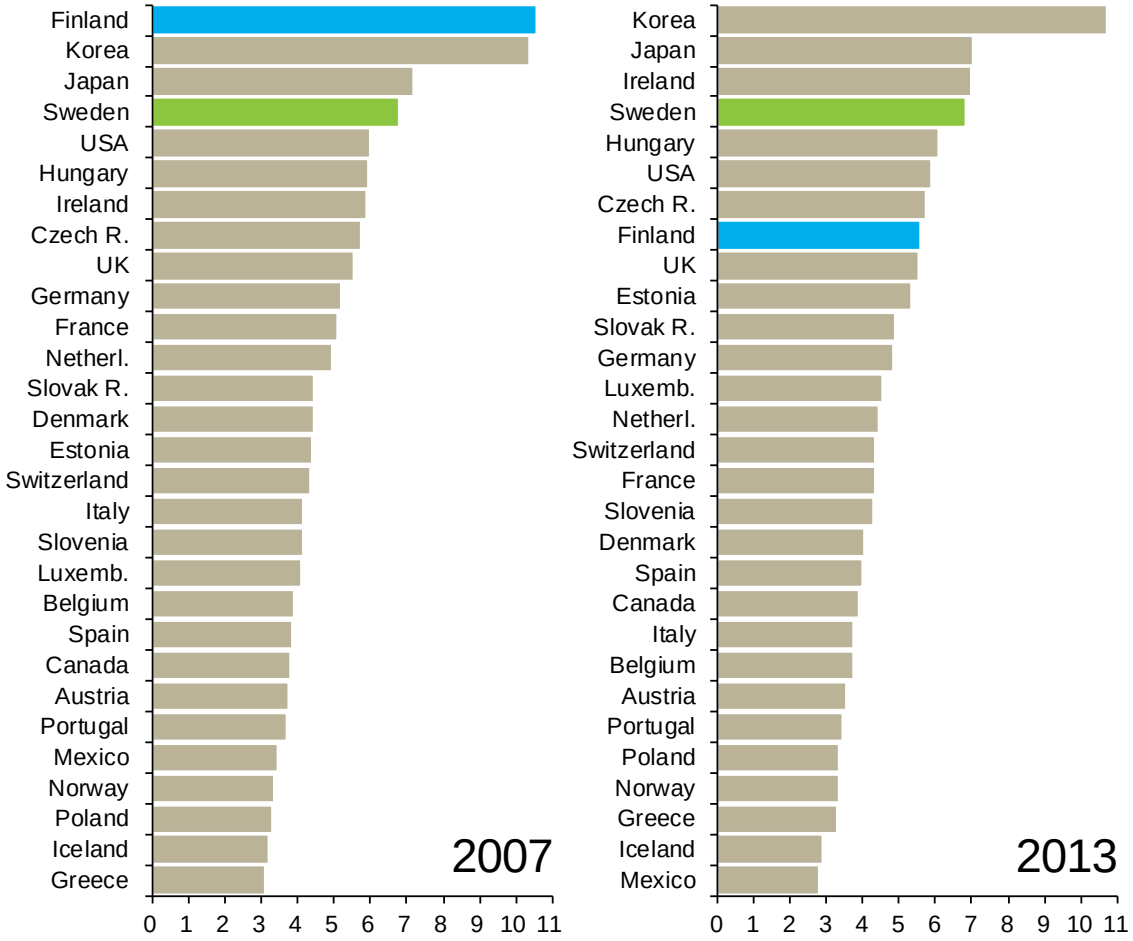
Finland and Sweden have been, and continue to be, considerable ICT *providers*, even if their global footprints are naturally somewhat limited by their relatively small sizes. Figure 3.1 is an outcome of a complex calculation attempting to capture a country's value added share of final ICT goods and services demand abroad. The point of the exercise is to remove the impact of all intermediate flows, which are particularly prevalent in ICT. Figure 3.1 suggests that the United States satisfies 13.19% of non-US final demand of ICT goods and services; the corresponding share for Sweden is 1.56% and for Finland 0.56%. While the Finnish and Swedish shares may seem small, both countries clearly "punch above their weights" in ICT.

Figure 3.1: Value added shares of worldwide foreign demand of ICT goods and services in 2011



Source: OECD Digital Economy Outlook 2015.

Figure 3.2: The ICT sector's share of the country's total value added in 2007 and in 2013



Source: OECD Digital Economy Outlook 2015.

In 2013, the ICT sector accounted for 5.5% the OECD area value added. This share has remained relatively stable, even though variations across countries and over time have been

considerable. Earlier in the 2000s, Finland and Sweden were among the most ICT-intensive countries in the world; currently they are still quite specialized in ICT, albeit not as clearly as in the past (Figure 3.2).

As seen above, Finland and Sweden are intense and competent users of ICT. In relative terms, both countries are also intense providers of ICT, even though their small sizes naturally somewhat limit their global footprint. In what follows, we discuss further aspects of the Finnish and Swedish ICT-providing sectors.

3.2 Definition

Defining the information and communication technology (ICT) sector is difficult due to the general purpose nature of underlying technologies and due to their ubiquity in virtually all current market offerings to a varying degree (in the form of directly embedded hardware/ software or in elements that support the provision and use of the offering).

In this chapter we mostly concentrate on comparing the Finnish and Swedish ICT sectors in light of available statistics. In order to do so, we adapt the most widely accepted definition of the ICT sector promoted by the OECD. Under the OECD definition we identify seven sub-sectors (NACE Rev. 2 industry codes in parentheses; the OECD definition of the ICT sector corresponds to the sum of the seven sub-sectors):

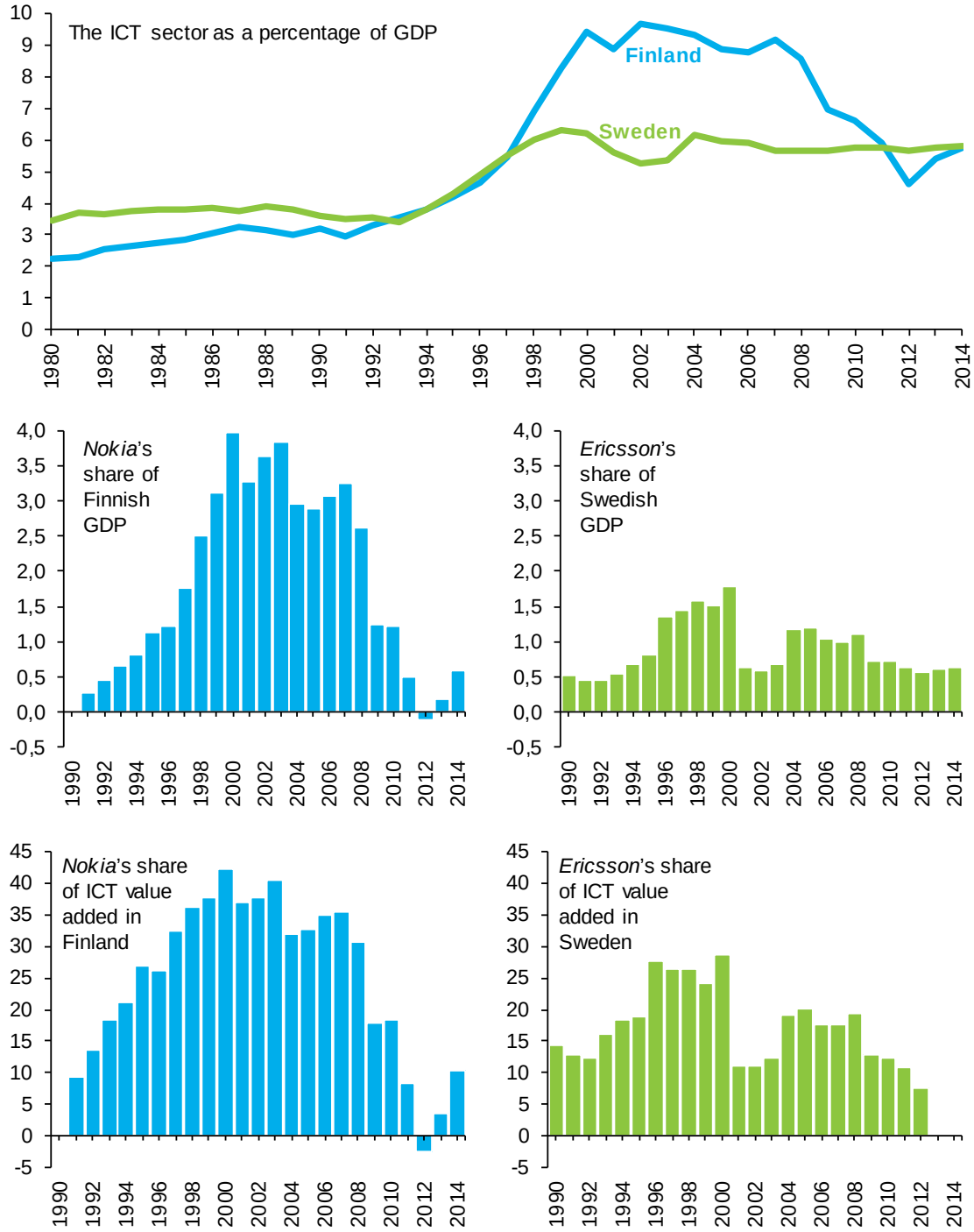
1 CT manufacturing (263);
2 IT manufacturing, incl. non-CT electronics and all repair ICT (261, 262, 264, 268, 951);
3 IT wholesale (4651, 4652);
4 Telecom (61);
5 Software (582, 6201);
6 ICT consulting (6202);
7 ICT maintenance (6203, 6209, 631).

The above seven sub-sectors provide a rough breakdown of the ICT industry, even though relevant economic markets – such as leasing cloud computing capacity – are more narrowly defined and to a large extent cannot be identified in the industrial classifications employed by statistical agencies.

3.3 Industry trends

Until the mid-1990s, The ICT sector was of similar economic importance in Finland and Sweden and it accounted for 3–5% of the countries' GDP (Figure 3.3) and employment (Figure 3.6). Since then, Finland experienced a *Nokia*-led boom-bust cycle. In 2002, the sector's GDP share was twice as high as in Finland compared to what it was in Sweden. In terms of employment, however, the difference was less drastic – the sector's employment in Finland was about one-fifth larger than what it was in Sweden. Ultimately in 2014, the ICT sector's GDP share was again about the same, 5–6%, in both countries and the ICT sector accounts for about 4% of total labor hours in Finland and about 3% in Sweden.

Figure 3.3: The importance of the ICT sector and Nokia/Ericsson in the Finnish/Swedish economy



Source: ETLA calculations on the basis of the Finnish and Swedish national accounts as well as Nokia's and Ericsson's financial statements. Here ICT consists of ISIC Rev. 4 classes 26 and 61–63.

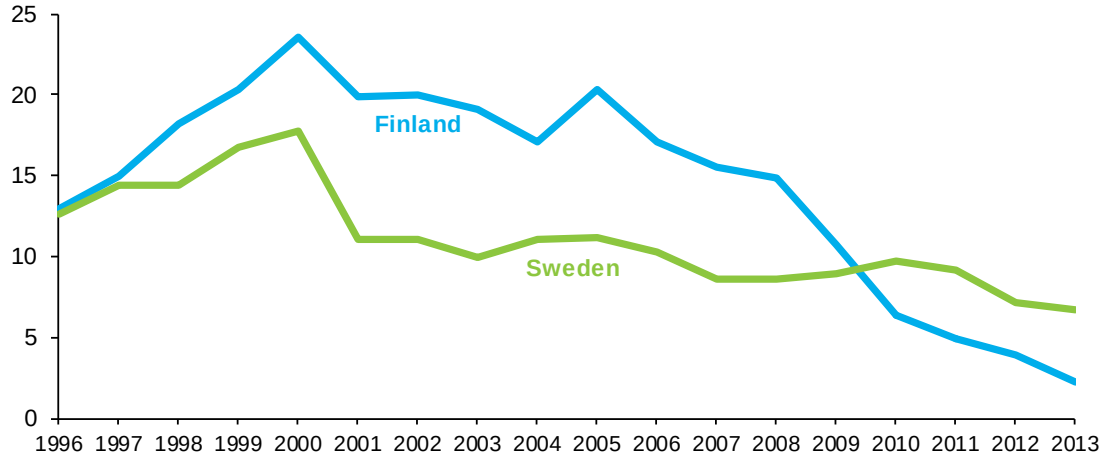
Nokia's share of Finnish GDP was the highest, four per cent, in year 2000, at which time it *directly* (excluding its domestic partner and supplier network, which consisted of several hundred companies at the time) accounted for over forty per cent of the sector's value added in Finland (Figure 3.3). In year 2000, *Ericsson*'s share of Swedish GDP was about two per cent

and its share of the sector's value added in Sweden was about thirty per cent. *Ericsson* too was both directly and indirectly a "national champion" and leader of the ICT sector, but it was never as dominating as *Nokia* was in Finland. Since year 2000, *Nokia*'s direct role started to shrink but remained large until 2008. *Nokia*'s indirect role reduced even earlier and to a larger extent, as in the course of the 2000s Nokia went from a significantly Finland-based to a wholly international partner and supplier network. *Ericsson* faced its greatest difficulties several years earlier and its clout in Sweden reduced in early 2000s, which – along with reductions in *Ericsson*'s external contracting – intensified the Swedish ICT sector's search for a new identity outside its historical core. The same search took place in Finland almost a decade later.

Currently, both *Nokia* in Finland and *Ericsson* in Sweden remain nationally important companies, but not overwhelmingly so.[55] *Nokia* accounts for about half a per cent of Finnish GDP and about one-tenth of the sector's value added in Finland. *Ericsson*'s corresponding shares in Sweden are comparable, albeit somewhat smaller.

The Finnish ICT sector's *Nokia*-led boom-bust cycle is most evident upon considering the share of ICT in total goods exports (Figure 3.4).[56] In 1996, ICT goods comprised of 13% of total exports in both Finland and Sweden. The shares peaked in both countries in year 2000: the share was was 24% in Finland and 18% in Sweden. Since then the proportions have gradually declined in both countries. In 2013, the share was 2% in Finland and 7% in Sweden.

Figure 3.4: The share of ICT in total goods exports

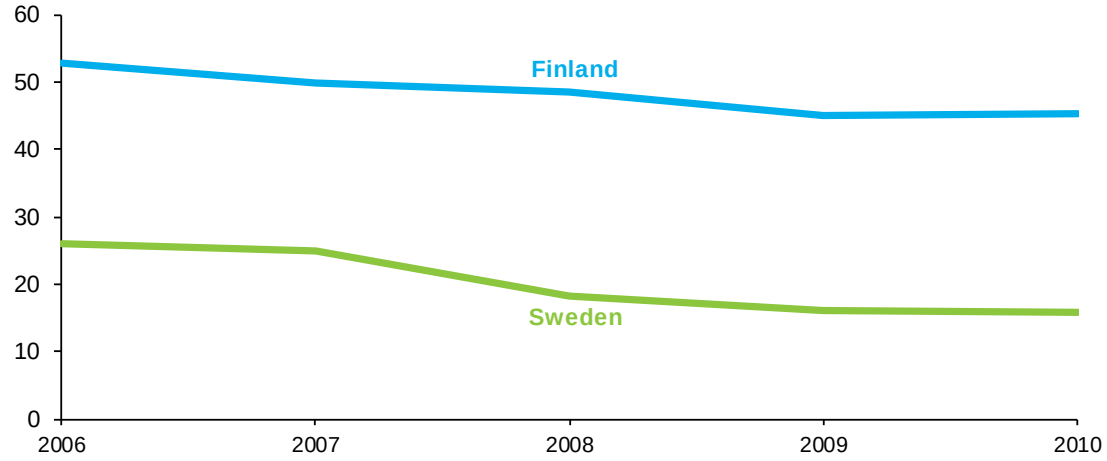


Source: United Nations Commodity Trade Statistics Database. ICT goods definition: 6-digit HS codes based on OECD Guide to Measuring the Information Society 2011, Table 2.A1.3.

In both countries, but particularly in Finland, the ICT sector is still dominant but shrinking part of business enterprise R&D (Figure 3.5). In 2006, ICT sector employed 53% of business sector R&D workers in Finland and 26% in Sweden. In 2010, the proportions were 45% and 16%.

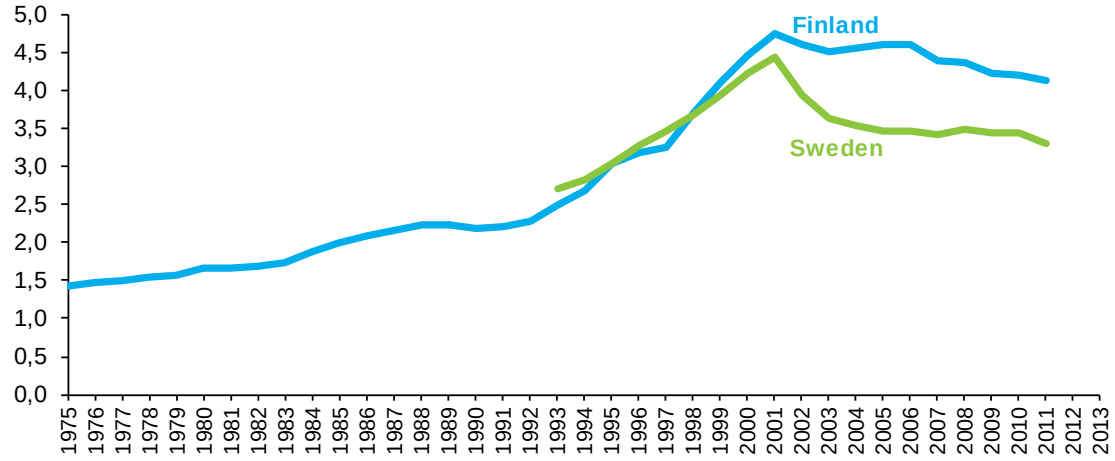
[55] Due to heavy global losses largely shown at Nokia's headquarter country of Finland, *Nokia*'s value added attributed to Finland was negative in 2012.
[56] It would be more appropriate to consider goods *and service* exports and *value added* rather than gross exports, but international trade statistics do not allow for this.

Figure 3.5: Share of the ICT sector in total business R&D employment



Source: European Commission PREDICT Database. Here ICT consists of ISIC Rev. 4 classes 26 and 61–63.

Figure 3.6: Share of the ICT sector in total working hours



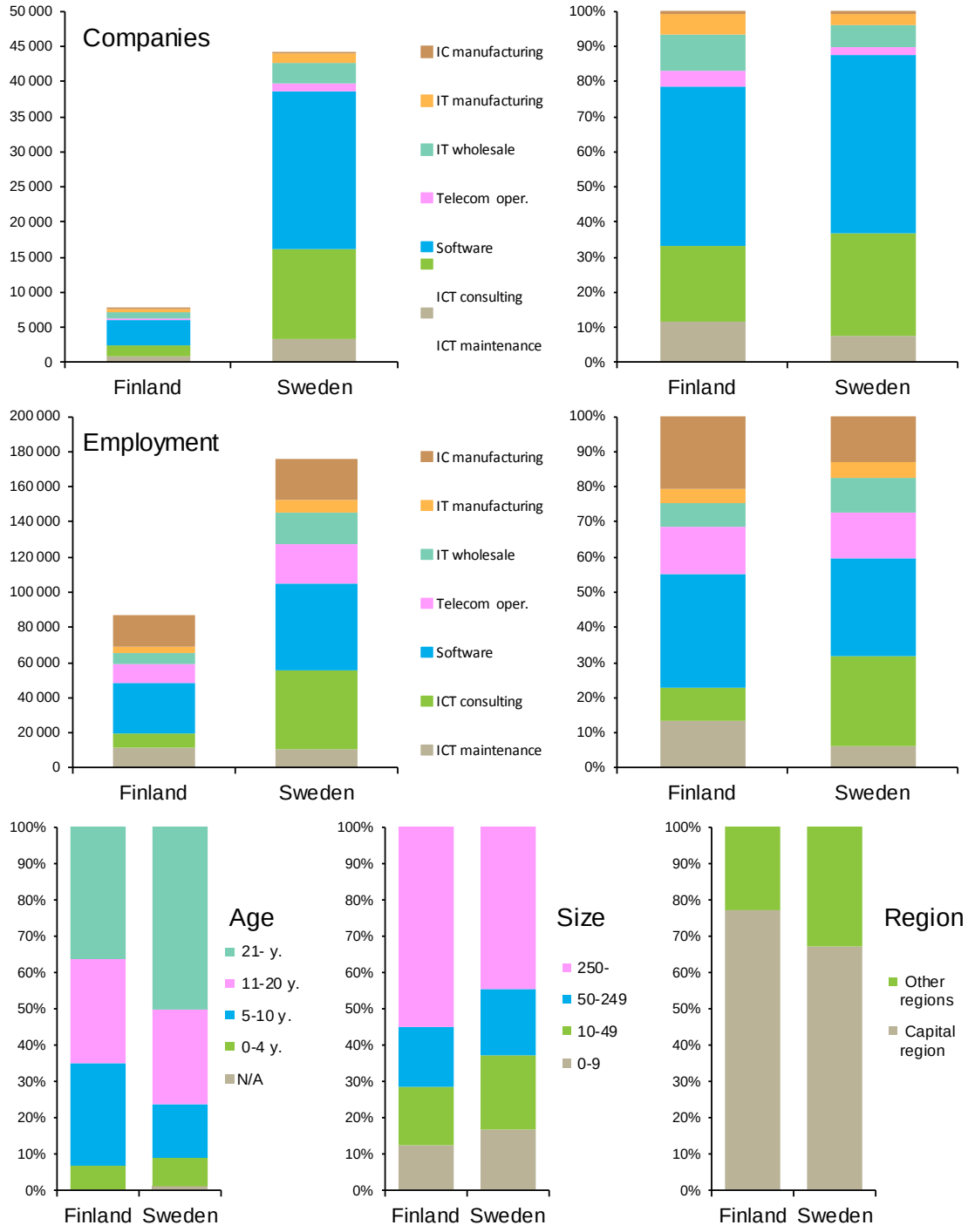
Source: OECD STAN database. Here ICT consists of ISIC Rev. 4 classes 26 and 61–63.

3.4 Industry characteristics in more detail

In the previous section, we considered the Finnish and Swedish ICT sectors at large. In this section, we provide a more refined view of the two countries' ICT sectors in light of Finnish and Swedish business register data. We first analyze the current structure of the sector and then consider sectoral dynamics since the beginning of the still lingering financial crisis.

As an economy, Sweden is about twice as large as Finland (Sweden is more populous and richer), which factors into any comparison. Thus, we provide both absolute and relative numbers. The Swedish ICT sector is larger than its Finnish counterpart (Figure 3.7): expectedly the sector in Sweden employs about twice as workers as in Finland, but observing that it consists of nearly *six times* as many companies is a striking disparity. In terms of employment, software is the biggest sub-sector in both countries (32% in Finland, 28% in Sweden). CT manufacturing is considerably larger in Finland (20% *vs* 13%) but the most apparent difference between the two countries is the prominence of Swedish ICT consulting (26% *vs* 9%).

Figure 3.7: ICT company (top) and employment characteristics (middle and bottom) in 2012



Sources: Business registers of Statistics Finland and Statistics Sweden.

If we consider ICT employment by *firm age*, we see that half of Swedish ICT workers are employed by old companies (established over twenty years ago). In Finland, the corresponding share is only about one-third. The share of 5–10 year old firms is Finland is quite high but the share of the 0–4 year old firms is quite low, which suggests that, in the course of the ongoing crisis, ICT startup activity has been better in Sweden.

When employment is split by *firm size*, we observe that 55% of Finnish ICT employment is in large companies (those with at least 250 employees in the country). The corresponding share for Sweden is 45%, a full ten percentage points lower. Correspondingly, the relative share of micro (under ten employees) and small companies (from 10 to 49 employees) are both 4–5 percentage points higher in Sweden.

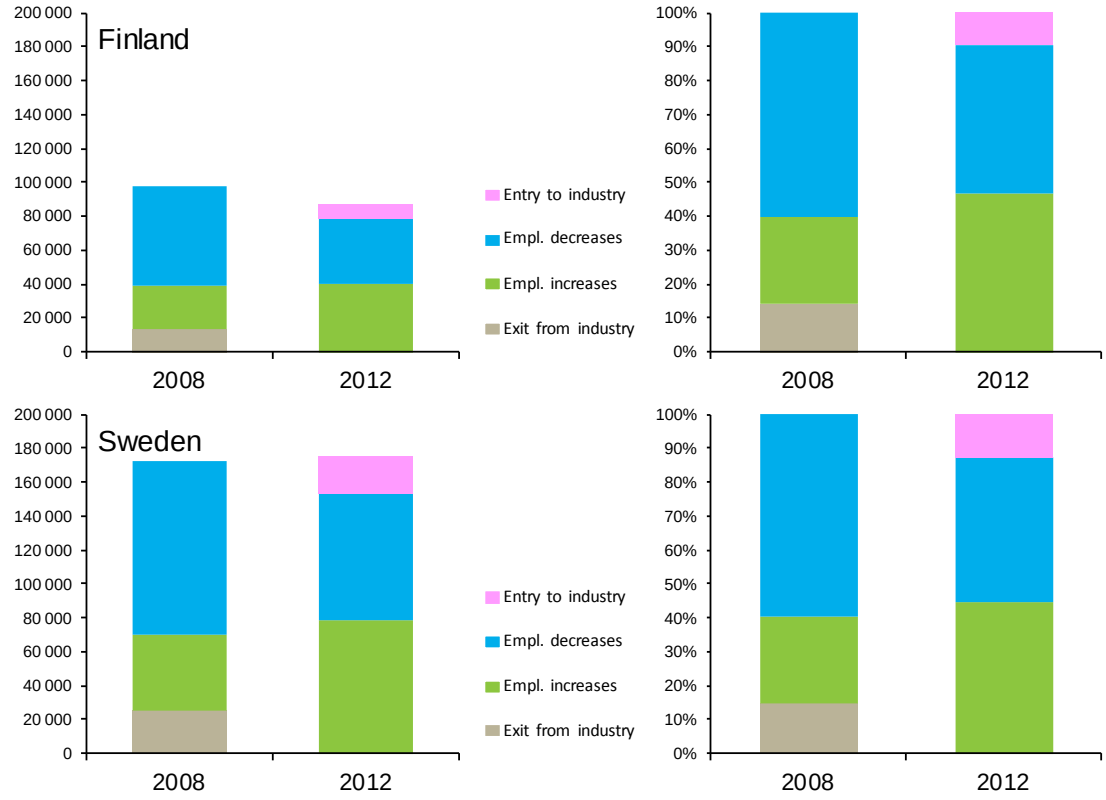
In both countries, the relative role of the *capital region* in terms of employment is dominant. In Finland, nearly 80% of ICT workers are employed by companies, whose headquarters are in the capital region. In Sweden, the corresponding percentage is smaller albeit still high, almost 70%.

3.5 Dynamics of the ICT sector since 2008

In this section we study ICT employment dynamics during the crisis, i.e., since 2008. We consider four types of industrial dynamics: **entries**, i.e., companies that enter into the ICT sector since 2008; **exits**, i.e., companies that exit from the ICT by 2012; **increases**, i.e., companies with larger domestic employment in 2012 than in 2008; **decreases**, i.e., companies with smaller domestic employment in 2012 than in 2008. Below we will sometimes discuss the above four categories separately but it should be kept in mind that it is their joint net effect that ultimately matters for a nation-state.

In 2008–2012, Finnish ICT employment decreased by over 10,000 persons; in the meanwhile, Swedish ICT employment increased by about 4,000 persons (Figure 3.8).

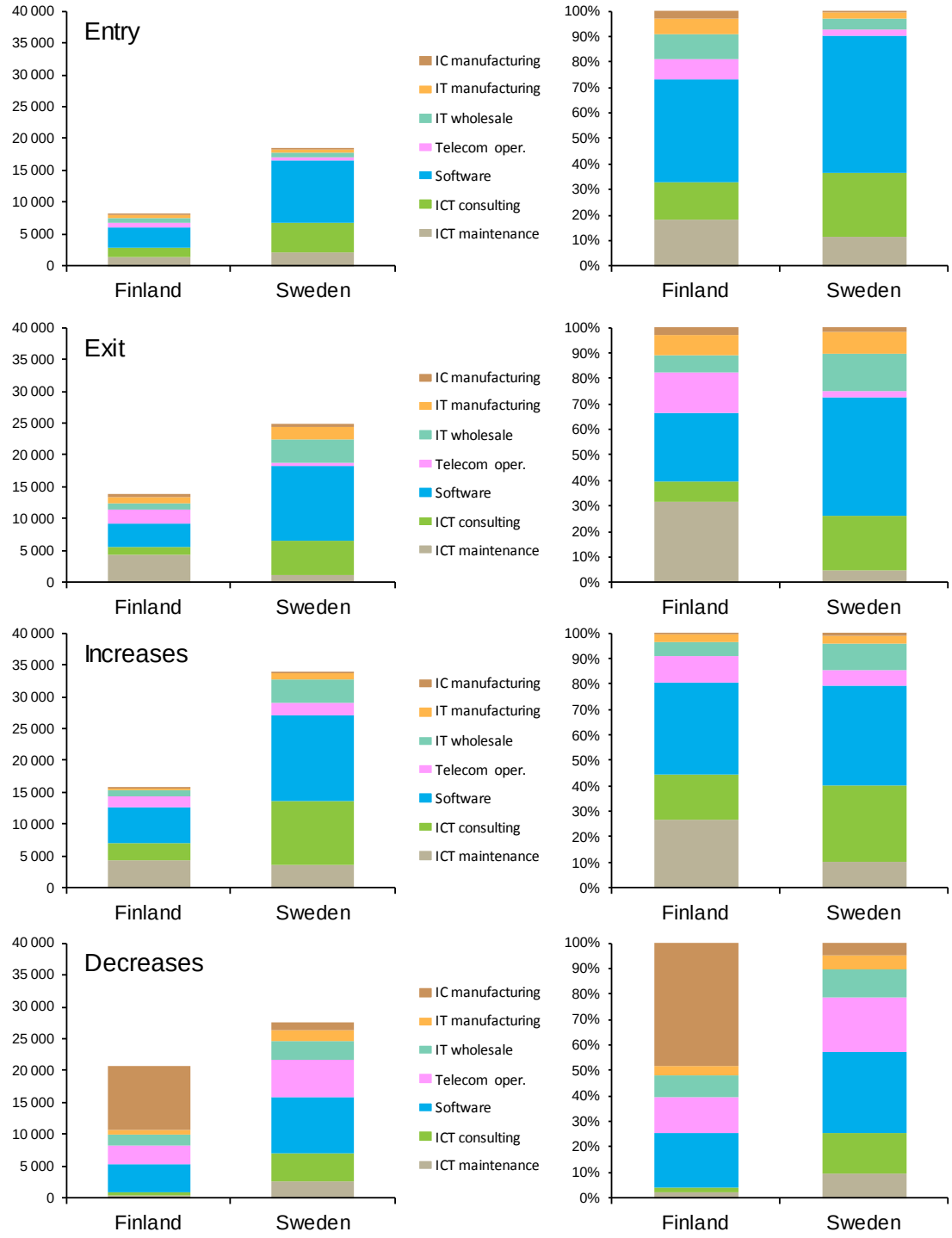
Figure 3.8: ICT employment dynamics in Finland and in Sweden



Sources: Business registers of Statistics Finland and Statistics Sweden.

The entry–exit dynamic was similar in both countries (Figure 3.8). In the window considered here, both exiting and entering firms accounted for 10–14% of the sector's employment. A closer look nevertheless revealed that entry–exit dynamic had a somewhat larger negative employment impact in Finland than in Sweden.

Figure 3.9: ICT employment effects of entries, exits, increases, and decreases in 2008–2012



Sources: Business registers of Statistics Finland and Statistics Sweden.

About 40% of entering Finnish and 53% of *entering* Swedish companies were in software (Figure 3.9). In Finland, the second biggest sub-sector was ICT maintenance, which accounted for 18% of new entrants (only 11% in Sweden). In Sweden, the second biggest sub-sector was ICT consulting, which accounted for 25% of new entrants (only 10% in Finland).

Regarding employment effects of *exits*, in Sweden the largest sub-sectors in this respect are the same as in the case of entries, i.e., software (47%) and ICT consulting (21%). This entry-exit dynamic indicates that there has been quite powerful consolidation and perhaps also offshoring processes occurring in these industries. A similar phenomenon took place in Finnish ICT maintenance, in which 4,405 jobs were lost via exits and 1,489 jobs were gained via entries.

In Sweden, the employment of *growing continuing companies* expanded by 34,018 persons, while companies of the same type added only 15,799 workers in Finland. In Sweden, the employment effect of growing companies was the highest in software (39%) and in ICT consulting (29%); in Finland, the main sub-sectors in this respect were software (36%) and ICT maintenance (27%).

Shrinking continuing companies lost 34,018 jobs in Sweden and 20,715 jobs in Finland. In Sweden, software (32%) and telecom (22%) had the largest shares of lost employment due to shrinking continuing companies. In Finland, the largest sub-sectors in this respect were CT manufacturing (48%), to which *Nokia* belongs to, and software (21%).

3.6 Recent global developments in ICT

Ever-deepening digitalization has induced a societal transformation that may ultimately prove to be comparable with the original industrial revolution. In the last ten years, we have seen a number of changes that have led to major discontinuities in the provision and use of ICT. This digital disruption has challenges previous industry leaders – companies and countries – and provided opportunities for new entrants. Finland and Sweden have felt both up- and downsides associated with this disruption.

The digital disruption has been brought about by two interrelated developments: the *convergence* of ICT industries and related technologies as well as the emergence of what is sometimes referred to as the *nexus of forces* in the digital space.

The digital/industry/technology *convergence* refers to the unification of digital communications, information systems, consumer electronics, as well as software and digital content of various sorts. This convergence tends to break previously prevailing sectoral silos. The convergence was a widely-discussed phenomenon among ICT consultants and scholars in the early 1990s. In early 2000s, seemingly both consultants' and scholars' interest in the discussion on convergence waned, even if the phenomenon started to accelerate. The convergence discussion was re-vitalized, and the phenomenon to a considerable step towards is completion, with the launch of *Apple*'s original *iPhone* in January 2007 and further blazed up with *Google*'s *Android* in 2009. Roughly since year 2010, all actors in the digital space have been dealing with aspects of the convergence. ICT sub-sectors do still exist – in an elusive form – but commercial success in them depends on other sub-sectors in a myriad of ways.

With the convergence, companies are continuously struggling in defining their target markets and "value propositions" to their clients. Previously dominant industry leaders have found themselves in vulnerable positions; often their previous market power have vanished, as new offerings have circumvented the companies' previous "choke points" (for instance, with the advent of cloud computing, the dynamics of corporate client-server architecture hardware and software markets have changed considerably).

The *nexus of forces* consists of three interrelated bundles of phenomena. *First*, the mankind's abilities to produce, store, process, and transmit digitally coded information have grown exponentially for several decades. The celebrated Moore's Law refers to the ability to pack transistors in an integrated circuit ever more densely; similar "laws" have been ongoing in several other relevant domains (with the notable exception of battery efficiency). The economic outcome of these engineering feats has been that the global volume of data, and capabilities to exploit it, has roughly doubled every one to two years. A feature of this exponential growth is that initially modest increments eventually become huge, like the doubling of the number of rice grains on a chess-board. This may be illustrated with this anecdote: "According to Benedict Evans of Andreessen Horowitz, the new iPhones sold over the weekend of their release in September 2014 contained 25 times more computing power than the whole world had at its disposal in 1995."[57]

Second, there are three important phenomena that were virtually unknown to global masses of people just a decade ago: *cloud computing*, *mobile internet*, and *social media*. Kushida et al. discuss how "cloud" transforms computing from a scarce to an abundant resource.[58] They note that abundant, ubiquitous, and cheap ICT resources – brought about by cloud computing and related business dynamics – have the potential to alter competitive dynamics in most industries also outside the core sectors. *Mobile internet* underlies emerging real-time and often location-based service solutions such as *Uber*, a controversial but globally expanding taxi service. Even if – in advanced markets – mobile devices and their diffusion have remained broadly-speaking the same in the last few years, the impact of mobility continues to deepen at a surprising pace, even in the Nordic countries. For example, in Finland, internet searches made via a mobile device roughly quadrupled in 2013 and doubled again in 2014. Some see *social media* as a waste of time, but if people globally spend in excess on one billion hours every day on something (from effectively nil a decade ago), it is bound to be a major societal force. And even though we continue to proxy social media by *Facebook*, *Twitter*, and perhaps a few others, the phenomenon is expanding more rapidly than what we readily observe. For instance, in certain contexts *Facebook* and *Twitter* are dwarfed by *WhatsApp*, an online messaging service, although it is not even characterized to be a part of social media.

Third, the digital revolution that has so far largely lived on "screens" is starting to mesh with our physical surroundings. *Robotics* is hardly a new phenomenon, but they have recently gained better senses (sensors) and become much more intelligence (software algorithms; processing capacity). At the same time the quality-adjusted price of a robot has plummeted; previously very

[57] The Economist (3 Jan. 2015), http://v.gd/U0h57t
[58] Kushida, Murray, and Zysman (2015).

expensive robotic lawnmowers and vacuum cleaners have become mass-consumer products. A bundle of technologies known as *3D printing* or additive manufacturing holds a promise of turning the world of physical objects in a fully-personalized on-demand infofacturing. With *internet of things*, or even "of everything",[59] we can make increasingly complete virtual model of our physical world, which in turn opens of host of new business opportunities.

The above three interrelated bundle forces have a few aspects in common. Each of them is undeniably a major global phenomenon. Each of them has experienced huge changes in the last decade and is evolving rapidly. And they all relate to underlying hardware and software. Yet, they are all just enablers; they only have a social impact, if they are embedded into day-to-day lives of individuals and organizations in such a way that behaviors and structures are adjusted to reflect the possibilities that have opened with technological advance. Because this complementing non-digital human-centric investment is quite large, perhaps ten time as large as the needed digital investment,[60] and because people and organizations often take years or even decades to fully adjust, the full impact of the recent tsunami of technological advance will unfold in the next *two to three decades*; even if one would (wrongly) assume no further scientific and technological advance to take place.

The disruption, caused by the convergence and the nexus of forces, end the "technology hegemony" that previously characterized the ICT sector. With the disruption, business models and user needs are the focal points; technology is seen as a tool.

ICT sector in Sweden was in considerable difficulty in the early 2000s. With these difficulties, the Swedish ICT sector was forced to explore new opportunities – effectively it entered the post-disruption world as the disruption itself was unfolding. At the same time in the early 2000s, the Finnish ICT sector experienced an unprecedented boom associated with *Nokia*'s growing dominance in mobile handsets. Finland was forced into the post-disruption world only after Nokia's collapse in 2008/9. With the above-mentioned difference in timing, and due to the structural differences in the respective sectors, Finland and Sweden now find themselves in different trajectories. Sweden has adapted/recovered quite well, whereas Finland is in the midst of making necessary adjustments.

3.7 Main observations

The size of the Swedish ICT sector is gigantic compared to the Finnish ICT sector in absolute terms – it has six times more firms and employs twice more workers. In comparison to the total economic activity by country, the differences, however, mainly vanish. The share of ICT in total value added is in the both countries, for instance, at the level of 5–6%. In relative terms the ICT sector's role in regard to employment, exports and R&D has been declining in both economies during the last decade.

Regarding the employment of sub-sectors of ICT, striking differences between the countries are the high share of ICT consulting firms in Sweden and ICT maintenance firms in Finland,

[59] Evans (2012).
[60] Brynjolfsson and Hitt (2000).

respectively. In both countries, incumbent firms are dominant employers. As employers the relative role of younger firms is larger in Finland and the relative role of micro- and small-sized firms in Sweden, respectively. During the years 2008–2012 the Finnish ICT sector lost over 10,000 jobs, mostly due to *Nokia*, whereas in the Swedish ICT sector created about 4,000 jobs. The main labor market effects have been occurring in the continuing firms; the employment effect of exiting and entering firms has been in range of 10-14% in both countries. By sub-sector, dynamic labor market effects have been the most significant in ICT consulting and software in Sweden and in IC manufacturing and software in Finland.

4 The historical evolution of the Finnish ICT sector

Petri ***Rouvinen*** *and Pekka* ***Ylä-Anttila***

National regulation, policies, and even politics, played a crucial role in the early history of the Finnish ICT sector. Subsequently Nordic, European, and ultimately global developments grew more important. The move from analog to digital technology in mobile telecommunications – that coincided with worldwide de-regulation and liberalization of telecom operation – was Finland's big break into the global ICT markets, which was capitalized handsomely.

4.1 A rocky ride

In 1990, Finland was one of the least ICT-specialized industrial countries; in the following decade, it became the most ICT-intensive countries in the world.[61] As far as its specialization in ICT-providing industries is concerned, Finland is now only somewhat above the OECD average. Finland's industrial specialization has shifted back towards its traditional strengths in forestry and engineering. As seen in Chapter 1, however, Finland nevertheless has the highest economy-wide share of ICT specialist in total employment.

In the early 1990s, Finland was on the brink of bankruptcy. The ICT sector had a major role in lifting the country. In 2015, Finland is again facing severe cyclical and structural difficulties, which in part are attributable to unfavorable developments in the ICT sector. While the ICT sector is again making a positive contribution for the Finnish economy, it is unlikely to become the engine of growth it once was. A single company, *Nokia*, has made a uniquely large contribution to the Finnish economy in the past two decades. In 2015, *Nokia*'s contribution to the Finnish GDP, without the handset business that was acquired by *Microsoft*, is sizable 0.5%.

The Finnish ICT sector's history dates back to the late 19th century, and is closely knit to the country's evolution from a resource-driven to a knowledge-based economy. In order to understand the current turmoil in ICT and assess the future prospects, one has to take a longer view not only to the history of the sector itself, but also to the economy as whole.

The forces that have shaped the evolution of the ICT sector include: regulation and market structure, links between different industries reinforcing each other, interplay between private and public sector, institutions, technological innovations, industrial policies, corporate strategies – and a chance. Finland as a country and *Nokia* as a company got a few lucky breaks – the fact that Finland was well-place when opportunity knocked had nothing to do with luck.

[61] Koski, Rouvinen, and Ylä-Anttila (2002).

4.2 Decisive role of regulation and competition

The early development of the Finnish ICT industry relates to telephony operation. Unlike in most countries, telephony was never a state monopoly in Finland. In addition to a public telephone operator (PTO), which was primarily in charge of long-distance and international operation, licenses were held by a large number of private companies that operated local networks**.**

This peculiar market structure can be traced back to the 1880s and to the Finnish Senate's desire to circumvent telegraph regulations of the Imperial Russia, under the reign of which Finland was at that time. The multi-operator market structure served not only in strengthening the independence struggle of the then semi-autonomous Finnish grand duchy, but it also had unintended implications for the future development of the Finnish ICT sector.

The dual market structure, consisting of the smaller private companies on one side, and the PTO-regulator on the other, created fruitful tensions, competition, and threat of losing locally strong market position. During the first decades of network construction, the PTO used its mandate as a regulatory body to take over poorly performing private operators. This threat induced technical competition and upgrading in the private networks. However, it should be noted that there was no actual market competition between operators, as their licenses granted them local monopolies.

Later on, starting in the 1960s, the private telephony operators intensified their demands on the liberalization of increasingly interesting new telecommunications services (e.g., fax, and later, analogue mobile services) that were under the monopoly right of the PTO. A series of amendments to the still operative imperial Telephone Decree of 1886 were made between 1987 and 1994, which liberalized the Finnish market among the very first in the world.

However, market competition started later, in 1988, when the private operators decided to construct a mobile network without a license, relying on ultimately getting one. They chose the newly developed digital GSM standard that was not yet commercialized anywhere else in the world. In 1990, the license was granted, after an intensive political debate on the viability of parallel networks in a small country, and the digital mobile service was commercialized next year among the very first in the world.

The long tradition in a "dual" market structure provided a basis for balanced competition from the outset of liberalization: transitory regulation to induce equitable competition between the incumbent and the entrants was not needed in Finland. Further competition was induced, as the association of private operators started to break up. Virtual operators and foreign companies also entered the market. Liberalization lowered rapidly and significantly the general price level of telecommunications. Together with more affordable phones, mobile communications started to take off.

In addition to the special market structure, there was another distinguishing feature in the Finnish telecom market: equipment provision in Finland was open to foreign manufacturers from early on. Unlike in countries with an equipment manufacturing monopoly, e.g., France,

and Germany, there was no public interest in protecting domestic supply. Independent operators were free to choose among different suppliers, and thereby put small local manufacturers under competitive pressure.

The multi-operator market attracted leading foreign equipment manufacturers such as *Bell*, *Ericsson*, and *Siemens*, to Finland to test their latest technology in small scale. Private companies, usually co-operatives, acquired advanced technical know-how. These knowledgeable customers proved valuable for the emerging domestic equipment industry later when it started to develop new telecommunications technology.

4.3 Knowledge complementarities and collaboration

The Finnish ICT was initiated around 1920 in three separate organizations that were finally merged in 1987 under the management of *Nokia*. The original companies had somewhat different focus areas at the outset: *Salora* concentrated on the resale of radio and TV sets; *Suomen Kaapelitehdas* focused on cables and electricity production; and the radio laboratory controlled by the Ministry of Defense, later named *Televa*, started out with military radio systems.

In 1963, a call for tenders issued by the Finnish army for a battlefield radio spurred companies to give physical expression to their accumulated expertise. Ultimately, the army did not have the resources to purchase the system. But the prototypes served as the forerunners of commercial portable phones. Also, state agencies, including the telecommunications administrator, the state railways, and the coastguard, with their demanding communications requirements, had a major influence on companies' product development efforts.

The *Auto Radio Puhelin* (ARP, car radio phone) network was introduced in 1971 as the first mobile telephone network in the country to provide nationwide service. It provided good geographical coverage but was not technologically sophisticated. In the mid-1970s, the service had some ten thousand subscribers. Finnish radio phone manufacturing gained a substantial market share across the Nordic countries. Although ARP did not turn mobile communications into a major business, it provided experience and customer interfaces for companies such as *Nokia*, *Salora* and *Televa*. It also indicated that there was commercial potential in mobile services.

In network systems, development was intense but yielded little sales revenue. In fact, it was other electronics applications, such as TV sets, computers, and industrial process control systems that dominated commercial electronics up until the late 1980s. The adoption of semiconductor technology in the 1960s served as the basis for electronics development. Coupled with pioneering product development in digital transmission and digital signal processing, it produced knowledge that proved pivotal for Finland's later success in digital telecommunications.

The development of the analog *Nordisk Mobil Telefon* (NMT, Nordic Mobile Telephone) standard in the 1970s was one very valuable outcome of the traditional cooperation between Nordic telecommunications administrators and industry. It aimed at creating a Nordic market

for mobile telephony and inducing competition. The standard development project was open to third-country suppliers as well. Openness promoted competition with regard to network equipment and handsets. Advanced features such as roaming were included and, fortunately, the diffusion-promoting "caller pays" practice was also adopted.

In the early 1980s, the Nordic countries constituted the largest mobile communication market worldwide in terms of the number of subscribers. *Mobira*, a joint venture of *Nokia* and *Salora*, supplied the first NMT portable phones. In contrast, Finnish companies were neither ready nor willing to supply network technology in the early phase of the NMT project. Eventually, under pressure from the PTO, which was keen to curb the market power of *Ericsson* and rein in equipment prices in general, *Mobira*, and later *Tele-Nokia*, started to manufacture network equipment.[62]

In 1988, the telecommunication authorities in the European Community published the *Groupe Spécial Mobile* standard (GSM, digital global system for mobile communication). The technological challenges surrounding GSM related primarily to the digitization of radio transmissions and to the exponential increase in the complexity of the signaling and control software. These were fields in which *Nokia* had accumulated competencies working with its customers in the advanced banking sector. Consequently, this expertise gave it an entry ticket to the standard development project.[63]

At the same time, *Nokia* reorganized its telecom divisions to cater to the envisioned GSM-based growth in cellular systems, and to help meet the deadline for the inauguration of the GSM Service in Europe in 1991. The tight deadline was met in Finland when the world's first GSM call was placed in June 1991, even though the pan-European launch of the service was delayed due to technical problems. *Nokia* and *Ericsson* were among the first companies to adopt GSM, which eventually became almost universally accepted.

On the operator side, the PTO had a monopoly of the NMT service. Owing to the lucrative nature of the mobile market, the private camp applied for a second license, but without success. In 1988, it decided, on the basis of a regulatory loophole, to construct a mobile network without a national license. This private venture chose the newly developed GSM standard, which was not yet in commercial use anywhere in the world. In 1990, a license was finally granted to a newly established company, *Radiolinja*, after an intensive political debate on the viability of parallel networks in a small country. The digital mobile service was commercialized the following year by *Nokia*, which thus made its global GSM debut with *Radiolinja*'s network. The PTO followed suit in a partnership with *Ericsson*.

The mobile market entrant started to erode mobile service pricing. Soon, Finnish mobile services were the least expensive in the world. Fueled by more affordable portable phones, which were gradually replacing common auto phones, mobile communications was adopted by the masses.

[62] Palmberg (2002).
[63] Palmberg and Martikainen (2003).

Although the foundations of domestic equipment manufacturing were laid in the 1920s, foreign manufacturers dominated the market up until the 1980s. During the 1970s and 1980s, Finland made rapid advances in digital and mobile technologies. *Nokia* participated in these developments and, since the 1970s, has become a central force in the consolidation of the industry. By the late 1980s, a fair part of the Finnish telecommunications equipment industry had merged under the aegis of *Nokia*.

The merger of *Nokia* (originally a timber-grinding mill), *Suomen Kaapelitehdas* (Finnish Cable Works) and *Suomen Gummitehdas* (Finnish Rubber Works) in 1967 can be regarded as the birth of *Nokia* that exists today. Although the forestry-based company lent the name, the cable company provided the core knowledge base for the new entity. In 1960, this unit had established an electronics department reselling computers, providing computing services, and also manufacturing some its own electronic devices. It also assumed an important role in educating its own staff, and Finns more generally, in the area of digital technologies.

Nokia was still pursuing a conglomerate strategy in the 1980s and made several sizable acquisitions in consumer electronics (e.g., Swedish *Luxor* in 1984 and German *Standard Elektrik Lorenz* in 1987), information systems (e.g., *Ericsson Information Systems* in 1988) and other fields not directly related to telecommunications. Indeed, *Nokia* was the biggest manufacturer of personal computers and color TV sets in the Nordic countries and ranked among the top 10 in Europe. This conglomerate strategy partly explains *Nokia*'s role in merging the various businesses of *Salora*, *Suomen Kaapelitehdas*, and *Televa*.

The conglomerate strategy was, however, not a success story. Exacerbated by managerial and ownership problems and the early 1990s recession, it plunged the company into a deep crisis. *Nokia* almost went bankrupt in the early 1990s, primarily as a consequence of its overly ambitious and costly acquisition and internationalization strategy. In 1992, *Jorma Ollila* became the CEO. Under his leadership, the course changed and activities outside mobile communications were divested. This process was completed by the late 1990s.

With the exception of UK-based *Technophone*, Europe's second-largest mobile phone manufacturer at the time (in 1991), *Nokia* largely avoided acquisitions in its rapid expansion in the 1990s. Alliances were nevertheless important from early on. In handsets, *Nokia* established joint ventures with America's *Tandy* and engaged in private labeling with *Tandy*-owned *Radio Shack*, AT&T and others. On the network side, it initially partnered with *Alcatel* (France) and AEG (Germany) to provide GSM solutions.

Nokia's global mobile phone market share peaked at 41% in 2006. *Apple*'s first *iPhone* was announced in January 2007, but the kiss of death for *Nokia*'s phones was rather *Google*'s strategic response to *iPhone*, *Linux*-based *Android*. *Nokia* had first developed Linux-based *Maemo* to be its new mobile phone operating system after *Symbian*, but later this effort was merged with *Intel*'s similar *Merlin* to form *MeeGo* (now developed by *Sailfish*). *Nokia* launched one favorably-received *MeeGo* phone but at that point it had already chosen *Microsoft*'s *Windows Phone* as its sole operating system in high-end phones. Ultimately, *Nokia* saved the remainder of the company by selling its mobile phone business to *Microsoft* in September 2013.

Nokia rode the wave of exploding global mobile telecommunication markets, fueled by worldwide deregulation in telecommunications. Thanks to its narrowly defined and globally oriented strategy, it was able to meet the market challenge somewhat better than its closest competitors. In the 1990s, its management was able to build an innovation-driven culture and supportive organizational structure, flexibly exploiting both internal and external networking. In the course of the 2000s, Nokia crew bureaucratic. It failed to develop a mobile operating system and ecosystem that could compete with the offerings of *Apple/iOS*, *Google/Android*, and *Microsoft/Windows*. And since *Microsoft*'s mobile ecosystem failed to gain traction, *Nokia* had to divest its handset business.

A closer look at ICT manufacturing in Finland suggests that the competencies, skills, and systems built to serve traditional Finnish industrial strongholds – pulp and paper making, metals, and industrial chemicals – proved invaluable in developing ICTs. Especially process control systems include a lot of similarities, links and even technical solutions with ICT systems.

Hence, the existence of complementary, rather than competing, technical knowledge and skills in the various firms and public organizations led to intensive collaboration in R&D, production and also marketing. Especially noteworthy joint ventures include mobile handsets and digital switching. These joint ventures were founded in the late 1970s. They were very important for consolidating limited resources in a competitive industry.

4.4 Public-private linkages

The development of the NMT standard in the 1970s was a highly valuable outcome of the traditional cooperation of Nordic telecommunications administrators and industry. It aimed at creating a Nordic market for mobile telephony and inducing competition. The standard development project was open to third-country suppliers as well. Openness promoted competition in network equipment and handsets.

Early on, NMT provided critical mass and relatively high penetration rates, which led to early recovery of development costs as well as accumulation of knowledge and scale economies. Many sorts of network benefits in both production and consumption were obvious.

The role of technology programs funded and coordinated by *Tekes* should also be recognized. Although technology and industrial policies have predominantly played an indirect, conditions-providing role, for the emergence of the ICT cluster, the importance and high priority of sector has been acknowledged in policy initiatives. Many technology programs funded and commissioned by *Tekes* especially in the mid-1980s contributed to the initial growth stage of the sector.

The role of *Nokia* as the industrial engine in ICT was recognized and harnessed throughout networks of firms participating in the technology programs. This is compatible with cluster-based industrial policies that seek to internalize externalities related to new technology fields.

Of course, competition policies, notably liberalizing the telecom market very early on, have had a considerable bearing on the sector. Trade policies and openness to the world market has been the very basis of the growth and productivity in all industries, not least in the ICT.

Without liberalizing the capital market in 1990s the ICT cluster would not have grown as fast as it did. In spite of many side effects and misfortunes of the liberalization the implications for ICT sector's expansion remain very important.

4.5 Towards more diverse sectoral structure

The recent history of the Finnish ICT sector is full of dramatic turns. The dominance of one company, *Nokia*, has drastically changed and its importance for the Finnish economy diminished very quickly. The global ICT landscape has transformed in almost all respects – key players come from the United States – particularly the Silicon Valley – and Asia, rather than Europe, manufacturing of ICT equipment has been relocated to lower-cost regions, digital services are driving the sector's growth and restructuring.

Finland was the last country in Western Europe to host a mobile handset plant. *Nokia*'s plant in Salo was closed in 2013, which marked an end of a highly successful era. The plant was the most important site of Nokia in the early 1990s, and a large one even in global perspective. Later it was an important site for developing production processes and technologies, but also experimenting with new devices. By the early 2000s, it had become a relatively small unit having only marginal role in *Nokia*'s world-wide production network. The core of *Nokia*'s phone business in Finland was in R&D, design, marketing, and headquarters activities. From the Finnish national economy's vantage the intangible assets – brand, IPRs, management skills – had become *Nokia*'s core. While ICT manufacturing shrunk, exports of ICT services continued to expand.

The most dramatic event in the recent history of the Finnish ICT is *Microsoft*'s acquisition of *Nokia*'s phone business in September 2013. The deal was completed in early 2014. In 2015, *Nokia* sold its only remaining part directly related to handset business, the HERE business unit build around digital maps, to German automotive manufacturers. Currently *Microsoft* is downsizing its mobile phone unit, which will have severe consequences in Finland. Mobile phones continue to be developed in Finland but the activity is takes place either in local subsidiaries of *Huawei* or other major manufacturers or relates to development of "boutique" phones such as the *London* phone for *Marshall*, which is best-known for its guitar amplifiers.

With *Huawei* and *Ericsson*, *Nokia* is currently among the biggest providers of mobile telephony network equipment and services. In September 2015, *Nokia* is in talks to acquire *Alcatel-Lucent*. Should the deal go through, the new Nokia would probably still remain behind *Huawei* and *Ericsson* in terms of market share, but the three companies would be within a few percentage points of each other.

4.6 A summary of factors behind the Finnish ICT boom

The ICT boom in Finland from early 1990s until about 2008 was most exceptional especially from a national but also from an international perspective. In this section we discuss factors that supported the boom.

A break with the past

For Finland, the recession of the early 1990s provided a decisive break with the past. It fostered a pragmatic and straightforward culture in both politics and business. Faced with deep recession, the Finns simply could not afford inflexibility or bureaucracy. Thanks to the country's stable political environment and social cohesion, political institutions remained functional. The necessary policy adjustments could therefore be made even during the crisis.

Vast unemployment in the 1990s gave the emerging ICT cluster the large recruitment pool it needed for its expansion. The public educational system also responded to ICT-related needs. Furthermore, the collapse of eastward trade with the Soviet Union freed up resources that firms could then channel into developing ICT (including GSM) and pursuing the subsequent expansion.

Relaxed capital constraints

The liberalization of global markets for goods, services, capital and technology, triggered by developments in the United Kingdom and the United States in the late 1970s, led to a globalization boom in the mid-1980s. As a result of this globalization and concurrent Europe-wide liberalization efforts, Finnish companies gained access to new markets and became increasingly exposed to global competition.

Lack of capital was long regarded as the Achilles' heel of the Finnish economy. This realization was instrumental to the liberalization of capital markets in the 1980s and to relaxed capital constraints in the early 1990s. After deregulation and Finland's accession to the European Economic Area (EEA) and the EU, larger Finnish companies in particular gained direct access to foreign investors. A huge influx of capital to Finland followed in the mid-1990s and, for a couple of years, the Helsinki Stock Exchange was the most international one in the world, measured by the share of market value held by foreigners.

The Finnish financial system moved away from a bank-centered system in the mid-1990s, when the stock market grew and indirect debt finance contracted as a result of the banking crisis in the early 1990s. Greater availability of venture capital has been especially important to small Finnish ICT firms, which apparently have a need to maintain conservative leverage ratios.[64]

Technological opportunity

Digitization was a major technological breakthrough in voice and data storage, processing, and transmission. This was important for Finland, as it provided an opportunity for new players with neither experience nor vested interests in computing or communication. Finland had sufficient

[64] Hyytinen & Pajarinen (2005).

expertise in digital technologies in general and in telecommunications in particular, both of which were vital to the big GSM breakthrough.

Radio technology, in addition to a profound understanding of telecommunications, was one of the prerequisites for building a mobile telephone system. Finnish university-level education in radio technology had started in the early 1920s. Radio technology lurked in the shadows in many Finnish firms well before being channeled into commercial applications.

Winning standards

Telecommunications standardization in the Nordic and European contexts may be the single biggest factor that explains the Finnish ICT success story. Finland was an early adopter of first NMT and then GSM, both of which eventually proved to be the winning technologies in their eras.

Early on, NMT provided critical mass and relatively high penetration rates, leading to early recovery of development costs as well as the accumulation of hands-on knowledge and scale economies. Many types of network benefits in both production and consumption also accumulated.

When the transition to digital technologies came, Nokia bet heavily on GSM as the second-generation (2G) standard. Eventually, this technology commanded three-quarters of the worldwide user base. Nokia managed to capitalize on its early lead in both GSM networks and handsets.

Sophisticated demand

During and prior to the Cold War era, telecommunications operation was often considered a natural monopoly and equipment manufacturing was largely kept nationalized for strategic reasons. Since then, both operation and equipment markets have been almost completely deregulated and liberalized. Finnish ICT firms, unlike many of their international competitors, had ample experience operating in a competitive environment with diverse customer needs. Besides having a history of telecommunications competition that dated back over a hundred years, Finland was also some three years ahead of other industrialized countries in taking the final steps toward completely deregulating communications markets.

In mobile telecommunications in particular, deregulation gave rise to eager second-tier operators and service providers that wanted to deploy new networks rapidly and with a minimum of technical problems. Former monopoly operators were forced to respond by upgrading their networks. Competition and the resultant lower prices, fueled demand, which in turn led to further investments. Thus, the industry indeed experienced a virtuous demand cycle in the 1990s.

Scandinavians seem to be accustomed and therefore quite willing to test new technologies. In the early years of mobile telecommunications, new generations of phones always caused quite a stir and “forced” many users to shop for an upgrade. Fortunately, customer needs in these markets preceded those elsewhere, thus giving something of a first-mover advantage to Scandinavian firms. Finland and Sweden are also leaders in certain types of ICT usage, such as

online banking and mobile payments. The Scandinavian market was therefore a rather happy marriage of technological competence in both production and use.

Cooperation and visionary management

Competition encourages efficient and lean organization. Somewhat paradoxically, cooperation has been equally important to the success of ICT in Finland. Indeed, international comparisons suggest that intensive inter-organizational cooperation is one of the essential features of the Finnish national innovation system.

A diverse array, but by no means all, of Finnish communications expertise was eventually merged into *Nokia*. In the 1980s, the corporation was relatively similar to some other Finnish conglomerates. In the 1990s, however, it transformed itself into something exceptional. Despite its roots, *Nokia* was able to give up its forestry-related activities and realized early on that Soviet trade was best treated as a cash cow. Focusing on mobile communications was a bold move on Nokia's part in the early 1990s, but one that paid off handsomely.

Supporting policies

The institutionalization and strengthening of science and technology policies began in early 1960s. Important changes that contributed to the knowledge-driven growth and expansion of the ICT sector took place throughout the decades that followed. The main aim of these policies was to strengthen industry's science and technology base.[65]

At the start of the 1980s, technology policy became increasingly target-oriented and systematic. *Tekes* was established in 1982 to coordinate public R&D support and related efforts, such as national technology programs. Technology transfer and the commercialization of research results were emphasized. *Tekes* and its programs became important instruments for implementing policies. The focus of the new agency’s operations was information technology. In fact, two extensive information technology programs had already been initiated before *Tekes* was established.

Toward the end of the 1980s, a more systemic view of policy-making was adopted. Then, in the early 1990s, the deep recession fostered the relative importance of microeconomic policies. In the 1990s, the *Science and Technology Policy Council* also introduced the national innovation system as a basic framework for policy-making. Innovation was seen as being of a systemic nature, contrary to the traditional linear innovation model. This enhanced cooperation between various policy agencies and improved possibilities for making use of emerging, complex ICT. The systemic view also highlighted the role of education in adopting, diffusing and utilizing new technologies.[66]

4.7 The way forward

Looking at the ICT sector’s history reveals that the forces shaping its evolution have greatly varied over time. While in the early stage regulation, national policies, and even politics, played

[65] Lemola (2002).
[66] Georghiou et al. (2003).

a crucial role, later innovation and corporate strategies have had the biggest influence. Today, the forces of globalization –unbundling of supply chains, corporate alliances, rapid development and diffusion of new technologies, and access to global skill pools – are among the most important factors.

For a small country globalization is primarily an opportunity, not a threat. Globalization has nevertheless challenged existing social and economic structures, as relocation of production needs to be compensated for via innovation and new entrepreneurial activity. While there is a fair amount of startup activity in Finland and many established businesses are constantly renewing, many central institutional arrangements, e.g., in the labor market, are still to be adjusted.

The ICT leading firms have had to constantly reinvent themselves throughout the history. The digital disruptions in the past decade have, however, been particularly drastic and most old incumbent companies are struggling to adapt, even as the sector continues to evolve at a feverish phase.

The history of the Finnish ICT sectors shows that even rapid and sizable transitions from one industry to another, without sacrificing the core values of the society, are possible. It should be noted, however, that the foundations for such transitions are built in the course of several decades and in several special circumstances.

5 Understanding the Swedish saga through an historical exposé

Eric ***Giertz***

The industrialization, and finally the development of a competitive ICT sector, in Sweden were formed by a complex interaction between business and governmental actions and regulations that set the rules for different operations. The regulations as well as the interactions and cooperation has changed considerable over time but the development during one phase built the foundation for the next. In this chapter the development 1850-2005 is divided into four different phases.

5.1 Introduction

The Swedish roots to information and communication technology can be traced to the rise of the telecommunications industry and the telecom operators in the late 1800s, as well as the tentative attempts to establish a Swedish computer industry in the early 1950s. The development of what we now perceive as the ICT industry was initiated, in essence, first in the 1950s. This development took place in the post-war corporatist Swedish society, which was characterized by a very close cooperation and interaction between government, industry and trade unions as well as between research, higher education, utilities and the Swedish export industry. Before we move on to the concrete development in the 1950s, it is necessary to briefly describe the development of the Swedish industry and the character of the Swedish corporatist society[67].

5.2 1850-1920 Liberal reforms, industrialization and entrepreneurship

Until the mid-1800s Sweden was relatively untouched by the incipient industrialization in other parts of Europe. Liberal ideas that had taken root elsewhere had not left any deep traces in Swedish society, but in the mid-1800s a series of liberal reforms were implemented. Alongside Sweden introduced the right for any citizen to establish firms and free trade was introduced; import and export ban was lifted, and both foodstuffs and raw materials were completely duty free. At the same time a new banking law was added, which led to the establishment of new commercial banks. These attracted capital which was loaned to an expanding industry. Predecessor was A.O. Wallenberg, who founded Stockholms Enskilda Bank already in 1856. The number of commercial banks peaked in 1908. Then there were 84 companies[68].

The liberal reform period in the mid-1800s ended with the reform of political life. The political new order brought new men to the representative bodies. Conservative groups (nobility, clergy,

[67] This whole chapter draws on Giertz (Ed) (2008)
[68] Lindgren (2008) p. 87

bourgeois and peasants) lost their former privileges and were replaced by more liberal forces which advocated industrial development. The state also took on new commitments, which were financed by large borrowings abroad. These included development of communications, which improved dramatically from the mid-1800s[69]. A novelty was the electric telegraph. A telegraph agency (Telegrafverket) was established in 1853 to build a state-owned national telegraph system. That same year the Stockholm-Uppsala telegraph line was in use for public traffic. Another novelty was the railroad. In 1853 parliament decided to build a nationwide railway. From the start the railway network was planned as a nationwide transport system. The state built a network of trunk lines but left it to private railroad companies to build the ramified connections. In 1880 there was a total of 6,000 kilometers railway in the country, of which 2,000 were owned by the state and controlled by Swedish Rail (SJ). So in constructing the nationwide railway system governmental initiatives were combined with local private entrepreneurship. For telephony, as well as electricity, on the other hand the exploitation started almost invariably by local initiatives.

Sweden takes the lead in telecommunication[70]

In 1880 the Stockholm Bell Telephone Company established the first telephone network in Sweden with just over one hundred subscribers. The phone was at this time a system for local communication with a range of up to ten kilometers. The contrast was great against the telegraph, which already was a worldwide communication system. The Bell Company focused on public institutions, companies and the most affluent businessmen. The business idea was that with a relatively small investment build small telephone networks for a small number of subscribers, who paid high subscription fees. Bell Company thus saw the phone as a service for a small elite. It applied the same concept in many other cities in the US and in Europe. In most places, the company could pursue this line in that it had a monopoly on telephone technology.

But in Stockholm the Bell Company, which lacked a patent in Sweden, was challenged. The engineer and entrepreneur Henrik Tore Cedergren responded to the Bell Company's pricing policy. He felt that the phone should also be aimed at households. He established a competing telephone company in 1883, Stockholms Allmänna Telefonaktiebolag (the Stockholm Public Telephone Company), which purchased all technical input from a newly founded engineering company, Telefonaktiebolaget LM Ericsson, which also supplied some spare parts to the state-owned national telegraph agency. Stockholms Allmänna challenged the Bell Company by offering significantly lower subscription fees. Bell company responded by lowering their fees. The intense competition between the companies led to a rapid increase in the number of subscribers. In 1885, there were 5,000 telephone sets in Stockholm, which was more than in any other city in the world at this time!

In Sweden almost free establishment of local telephone networks prevailed during the telephony childhood. Neither state nor municipal authorities put obstacles in the way. The result was that not only in Stockholm, but also in Gothenburg and some other major cities, several competing telephone companies were established. In this regard Sweden differed from most other

[69] Kaijser (2008:1)
[70] This section draws on Kaijser (2008:1)

countries. In smaller cities cooperative telephone compounds often formed. In 1885, there were about 50 local networks and in 1890 the number of telephone networks had grown to 400.

During the first years of the 1880s telephone technology gradually improved. It became possible to make phone calls at distances up to 100 kilometers. During the end of the decade the single wire was replaced with double wire, which allowed telephone calls of up to 1 000 kilometers. Telephony began to get the character of a nationwide infrastructure system. The Swedish Parliament decided that the telephone system should be organized and regulated in a similar way to the railway system. The state would be responsible for national lines, which were perceived as a general interest. But unlike in most other European countries, the Parliament never gave a monopoly on the telephone to the Telegraph Agency. The Parliament wanted to uphold the right of local associations and private companies to operate local and regional networks. The Swedish railway system was working as a model when the Parliament made its decision.

A belated but rapid industrialization

The liberal reforms, the freedom to start new companies, a political new order and free trade – which was introduced in the mid-1800s – put, along with investments in infrastructure and a new banking law, the foundations for a belated but rapid industrialization in Sweden. New manufacturers produced food, agricultural implements and textiles for the home market. Borås converted from a marketplace to a textile city, and Norrköping became the center for the wool industry. The first steam sawmill began operating in Ådalen in 1849 and was quickly followed by more. Thus the export of sawn timber grew. A new industrial capitalism flourished, which hardly resembled the traditional and stable social structure. Parallel many new successful export companies in the pulp and paper, steel and engineering industries were born during the second half of the 1800s.

Towards the end of the 1800s internationalism and free trade ideals did indeed give way to the rise of nationalism, but industrial production still pushed further momentum and increased prosperity. Exports tripled around the turn of the century, thanks mainly to the success of the pulp and paper industry as well as the engineering industry. But the increase in trade came to an abrupt end during the First World War. Engineering companies however were compensated since they benefited from an increasing domestic demand in the expanding war economy. They were very profitable and many integrated backwards and increased their leverage through large investments in e.g. the electrification of the operation. Some of the banks also combined their lending to investing companies with buying new issued preference shares through their newly formed investment companies.

5.3 1920-1970 Consolidation, centralization and corporatism

During World War I and the years immediately following inflation rates went up. The prices quadrupled in 1913 to1920. But the inflationary period was followed by a deep depression and a tough deflationary monetary policy, which led to prices again halved in two years. Companies that during the war had issued new preference shares and borrowed money from the banks ended up in difficulties. They still had their big debts, but the assets no longer corresponded to

purchase values. They were also confronted with an extremely tough market. Many engineering companies, which had been favored by the war economy, lacked customers when they would switch from military to civilian markets. Other companies, including L.M. Ericsson, also had their assets confiscated in Russia after the revolution.

Ownership is concentrated to a few financial spheres

During 1920 to 1922 liquidations and bankruptcies succeeded each other, which led to large transfers of ownership in Swedish industry. Also many individuals were driven into bankruptcy and livelihoods deteriorated in the short term for a large majority of the population. Unemployment was widespread. In early 1922, a third of the members of LO (Sweden's combined blue collar union) were unemployed. But from the rubble grew a new competitive export industry. Many company founders; entrepreneurs and engineers lost their businesses. But in came new owners; commercial banks and financiers. The number of commercial banks had peaked in 1908 and through mergers they were fewer after the war. It was therefore a relatively small number of dominant ownership spheres within the Swedish financial circles who came to answer for the reconstruction. The control of the iron and steel industry, the pulp and paper industry and the expanding engineering industry gathered at a small number of hands, which became even less after the Kreuger crash and a new depression in the beginning of the 1930s. In 1934 a very large part of the Swedish export industries was controlled by less than a dozen financial spheres.

The new principal owners of Swedish export industries were interested in implementing consolidation and structural changes in the half-century old export industries. They were also eager to expand the markets and start rationalization and streamlining in the companies that had ended up in their enclosures. They recruited rationalization oriented engineers to the company's leading positions. The new executives were more industry strategists than former inventors and entrepreneurs. After the First World War the profile of Swedish business leaders changed. You no longer became a CEO in a large company by starting or inheriting a business, but by educating yourself and making a civil service career to a profession of a business leader. Under the new leaders, many of the existing companies would develop very positively. But industrial development in our country was after the mid-1930s more about rationalization, restructuring and internationalization of existing businesses. More rarely, about creating or establishing new ventures. It was mainly within already established Swedish companies that one would come to pick up innovations and establish new product areas.

Government increases its grip on infrastructure

While the export industry consolidated and rationalized there was an apparent consolidation also in the infrastructure area. Government increased its grip on the infrastructure[71]. It took, through the establishment of Vattenfall in 1909, first responsibility for regional power generation and then the deployment of a nationwide transmission grid. Even greater became the governmental responsibility for the railways. In 1938 a decision was made on the nationalization of all the private railways in Sweden. Swedish Rail (SJ) was then a national railway monopoly in the whole country. Telegrafverket successively acquired all local phone associations and telephone

[71] This section draws on Kaijser (2008:2)

companies. In 1918, the acquisition was finally made of Stockholms Allmänna Telefonaktie-bolag. Telegrafverket (later Televerket) thus created a nationwide de facto monopoly in the telephony field and turned to a kind of Swedish PTT. From the 1930s the government did chose to direct and control the expansion and tariffs so that companies and people in all parts of Sweden were given access to the infra services on almost equal terms.

It was not only the control over the Swedish industry and infrastructure that was centralized in the 1930s. After the 1936 election the political power in Sweden was gathered in the reformist labor movement's hands. The Social Democrats began, under the leadership of Per Albin Hansson, to build the Swedish welfare society. Already before 1936 Per Albin Hansson had built very close, but discrete, personal contacts with some of the most important owners and CEOs in Swedish industry[72]. The social democratic visions included the creation of an efficient and streamlined Swedish export industry. They also desired a peaceful labor market and the avoidance of blockades, boycotts and strikes. Efficient manufacturing processes and a competitive export industry was seen as the foundation of the social democratic vision for a future welfare society. It was the foundation that would allow for increased living standards for a large majority of the Swedish people.

A corporatist Swedish society is born

The new industrial owners and industry leaders' interests coincided largely with the reformist labor movement. After the election in 1936 the leading representatives of the large Swedish corporations chose to abandon their previous negative attitude to the Social Democrats. They decided instead to cooperate with the two branches of the reformist labor movement in Sweden; the workers union (LO) and the government. They could also gather around the common interest of a rational economy. After the 1936 LO Congress the reformist trade unions also took an active responsibility for the development of a more competitive Swedish industry and promoted rationalization; consolidation as well as automation and work study. Negotiations were started with the Employers' Confederation (SAF). A master treaty, the so-called "Saltsjöbaden Agreement", was signed in 1938. The agreement gave the central organizations, SAF and LO, increased influence and acted in a clearly centralist direction.

The rapprochement between the central organizations on the labor market was followed by cooperation between government and industry. The outbreak of the Second World War in the fall of 1939 gave an extra boost to the corporate efforts in Sweden. Closures and refurbishment of defense also contributed to the close collaboration between the state and parts of the industry. The government introduced special military taxes and took out war loans, which allowed very large and rapid increases in public spending. These were channeled largely to the Swedish engineering industry, whose technically advanced products gained an increasingly important role in military defense. During the war, there was a pronounced spirit of cooperation both at the political level and between the parties on the labor market. Laws, including regulations about working hours and holidays, were breached and overtime and shift work became much more common. At the same time new regulations about official duty made strikes and conflicts

[72] Isaksson (2008)

impossible. During the war there also was in essence a wage freeze even in the expanding and lucrative engineering industry.

The good relations persisted after the war. The Prime Minister Per Albin Hansson, who died in 1946, had replaced the socialist dogmatism for a role as pragmatic father of the nation. This was also true for his predecessor, Tage Erlander, who served as Prime Minister of Sweden and the leader for the Swedish Social Democratic Party from 1946 to 1969. The Social Democrats disassociated themselves from further nationalizations of private industry. World War II was, in contrast to World War I, followed by increased economic activity. Swedish industry was blessed with increased orders. During the 1950s and 60s Swedish industry harvested major export successes. Sweden's share of world trade rose almost dramatically, Sweden took the lead in terms of economic growth. The export industry increased its share of employment and was the driving force in the whole of the Swedish society.

The flourishing Swedish export industry laid the foundations of the welfare society that emerged in the decades after World War II. It created the preconditions in terms of economic growth and employment and contributed, both directly and indirectly, to the financing of the growing public sector. The export industry's success was therefore not only a concern for business owners and leaders, but equally for the Social Democratic government and the labor movement. In the late 1960s, Sweden was one of the world's richest countries and the Swedish welfare society attracted international attention. In a relatively short time broad population groups had raised their standard of living from a precarious life of poverty to a life of full employment, relatively good income and seemingly great security. In less than half a century the average industrial worker had tripled their real wages. In addition, he was covered by pension insurance, medical insurance, unemployment insurance and statutory paid holiday. In the welfare society government also took responsible for the welfare of citizens in terms of health care, education and housing. Government reallocated resources, through taxes and charges, between different stages of life, between rich and poor and between those who worked and those unemployed or unable to work.

There was a national consensus that laid the foundations of the welfare society. The development was driven systematically by central representatives of government, industry and trade unions in the context of a very centrally and informally managed corporately social system. This was based on a clear division of roles between government, industry and trade unions.

Some characteristics of the corporatist Swedish society

The Swedish industry's export success after World War II laid the foundation for full employment. There was a shortage of labor – not a lack of work. Therefore, there was almost total agreement in Sweden that it is desirable to systematically streamline human labor in factories. The Swedish labor movement ensured that work and motion studies were made compulsory in Swedish industry in 1944 to ensure that objective piecework salaries were guaranteed throughout the engineering industry in Sweden[73].

[73] See Giertz (1981)

The labor court (Arbetsdomstolen) ruled that piece-work times should be determined objectively by motion and time study men. One consequence was that the Employers Confederation and The Labor Union reached an agreement on work-study in 1948. The companies thus not only had the right but a contractual obligation to employ motion and time study men and to perform time and motion studies on all manual work on the shop floor. Starting with the 1955 agreement the parties also agreed upon introducing a performance standard based upon Methods-Time Measurement (MTM). MTM is a predetermined motion time system to analyze the methods used to perform any manual operation or task and, as a product of that analysis, set the standard time in which an average worker should complete that task. MTM was launched by Maynard's in 1948 and soon became widely spread in the Swedish engineering industry. Thus, from 1955 the parties could check the performance appraisals and piece-work times made by any time and motion study man against hindsight. This unique arrangement is nowadays often overlooked in the description of the corporatist society which created the post-war economic miracle in Sweden.

In their deliberations in Saltsjöbaden in 1938, the parties on the labor market had declined governmental interference. To avoid governmental interference also became the main track for three decades in the postwar labor market policies. The state legislated working hours and holidays, but refrained in general from the regulation of employment conditions. The parties included in the agreement that it was the employers' right to organize, manage and freely hire and fire employees. The agreement supported the structural changes and efficiency measures that the Social Democrats also sought. The government on the other hand, took an active role to facilitate labor mobility. It built up the resources to cope with the information to re-educate people, to move people and set up employment agencies. The relatively widely accepted "moving van policy" explicitly aimed at facilitating and supporting the restructuring and rationalization of the Swedish industry.

In the corporatist society the Social Democrats went arm-in-arm with the owners of major companies in Sweden. They pursued a policy that clearly favored the accumulation of capital within established companies and disadvantaged new ventures[74]. The list of listed companies at the Stockholm stock exchange also stayed more or less unchanged from the mid-1930s to the mid-1970s. At the same time the Social Democrats gradually tightened taxation of wealthy individuals through the introduction of progressive income tax and wealth tax and they increased gift and inheritance taxes. One consequence was that the dominance of the larger well established Swedish export companies increased heavily in Swedish industry. Ideologically the Social Democrats justified their close cooperation with the Swedish capitalists by pointing out that large established companies became increasingly dominant. It was argued that the individual entrepreneurship had played out its role. Consolidations and economy of scale would eventually lead to capitalism undermining its institutional and political importance. It would peacefully pave the way for socialism in democratic countries.

[74] See Jakobsson (2008)

Demand-driven engineering science is introduced

The corporative consensus also included an increased governmental interest in research and higher education. Even before World War II the technical universities started to change. The academic engineering education was extended to four years and the teaching was made more theoretical. Chalmers in Gothenburg became a technical university in 1937, after much resistance from KTH in Stockholm. In parallel the earlier conflict between the more subtle natural sciences and the more practical-oriented engineering sciences was erased.

During World War II government started to look upon engineering sciences as a national investment[75]. That thinking was inspired by Professor JD Bernal at the University of Cambridge. He argued that engineering sciences should be more demand-driven for the benefit of citizens, society and businesses. Gösta Malm was a driving force when the ideas gained a foothold in Sweden. Malm had retired from Vattenfall in 1938 and he had a lot of experience from public investigations. He was also a member of the Board at KTH and the former chairman at The Royal Swedish Academy of Engineering Sciences (IVA). He became chairman for a committee that dealt with the higher technical education as well as one that investigated future organization of research in engineering sciences. The two technical universities (KTH and Chalmers) and large corporations were benefited by the model that emerged. The consensus between the different political camps was striking. They all came to similar conclusions on how to divide responsibilities and work between government and industry.

Consensus between government, industry and academia of the challenges that engineering sciences were facing was reinforced by the needs created during the war and the spirit of cooperation that followed the Saltsjöbaden Agreement trails. The investigation led by Malm began in 1940. A first interim report was fixed at the beginning of 1942. In this the importance of strong links between education and research at the technical universities were highlighted. Through a special grant and larger direct grants to KTH and Chalmers research conditions for engineering sciences in the technical universities were strengthened.

The committee further suggested that applied research linked to common needs in different industries should be performed by specific sectorial research institutes. Each institute would be co-funded by corporations in one specific industry along with government. The research institutes would function as autonomous units but they were to be located next to corresponding institutions at the technical universities, especially KTH. The interest of the companies in one industrial sector was tied to special collective foundations, which all companies in a particular industry could join. That a research program in an institute was jointly sanctioned by large Swedish corporations in one industry was sufficient justification for government to put in corresponding funding. Government completely relied on market forces – that of incumbents – to control the direction, expansion and contraction of applied research in various fields. The investigation led by Malm created a major expansion and upsurge of the higher education and research in engineering sciences. The investigation also laid the foundation for a political

[75] This section draws on Deiaco & Reitberger (2008)

consensus on governmental investments at technical universities. New public spending was transferred to the faculty and to research councils.

During the 1950s, there was a very common optimistic belief in a better future that relied on technological development. This belief was one reason to further increase governmental investments in PhD studies and basic research at the technical universities. In parallel incumbents initiated applied research programs next door. They decided on large research projects, which were co-funded by government, in different sectorial research institutes. Sometimes the researchers almost didn´t know who was employed by the university and who belonged to the institute. The investigation thus laid the foundation for a Swedish university model that was quite unique. The institute sector stayed fairly small but there were strong links between basic research, applied research and industry. Education at technical universities was also closely connected to research and to actual problems in industry. This created a Swedish doctrine that was valid at least until 2000.

The close cooperation and interplay between technical universities, research institutes and incumbents were combined with an extremely close cooperation between individual public customers and individual private corporations. In those so-called developing couples, engineers and technicians from both companies work side by side with research, product development and implementation of new products and systems. This really gave way for very special conditions for the commercialization of research and new technology in the corporatist Swedish society.

Developing couples paves the way for export industries

As mentioned earlier, after World War I government assumed greater responsibility for the development and operation of the infra service systems in Sweden. The extension, expansion and modernization of the infra service systems involved major technical challenges and led to a very close relationship between public clients and the engineering corporations that supplied the technical input.

When power generation and the nationwide transmission grid was built it was the public company Vattenfall and the private company ASEA – the country's leading manufacturer of electrical equipment – which jointly took on the challenge. They developed a close cooperation in high-voltage engineering. This form of close and long-term cooperation between a private Swedish company and a public customer has been named a *developing couple*. ASEA obviously found it very valuable to constantly have a close cooperation with a demanding pilot customer. ASEA relied a lot on Vattenfall's engineers who had great expertise in the operation of large power systems. Additionally, ASEA could perform pilot tests with new equipment in Vattenfall’s existing plants. It contributed greatly to ASEA in the 1950s becoming a world leader and a successful export company in high-voltage technology. Even in the nuclear sector ASEA got a leading position through public orders.

Developing couples played important roles in post-war Sweden. Each couple consisted of a public client and a private engineering company, which developed, manufactured and supplied necessary products and systems. Developing couples also arose within the railroad sector. SJ developed a close and long-term technical cooperation both with ASEA in the electrification of

railroads and with LM Ericsson in developing signaling systems and equipment used for control and security of railway traffic. During the 1950s, an indigenous development of locomotives also started with ASEA that first resulted in thyristor converters for DC motor drives and Rc locomotive and later in asynchronous motors and X2000 trains[76].

Perhaps the most pronounced development couple, however, was the cooperation between the Swedish PTT, Televerket, and LM Ericsson. When Stockholms Allmänna was acquired by Televerket in 1918 many leading engineers and technicians in the company went over to their former supplier, LM Ericsson. Ericsson received a substantial addition of expertise that also started to cooperate with their former competitor, Televerket. Televerket and LM Ericsson soon initiated a very close cooperation in the development of switchboards and other important components. In 1926 the two companies commonly launched an automated tele station with crossbar switches that had been installed in Sundsvall.

The collaboration between Ericsson and Televerket however differed somewhat from that in other developing couples. Televerket had since 1891 developed and manufactured their own products and systems in Teli, an industrial division of their own. Teli's first factory was located in Stockholm but was through a parliament decision moved to Nynäshamn in 1913. Later Teli established new factories all over Sweden in Vänersborg, Gothenburg, Sundsvall, Kristinehamn and Skellefteå. Since Televerket manufactured their own products they almost didn´t buy anything from Ericsson. But Televerket and Ericsson joined forces to develop new products and systems. Televerket and Ericsson manufactured more or less identical products for the domestic market respectively the export markets. The close cooperation with Televerket gave LM Ericsson a great advantage in being able both to share development costs and to quickly gain experience from the operation of new products and components before they were launched abroad.

There were also other developing couples of great significance, such as The Air Force and FMV (The Materiel Administration of Swedish Armed Services) as clients and engineering companies like Saab as suppliers.

A Swedish computer industry is born

Already in the late 1940s a computer development was initiated in the corporatist Swedish society. The first computers had by then been developed in the United States, but for security reasons they were not allowed to leave the country. It was the Swedish government who took the lead in 1947 by appointing a computer investigation (Matematikmaskinutredningen).

On November 26, 1948 government established a new public agency, Matematikmaskin-nämnden (MMN), which got the assignment to develop and manufacture the first Swedish computers. Alongside Sweden, it was only England and France, who had started the development of computers in Europe. The first computer BARK (Binär Aritmetisk ReläKalkylator) was a relay-based computer that was completed in 1950. It was an interim solution while awaiting the second Swedish computer, BESK (Binär Elektronisk

[76] Kaijser (2008:2)

SekvensKalkylator), which was completed in 1953. Both computers were developed and installed on KTH premises. BESK was for a while Europe's fastest electronic calculator. It was used, among other things, by the National Defense but also for civil purposes, including by SMHI and by different companies with great need for calculations.

One of the users was Saab, who had to solve large and difficult computational tasks in their technical development. Saab soon saw the need for a computer of their own. In 1957 Saab had completed its first computer, SARA (Saabs Räkneautomat). SARA was more or less a copy of BESK and also based on the electron tube technology. A machine hall of several hundred square meters was needed to make room for the new calculator. It was used for technical computing in the development of the fighter Viggen and various robot armaments.

That a computer developed by government later was copied by a single commercial enterprise was the most natural thing in the corporatist Swedish society. An agreement was signed in 1954 between MMN and Saab, which basically amounted to that Saab without charge could take over where government ended. Saab continued development work by improving the computer. In 1960, the company had developed a transistorized computer, D2. It was a fast, reliable and relatively compact computer that weighed only 200 kilograms. D2 also became the prototype to a commercial computer, D21. Saab launched D21 on May 11 1962. The first computer had been ordered by AB Skandinaviska Elverk and it was shown at the customer's premises in Stockholm. In Saab's press release[77] you could read:

> *"The new computer's competitive potential, which has already resulted in several orders and an increasing number of requests – currently D21 is being examined for more than 20 different applications – represents a promising breeding ground for a new Swedish industry ... A Swedish computer industry also enables Swedish industry in general and the Swedish research, to streamline their methods and thus maintain the leading position in the progress, which is so important for our society."*

It was initially not given that it was the fighter manufacturer Saab that should be given the task to develop and manufacture commercial computers in the corporatist Swedish society. Saab had originally copied BESK to meet their own computing needs in the development of fighters and robots. The original idea actually was that Åtvidabergs Industrier (later Facit AB) would take over the baton after MMN.

Åtvidabergs Industrier was an industrial corporation and manufacturer of office products. The company had manufactured ten-digit mechanical calculators, named Facit, since 1932. The calculators soon became a great success. By the early 1960s the corporation had a total of 8,000 employees with subsidiaries in over 100 countries, and the subsidiary Facit had come to dominate the business of the corporation, which in 1965 made the entire corporation change its name to Facit AB.

Facit, who then made mechanical calculators, was looked upon as a natural platform for the Swedish computer industry to be. A special subsidiary, Facit Electronics, was formed in 1960

[77] Saabs Pressinformation MP-19-62 (1962)

for the purpose. Facit Electronics also took over engineers and technicians from MMN, which was shut down by government when it had fulfilled its mission. There was no need for MMN went computers went into a commercial and industrial phase. The first product in Facit Electronics was the computer Facit EDB, essentially a copy of BESK but equipped with new external devices. A total of 11 computers Facit EDB were produced, mainly for technical calculations and for Facits own data centers, who delivered time sharing services to different customers. Facit EDB also delivered 12 other computers to the Swedish Air Force's air defense system.

Operations in Facit Electronics suffered losses and required substantial investments. When Saab, by launching D21 also turned up as a domestic competitor, Facit decided to close down. Facit ended the civilian computer manufacturing in 1963 after fruitless negotiations with Saabs computer division regarding a merger. Other activities continued with another organization: the group developed printers and text screens that reached a relatively large market and later also small computers. The time sharing services was moved to an independent company, Industridata, with e.g. ASEA and Saab as co-owners. Facit focused increasingly on its mechanical calculators, branding, marketing and global expansion. Throughout the 1960s Facit experienced an increased growth and a very high profitability.

The incumbent given the task to form a Swedish computer industry thus became Saab. Saab formed a computer division for that purpose. The first commercial computer, D21, was mainly sold domestically but some units were also exported. In total some 30 units were built. Later new versions, D22, D23, D5, D15, and D16, were developed and launched. The Swedish government became one very important customer. When the Swedish government needed 20 computers in the 1960s to calculate taxes, an evaluation between Saab's and IBM's computers was done and surprisingly enough it proved Saab's better. You could very well argue that a new developing couple was born during the 1960s. Of course the Swedish Defense was an important costumer to Saab but Swedish central government was also a very early adopter of computer-ization in various authorities and agencies. During the 1960s (and later the 1970s) the choice always was Saab (later Datasaab). D5 computers from Saab were also used to set up the first and largest bank terminal system for the Nordic banks, a system which was partly in use until the late 1980s. By 1976 12,000 main frame computers from Datasaab had been sold. Still one problem remained. Large Swedish export corporations, including groups in the same financial sphere as Saab, did not buy computers from Saab but from IBM. Partly due to a rather odd Swedish standard the export also stayed very small.

Fixed telecom becomes digital through a joint venture

The cooperation between the Swedish PTT, Televerket with its own industrial division Teli, and L M Ericsson was given a much firmer shape in 1970 when they established a joint research and development company, Ellemtel Utvecklings AB. The Ellemtel agreement was approved by the Swedish Parliament and Ericsson’s Board of Directors. The new company was owned equally by Ericsson and Televerket. Ellemtel was purely a development company without its own production. Production would instead be the responsibility of the company’s two owners using their respective production facilities. The company’s primary task was to develop on its owners’

behalf an electronic and automated telephone switching system for telephone stations that would become the AXE system.

Ellemtel was a way to manage the emergence of a disruptive technology that threatened most players in the telecom industry. Since the early 1960s both Televerket and Ericsson had been working on developing commercial electronic switching systems of their own, but at the end of the decade they feared that they could not master the industrial dynamics along. It had become clear that this new development effort would be of a completely different magnitude than the previous development of electro-mechanical switches. Ericsson had also realized that the system they had developed so far would be far too slow and expensive to compete. It also appeared that the international competitors had made considerable progress in their electronic switch projects. In late 1969 this was confirmed when Ericsson lost a large order to its competitor ITT.

Both Ericsson´s and Televerket's positions as telecom industries were threatened and both companies concluded that it would be most effective to combine resources and jointly develop an electronic telephone switching system. Ellemtel recruited personnel from both owners and could thus not only bring together the expertise from two manufacturing companies but also from one progressive user of telephone stations. Ellemtel's organization was such that ideas and influences from Ericsson and Televerket impacted development work at all important levels, from the boardroom down to the engineers' drawing boards. Ellemtel's work on the development of the AXE system began in 1970 and achieved its decisive breakthrough in 1972, when Ericsson decided not to continue with the development of its former system but instead to concentrate its resources only on AXE. The company's assignment included everything from developing the AXE system's modular system design to developing hardware and software consisting of the computer programs and processors that would control the AXE stations. By 1976 the first AXE system was put into operation in Södertälje by Televerket. The success of AXE electronic switching system enabled both Televerket and Ericsson to continue as telecom manufacturers. Televerket took care of the domestic needs in their own industrial division and Ericsson could compete successfully on export markets. At the same time, the product allowed Televerket and Ericsson to take the next step in mobile telephony. By 1978, Ellemtel's task of developing the AXE system was complete and the company began handing over the technology and transferring its expertise to its owners Televerket and Ericsson. Later Ellemtel worked with other strategic assignments for its principals consisting of technical development for smaller electronic PBXes equipment for data networks and digital transmission systems and new telephones.

5.4 1970-1990 Confrontation, stagnation, crises and a turnaround

Introduction

So the Swedish welfare state of the post-war period was built through a corporatist consensus between government, industry and trade unions. In the early 1970s the well-organized Swedish welfare state, with its high standard of living, still brought much attention and admiration. But new forces were in motion under the welfare society's idyllic and polished surface. The once

docile inhabitants of the Swedish community began in the late 1960s to oppose of those in power in the corporatist Swedish welfare state. A series of reactions against the established society was expressed. Protests, unrest and discontent also spread to the workplace. In the early 1970s both contractual and unlawful strikes became increasingly common. The commotion contributed to the previously cherished work and motion studies and piece rate systems being thrown out of the Swedish industry. Parallel the "moving van policy" was reconsidered and labor law was fundamentally changed. These changes occurred at the same time as demands for socialization were raised. The requirements also received backing from a new generation of leading Social Democrats. In both the unions and the political ranks voices were raised to break the cooperation with the Capitalists. The ownership of the increasingly fewer and larger corporations in Sweden should either be transferred to government or to the employees. The corporatist Swedish model was partly dismantled. But the dismantling only just begun before the industrial crisis hit with full force. After 44 years of uninterrupted government a liberal-conservative coalition took over government. But the new Minister of Industry barely had time to take up the post until his office became an Emergency Room for failing firms.

During the 1980s – after more than a decade of stagnation, industrial crisis, foreign debt and an underfunded public sector – the concept of growth was once again put high on the political agenda in Sweden. The industrial crisis of the 1970s led to political reassessments. The incumbents that had survived the crisis rebounded in the early 1980s, partly thanks to a devaluation of the Swedish krona, but profitable large export companies no longer employed as many people as before. In the wake of the crisis the hostility towards new technology basically disappeared both in society and on the political agenda. In the early 1980s, political ambitions to implement new technologies, particularly IT, to rationalize administration and working methods were back on the agenda. At the same time various regional R&D activities were established. One hope was that they would contribute to the emergence of new ventures, especially in the IT sector, that could develop into new large export companies.

More orthodox socialistic ideas rules government

In 1969 Olof Palme, who was then 42 years old, succeeded Tage Erlander as Prime Minister in Sweden. Palme had previously been the Minister of Education and was responsible for the work behind a university reform, U68. The reform, which would be decided by parliament in 1975, was a gigantic Man Power Planning for the nation-state Sweden[78]. The ambition was to follow and foresee future changes on the labor market and to regulate the number of university graduates in each program to the future demand in each region. Palme had also attracted international attention. At a peaceful demonstration in February 1968 he held a widely spread speech. He explained that the European public opinion did not feel that the US war in Vietnam was in favor for democracy, but rather a threat to the democratic ideals not only in Vietnam but around the world. The statement caused strong reactions in Washington and the US shortly after made its ambassador leave Sweden.

[78] Sörlin (2008)

Palme rejuvenated the government, paving the way for more radical ideas which had taken root among the young Social Democrats. A few years earlier, in 1967, the Social Democratic Party Youth League (SSU) held a Congress that really reflected the left winds[79]. The Congress adopted a very radical action plan. The resigning President, the future Prime Minister Ingvar Carlsson, and the new President elected by the Congress, the future Minister of Finance Bo Ringholm, had endorsed the congressional opinions. The Congress demanded, among other things, the nationalization of the banking industry, pharmaceutical industry, pharmacy services, construction materials industry and petrol and oil trading. SSU also demanded an end to the cooperation with capitalists and demanded that citizens would have real power and control over the means of production. Thus the government's close collaboration with the capitalists should be replaced with more orthodox socialistic ideas.

Government takes a more active role in industry

Krister Wickman took up a new position as Minister of Industry in Olof Palme's cabinet. Already May 29, 1969, he presented Bill 121, which became the basis for the formation of Statsföretag AB; an industrial conglomerate with extravagant expansion plans[80]. The idea was that government, through Statsföretag, would be responsible for the production of basic goods in the Swedish society, such as schoolbooks, computers for pupils, plastic bicycles, postal cars, steel, food and medicines.

Government also introduced a more active industrial policy in other respects. Already in 1967 government had started a state-owned investment bank, Sveriges Investeringsbank, which should give loans and buy equity in new ventures. A new governmental agency, the Board for Technical Development (STU) was established in 1969. The background was government felt that the pace of technological developments had increased in the 1960s. Government argued that the innovation process – the transfer of ideas and research results into commercially successful products – must be seen as a single, cohesive chain of activities. When STU was established government also started a new investment company, Svenska utvecklingsaktiebolaget (The Swedish Development Company). One mission was to exploit innovations made by employees in government authorities and agencies and state-owned companies. Formally the state's more passive role in the industrial development would be replaced by an active, proactive involvement at government level. It meant a sharp departure from the previously established division of roles between government and industry, where government completely handed over the commercialization to private incumbents.

While STU was awarded a role in the development and commercialization of new technology a more hostile approach towards technology and rationalization also gained a foothold among social democrats and in the trade unions. The increasing computerization, automation and use of industrial robots were particularly highlighted. Demands were raised to stop or stem the use of new technology, so that people could adapt to new conditions instead of large occupational groups hurriedly being moved into unwanted unemployment. Government started new delegations (Dataeffektutredningen, Datadelegationen and Data- och elektronikkommittén).

[79] Ljunggren (2008)
[80] Fredriksson (2008)

This signaled a very radical change of perspective in the Swedish labor movement that spread real fast.

Even if few people noticed, you could in the early 1970s also see the first signals of an upcoming crisis. As a consequence subsidizes became a part of the newly established concept of industrial policy. Selective support measures, targeted at industries dominated by small enterprises, like textile and clothing, footwear, glass, furniture and foundry industry, were the result. The responsibility for handling the programs of selective subsidizes was given to a new government agency, the National Industrial Works (SIND), which was established in 1973. During the period 1973-75 pay-outs doubled, mainly due to increased support operations in crisis-affected companies and sectors, but also through increased R&D funding and increased payments for export promotion. In the 1975 Budget Bill, the Minister of Industry stressed that government must continually acquire information on how different industries develop in terms of, for example, investments, profitability, funding and employment. SIND took on the responsibility to provide a basis for selective government actions, which were intended to control the industrial development towards the desired effects in terms of employment, salary pay, growth, export and regional balance.

The corporatist Swedish cooperation is put to an end[81]

Despite the "oil crisis", and the increased costs of industrial policy, there was not a widespread "sense of crisis" in the country before 1976. In 1974, the major export companies made very high profits overall. The political debate was dominated by discussions about the "excess profits" – not on "industrial crisis". Growth and increased standards of living were seen rather as governed by the laws of nature than as a result of innovations, rationalization and hard work of the population. The older social democrats assiduous missionary on these matters was more or less forgotten, which gave significant consequences for the actions taken by government and trade unions.

LO pushed the issue of economic democracy at the beginning of the 1970s. The list of companies on the Swedish stock exchange had remained basically intact since the mid-1930s. To own shares therefore appeared as safe as putting money in the bank, and there had not been any need for venture capital as new technology, new products and new markets had been intercepted by the established incumbents. In 1971, the convention of Sweden’s confederation of blue-collar unions (LO) proposed a study to investigate the possibility of introducing collective capital formation. In 1975, the persons carrying out the study, under the leadership of LO economist Rudolf Meidner, presented their recommendation for wage-earner funds, commonly known as the Meidner Plan. It was proposed that 20 percent of a company’s profits should be used to buy newly issued equity shares. This proposal entailed a gradual transfer of ownership from private individuals and institutions to collective entities governed by union-appointed directors. The funds would eventually own 50 percent of companies in the long term. The LO convention supported and approved Meidner Plan in the summer of 1976.

[81] This section draws on Giertz (1991) p. 253-269 and 387-407

The discussions about wage-earner funds were partly ditched when the Social Democrats lost the election in the autumn of 1976. But in 1982 Olof Palme was partly forced against his will to make wage-earner funds one of the election's key issues. LO demanded that wage-earner funds be given a prominent position on the Social Democrats' agenda. However, a considerably modified proposal had been put on the table by that time. A group led by the future Minister of Finance Kjell-Olof Feldt, had revised the original plan. When the Social Democrats won the election wage-earner funds were introduced in a modified version in 1983. However the taxation was immediately cancelled in 1991 when a right winged government, under the Conservative Prime Minister Carl Bildt's leadership, was appointed and a few years later the funds were closed down.

When the ideas of wage-earner funds started to take shape, it was the death knell for the government's earlier cooperation with industry. The tension between industrial owners and CEOs on the one hand and Social Democrats and labor unions on the other increased considerably at the beginning of the 1970s. Thus the foundation of the corporate Swedish society was destroyed. The tension increased even more since government implemented new legislation on the labor market. During the period 1972-77 labor laws were completely changed by the Minister of Justice, Carl Lidbom. It resulted in an almost complete turnaround compared to the previous "Spirit of Saltsjöbaden". There is surprisingly little attention paid to this turnaround in more recent discussions about the content of the so called Swedish model. There might even be some who believe that the 1970s labor law reform is part of the original Swedish model and a reason for the Swedish economic miracle in the 1960s.

Behind the visible changes also a more subtle but important development lurked. The relationship between the government and the business community's top representative changed radically. In the previous social democratic post-war governments the Prime Minister as well as other important ministers – such as the ministers of trade and finance ministers – had close personal contacts with both top representatives of the important financial spheres and their employed CEOs. Confidentiality, personal contacts and informal consultations between government and business leaders were in the 1970s gradually replaced by bureaucratic contacts between officials, officers and ombudsmen of various kinds. The contacts between the government and the industry became frostier. The earlier consensus had been replaced by powerful confrontation at crucial points.

In the early 1970's. Immediately after the liberal-conservative coalition took over the government in 1976, the Minister of Industry opened his "Emergency Room". Sweden's economy was greatly unbalanced. A shrinking export industry could no longer finance government´s galloping spending.

From picking presents off a Christmas tree to crises management

During the first half of the 1970s the former corporatist Swedish model began to be dismantled. But the dismantling only just begun before the industrial crisis hit with full force. In 1976 the Social Democrats lost the election. After 44 years of uninterrupted government a liberal-conservative coalition, led by the Centre Party leader Thorbjörn Fälldin took over. Their predecessor said that when entering the cabinet they could just start picking presents off a

Christmas tree arranged by the Social Democrats. But the new Minister of Industry, Nils G Åsling, barely had time to take up the post until his office became an Emergency Room for failing firms.

Shortly after the seemingly good "excess profit year" in 1974 – which brought with it greatly increased wage costs for industry – structural problems appeared. Productivity decreased and real earnings were reduced. Unemployment rose, particularly among young people. AMS received increased funding, special support measures were directed at small enterprises and companies who arranged jobs for young people received special grants. But above all there was a dramatic increase in direct efforts to sustain employment in the country's ailing basic industries and incumbents. Concealed behind the increase was direct aid to shipbuilding, steel, forestry, mining and textile industry. During the period 1977-79 over nine Bsek was paid in direct subsidies only to the shipbuilding industry, which represented approximately sek 280,000 per employee, or 120 percent of the shipbuilding industry's total payroll. The crisis also made, ironically, the new liberal-conservative government responsible for the largest socializations in the country's history. With an ambition to pursue structural rationalization, the state entered as the sole owner of several companies; for example, Svenskt Stål AB (Swedish Steel) and Svenska Varv AB (Swedish Shipyards).

When the incumbents in basic industries went into trouble the country's total production was greatly reduced. The industrial crisis also spoke quickly in reduced market shares on the world market, rising unemployment, negative trade balance and low profitability in many industries. In the wake of the crisis the liberal-conservative government's interest to encourage the growth of small and medium sized enterprises increased. As a result the business associations were converted to regional Development Funds in 1978. SIND and the county council in each county became principals. The Development Funds, which received increased resources and access to their own loan funds, would primarily focus their support to start-ups and existing businesses with up to 200 employees.

Successful production of peripherals close to Kista

During the crises in the mid-1970s much hope and trust was put in the IT industry which seemed to belong to the future. Not only computers but also peripherals were of great interest in those days. One interesting company was Stansaab. Stansaab Elektronik AB was founded in 1971 as a joint venture between Standard Radio & Telefon AB (SRT), Saab Scania AB and the state-owned Svenska Utvecklingsaktiebolaget (The Swedish Development Company).

SRT, owned by the US Company ITT, was established in Sweden already in 1938. In 1970 SRT had about 2,000 employees at three different locations in the Stockholm area. SRT had a turnover around 150 Msek. Two thirds of the products, for example air traffic control systems and military radar systems were sold domestically in Sweden. Thus SRT could be looked upon as a Swedish defense industry. When the joint venture Stansaab was established in 1971 SRT provided the core technology. The original idea was to focus on systems for real-time data applied mainly to aviation and health care applications. Stansaab took over the computer division of SRT and the premises with 800 employees in Barkarby, close to Kista, outside Stockholm. But the development of Stansaab soon deviated from the original idea.

One thing that was important when working with real-time data was to replace punched cards and paper tape with data terminals. Users had to be able to interact with the computer in a new way. Due to its work for the aviation industry, one of SRT's core competencies was the display of radar images. That expertise was thought to be important also when developing data terminals. But Stansaab came up with a rather simple idea. They ordered 12 inch TV screens from the TV manufacturer Luxor in Motala. Stansaab could launch the first generation of Alafaskop – an alphanumerical, 80 characters and 24 lines, terminal that quickly became a standard. It soon gained a foothold in the market. Scandinavian Airlines Systems alone ordered 1,000 Alfaskop terminals for airline reservations. There were more large Swedish customers in the pioneering phase such as newspapers, the police, insurance companies and Televerket. In 1972 Datasaab purchased the data terminal operations of Facit. The main reason was to close down a potential competitor. In 1973 SRT sold its shares in the company. Stansaab suddenly was a fifty-fifty joint venture between government and Saab Scania.

In 1977 negotiations between Saab Scania and government led to a new agreement. In 1978 Stansaab Elektronik AB merged with Saab Scandia's computer division and formed the new Datasaab AB. Government, through Investeringsbanken AB, and Saab Scania each owned half of the shares in the new company. By then the main frame computers were outcompeted by IBM and the combined company, Datasaab AB, made a loss of 230 Msek in 1978. But even though the whole company was very unprofitable the success of Alafaskop continued. A key benefit of the Alfaskop was that it was IBM compatible but cost less. This meant discounts for volume customers made the terminals attractive. The Alfaskop terminals enjoyed considerable success, outselling IBM on the Swedish market and successfully competing all over Europe. The terminal business in Datasaab was very profitable and in 1980 the factory in Barkarby had almost 1,200 employees.

Almost next door to Datasaab in Barkarby another successful manufacturer of peripherals was located. IBM in those days manufactured their printers intended for the European market in Sweden. IBM had started production in Sweden in Vällingby, another suburb to Stockholm, in 1954 but moved to a new factory in Barkarby in 1970. In 1976 The Järfälla plant started the production of IBM 3800 – the first electrographic printer in the industry operating at up to 20,000 lines per minute. Still in 1988 the Järfälla plant was IBM's largest printer plant globally. The export value was considerable. The exports from IBM's plant in Järfälla more than compensated for the import of IBM products to Sweden. But in 1989 IBM sold the factory and prepared for a new product generation. IBM partnered with Hitachi to OEM a Hitachi developed printer, released as the IBM 3900. It was announced October 1990 and shipped in late 1991. The Järfälla factory finally closed down in 1994.

A state-owned Personal Computer industry is born

When six people met at a hotel in Linköping in January 1978 a new Swedish computer industry was born. The driving force was an engineer, Lars Karlsson, who had founded a company, Dataindustrier AB (DIAB), in 1970. DIAB had among other things developed process control for customers in the sawmill industry. Lars already had convinced Karl-Johan Börjesson at Scandia Metric AB that he could develop a competitive computer. Scandia Metric was involved

in factory automation in various industries and Börjesson saw the need for a new computer on the industrial automation market. If Karlsson succeeded Scandia Metric could, according to Börjesson, sell 2,500 computers to Swedish industry. Now Karlsson and Börjesson met with three representatives from Luxor to convince them to start a joint venture. When they left the meeting they had all agreed upon their common mission and the distribution of duties and responsibilities.

Luxor AB was a Swedish company founded in 1923 and located in Motala. It used to be a very successful manufacturer of home electronics, such as radios, gramophones, tape recorders, television sets, and stereo systems. It used to have a dominating position on the domestic market and a foothold in other Nordic countries. But Luxor was severely hit when a new transistorized product generation was introduced by foreign competitors in the beginning of the 1970s. Troubles also increased because of devastating fire in the factory in 1976. Still Luxor had stayed fairly competitive on the domestic market for TV sets, but was definitely outcompeted on other home electronics. Luxor had also been helped by delivering TV screens to Alfaskop terminals at Datasaab.

The idea was that Luxor would manufacture home computers. Lars Karlsson declared that he took care of all product development if Luxor took care of manufacturing and sales to the home market, while Scandia Metric was responsible for the industrial market. The parties agreed upon the idea and in August 1978 the first ABC 80 (Advanced BASIC Computer 80) It was named 80 because it used a Zilog Z80 processor running at 3 MHz. Luxor now was about to become a computer company, but the founder was about to die and the owner-family lacked necessary financial resources. In 1979 government took over Luxor from the family on the verge of bankruptcy. The state-owned company was divided into three subsidiaries: Luxor Consumer Electronics AB, Luxor Electronics AB and Luxor Computers AB.

ABC 80 used a dedicated tape recorder for program and data storage, but could also be expanded to handle disk drives and other peripherals. The monitor of course was a modified black and white TV set. The computer had excellent I/O response times. Some sound effects could also be produced but the graphics and the sound was not good enough to compete with home computers like Commodore 64 on the gaming market. Still ABC 80 was a huge success on the domestic market. It was used for industrial automation in similar ways that embedded systems are used today. But most of all it got a foothold on the rising personal computer market thanks to the availability of office software in Swedish.

Luxor increased sales on the office market when introducing the ABC 800 series, which had a more extensive BASIC, more memory, but otherwise similar performance. ABC 800 was the personal computer and office-version of ABC 80, which had originally been aimed for the home market. The storage was usually two 5.25” floppy disk units, but external hard disk eventually became available. The ABC 800 computer was also sold by Facit by the name Facit DTC (Desk Top Computer). ABC 800 had, compared to other PCs on the new market, great technical performance and it cost about 10,000 sek, which was fairly cheap in those days. Luxor initially took about 60 percent of the domestic PC market and it was widely spread. Many Swedes got the first contact with a computer through ABC 800. The Swedish Employers Confederation

started free of charge mass education for unemployed young people and so did AMU Gruppen – the public agency responsible for labor market education. AMU in Stockholm did run training in three shifts in a lot of class rooms to get the most out of their investment.

The success of ABC 800 came to an end a few years after the introduction of IBM PC in Sweden around 1983. Microsoft DOS became more or less a de facto standard but Luxor's adverts asked; "Who needs IBM-compatibility?" However, most computer buyers eventually considered it a requirement. The production of ABC 800 closed in 1986.

Ericsson and Nokia takes over

The introduction of AXE initiated new ideas at Ericsson. Ericsson had almost manufactured all components and products in a telephone system including telephones. Through digitalization it would eventually be possible to transfer, not only voice, but also data, text and images in a telephone network. This understanding was a starting point for Ericsson when forming visions about what in those days was called office automation.

The first steps in forming Ericsson Information Systems (EIS) were taken in December 1980 when Ericsson signed an agreement with Saab Scania to acquire all of their shares in Datasaab. At the same time government agreed to sell 40.5 percent of the shares in Datasaab. Thus government initially kept 9.5 percent. Datasaab was from the start the core of EIS. The Alfaskop business in Järfälla was very profitable, while other product ranges at Datasaab were losing money. Ericsson soon invested 40 Msek in the Järfälla plant but moved product development to own premises in Kista.

Ericsson also acquired the remainder of Facit. In 1970, Facit had reached its peak with more than 14,000 employees worldwide. In 1971, modern Japanese-made electronic calculators started to seriously disrupt the industry, instantly making Facit's mechanical calculators obsolete. As a result, Facit went out of business virtually overnight. Facit was sold to Electrolux in 1973 and Electrolux passed Facit on to Ericsson in 1983. Facit was thought to be instrumental for Ericsson when developing PCs. Ericsson almost vacuum cleaned the Swedish ICT industry when expanding the information systems business. Besides Datasaab and Facit Ericsson also acquired companies like AutoTank, Addo, Z-tryckerierna and ID-Kort. To integrate all these very different business cultures proved difficult.

But visions were great when EIS was formed. Ericson’s product portfolio would span over a very broad spectrum including data processing, communications and office automation. Of great interest were the terminals. Visionaries began to dream about how the telephone would eventually develop into a more versatile terminal that would also be connected to data networks. Meanwhile Ericsson continued the profitable production of Alfaskop but also developed new products. An Eritex workstation comprising a telex and a data terminal was soon launched. The first PC – the EPC – was introduced in 1984. The Eritex terminal was retired already in the mid-1980s and different new PCs all became failures on the market. But the Alfaskop, which Ericsson wanted to phase out, continued to sell. 100,000 units were sold by 1983 and annual sales climbed above 25,000. When eventually production was closed (by Nokia) almost a million terminals had been delivered.

Breaking into the US market, which was the home of computing, proved to be an impossible task. Ericsson's personal computers were not a success in the competitive PC market. Problems with profitability arose immediately. Ericsson's own stores for office equipment, which operated under the name Ericsson City, did not attract customers. Already in 1984 the entire business area was re-structured, but the losses continued. Ericsson decided to abandon its paperless office strategy and all computer operations were sold to Nokia in 1988. Further development within the area of business communications were transferred to the newly established company Ericsson Business Communications.

Almost all remainders of Swedish-owned computer companies in Sweden ended up in Nokia. Nokia became a principal owner in Luxor already in 1984. Computer production was discontinued in 1986, followed by television production in Motala in 1992, when the production moved to Finland. A partnership with Autoliv, which in those days was owned by Electrolux, ended up in Autoliv buying Luxor Electronics in 1998. Autoliv Electronics in Motala is still manufacturing electronic products for the automotive industry.

While Ericsson had tried to build its own brand in the PC business, Nokia was willing to trade on the Alfaskop name. By 1989, they were showing the “Alfaskop Workgroup System”. From 1990 Nokia Data encouraged the development of several franchise partners to drive sales of PCs and network technologies. From 1994 these companies were co-operating closely and delivering network technologies, Microsoft solutions, and system integration. In 1995 these companies were merged to form Alfaskop AB. In 1997, the company was listed on the Stockholm Stock Exchange. However, by 2001, the company was bankrupt and its remaining 400 employees were laid off.

A global standard opens the world market for Ericsson

Swedish computer industry had developed computers, both main frame computers and PCs, which were technically competitive. Computers had also been successfully introduced on the domestic market and gained substantial market shares until de facto standards from US companies took over completely also in Sweden. But when a global standard for digital mobile telephony was developed Sweden was in the lead.

Analog mobile telephony had been introduced in Sweden by Televerket already in 1956. The first system, Mobile Telephone System version A (MTA), was followed by new versions, MTB, MTC and MTD. The MTD still was a manual system with operators. The phones were heavy and not called handsets but car phones. In 1969, two years before MTD was introduced, the idea of developing a common and automated Nordic mobile system was introduced at a conference with all Nordic telecommunications administrations (PTTs). The Nordic Mobile Telephone Group (NTR 69-5) was formed. Both the chairman and the secretary were employed by Televerket.

The Nordic Mobile Telephone (NMT) system was opened for service in Sweden and Norway in 1981 and in Denmark and Finland in 1982. It was the first fully automatic cellular phone system and it was specified by the Nordic PTTs. It took care of the increasing congestion and heavy requirements of the manual mobile phone networks. In Sweden alone, the MTD-system had

19,000 subscribers and employed 700 operators. NMT was based on analog technology (first generation or 1G). The NMT specifications were free and open, allowing many companies to produce NMT hardware and pushing prices down. By 1985 the network had grown to 110,000 subscribers in the Nordic countries, 63,300 in Norway alone, which made it the world's largest mobile network at the time. The success of NMT was important to Ericsson and Nokia (then Mobira). The NMT system enabled roaming among countries and in 1990 NMT had 1 million subscribers.

The NMT system was only just opened when preparations for the next generation (2G) of mobile systems started. Already in December 1982 the Conférence Européenne des Postes and des Télécommunications (CEPT) formed the Group Spécial Mobile (GSM) in order to decide future standards for mobile telephony. This marked the beginning of the formal procedures that in time would lead to the adoption of a pan-European standard. Televerket took a lead in the work. Thomas Haug, who was the former secretary in The Nordic Mobile Telephone Group, chaired the steering committee of experts that standardized the GSM system. Ericsson also engaged heavily in the standardization work. The new standard received its three-letter abbreviation, GSM, from the group that developed it but in time the interpretation of the letters was changed to Global System for Mobile communication[82]. Haug remained chair of the standards work until the new system was introduced to the market. It was first opened by Televerket in Sweden in July 1991.

The GSM standard was quickly accepted, not only throughout Europe, but also in Asia, where much of the hardware was manufactured. This made GSM more of a global standard and the US was more or less forced to adapt to it. The world market was opened for Ericsson and Ericsson’s core business would eventually transform from fixed to mobile telecommunications. Of course Ericsson, through its close cooperation with Televerket, had a competitive advantage when a global and more deregulated market opened up in the years to come.

Industry recovers during the 1980s

The election in 1982 reiterated the Social Democrats to power. The crisis had drained government finances. A widespread sense of crisis had helped to keep the Swedish wage increases and inflation in line with the main competitor countries. Consolidations and eliminations had also cleaned up the structure in industry. The remaining companies did well, and the industry's competitiveness on foreign markets was further improved by a devaluation of sixteen percent, which the Minister of Finance Kjell-Olof Feldt pushed through immediately when the new government was installed.

Ingvar Carlsson, who assumed the position of Prime Minister after the assassination of Olof Palme, got support from Kjell-Olof Feldt when he tried to adapt Sweden to the rapid internationalization of the economy. The so-called right-wing in government secured that productivity issues were once again put high on the social democratic agenda. Feldt spoke as former social democrats did, when he stressed that growth requires a more efficient production throughout society – of goods as well as services. This could be the result of introducing new

[82] Gessler (2002)

technologies, but also from introducing new and more efficient organizations, structures and work methods in working life.

A productivity delegation was appointed in 1989. It stressed that real growth is based on efficiency improvements, which ensure that we get better productivity and quality and better service in all parts of working life. The delegation's report, which was delivered in 1991[83], focused on weak productivity improvements in the Swedish working life. The delegation looked at the nation's total production capacity and stressed that the transformation pressure, especially in the service sector, must increase.

Universities – a new instrument for regional policy

As stated earlier Swedish industry in general had started to recover in the 1980s but there were significant regional imbalances. The eliminations of plants, enterprises and certain industries had resulted in a redistribution of employment. Employment increased in those cities where a dozen successful engineering corporations or pharmaceutical groups decided to expand, but declined sharply in regions with previous employment in industries such as shipbuilding and steel works. The regional imbalances had great impact on industrial policy in the mid-1980s. By then the Social Democratic Minister of Industry, Thage G. Peterson, no longer had the possibility to direct an increasing number of blue collar jobs to regions with unemployment. Now when successful Swedish industrial corporations gained market share, invested in research and development, introduced new technology and improved their profitability, they did not increase the number of blue-collar jobs in Swedish factories. On the contrary, manufacturing industry's share of employment in Sweden decreased throughout the 1980s. Nearly 100,000 jobs disappeared from the export industry. At the end of the decade, all companies producing any kind of goods accounted for less than 20 percent of employment in on the Swedish labor market.

While routine factory jobs vanished, the need for skilled technicians and engineers increased in the export industry. Overall, the industry doubled its spending on research and development during the 1980s. The need for MSc´s in engineering took off. But the investments were concentrated to a little more than a dozen corporations in the engineering, pharmaceutical and chemical industries. They concentrated largely on the metropolitan areas and the vicinity of universities. A lot of investigations, as well as the media, also highlighted research as a vehicle for growth in the emerging knowledge society. Cities with a university were pinpointed as the winners in the future society. They argued that there was strong links between research and higher education, the creation of new competence, the growth of new knowledge-based businesses and thus new jobs[84]. Cities with universities were pinpointed as the growth centers the labor markets of the future, where highly skilled, highly paid and creative people flocked.

Media made out the universities to be the engines for the growth of new knowledge-based companies. For regional policy-makers it seemed obvious that there were strong links between research, new knowledge-based companies and future employment. International studies also

[83] SOU 1991:82
[84] See Deiaco, Giertz, Reitberger (2002)

supported a positive correlation between the percentage of highly educated and the economic growth of a country. This made higher mass-education get its definitive breakthrough in Sweden. The expansion also enabled the dispersion of both higher education and research. In 1988, Sweden received four new universities in Luleå, Karlstad, Växjö and Örebro. At the same time there were investments made in regional colleges, which almost invariably came to engage themselves in some kind of research. Thus from the mid-1980s research and higher education became an instrument of regional policy. New universities and regional colleges were the base for regional business policies. They were not only designed to satisfy the need for skilled labour on the regional market. They would also conduct their own research and hopefully become the breeding ground for comprehensive new enterprises with great employment potential.

5.5 1990-2005 Hunting for economic growth in a global market

Introduction

In the beginning of the 1990s a recession was waiting. It was magnified by Iraq's invasion of Kuwait in the summer of 1990. The industry was forced to adjust production capacity to a declining demand. Cutbacks arose in virtually all industries. Questions concerning the location of production no longer dealt with the location of new plants but rather where necessary closures would be made. Confidence that incumbents could guarantee full employment in the future faltered in almost all political parties and on all levels. In the industrial and regional policy more and more weight was given to new ventures and to small and midsize enterprises. This also enforced a shift in the governmental regional policy, from measures that primarily reallocated employment, to efforts that supported regional or local development programs. By now the Social Democrats were no longer very keen on owning the Swedish industry. The industrial dynamics during the 1970s and 1980s, and the failures in state-owned companies, made politicians in almost all parties hesitate towards governmental ownership in industry.

Sweden's relationship to the EC also was an important issue in the growth debate. As the vision of a common internal market took concrete form, it became increasingly clear that Sweden would join EU, which happened in 1995. The development in Europe also took a different turn in 1989-90. With a speed that aroused astonishment everywhere the walls between the East and the West were torn down. Over time, it also created a greatly enlarged EU.

A wave of deregulations in sectors such as energy, telecommunications, postal services, aviation and media were also rolled out across the West. Sweden was to play a leading role in that transformation. Firms and agencies in domestic monopoly or oligopoly industries faced competition from new competitors and international players who expanded their geographic markets. The regulated credit market and the currency exchange controls were also abolished, which rapidly increased Swedish companies’ direct investments abroad. At the entrance to the 2000s it was clear that the pursuit of further growth in Sweden was very much dictated by developments on European and global markets.

Recession initiates crises package and a financial crises

In the wake of the recession prices on commercial real estate plummeted. In two years they fell by more than 50 percent. New construction ceased, which hit hard on the construction and building industries. The downturn on the property market first hit the real estate companies, but also had serious repercussions on investment companies and banks. The Social Democratic government presented a "crisis package", which included savings in the public sector and reduced health insurance. It also included a positive statement on Swedish accession to the EC.

The social democrats also made some other changes related to industrial policy. Three governmental agencies – SIND, STU and Statens energiverk – merged into a new governmental agency, The Swedish National Board for Industrial and Technical Development **(**Närings- och teknikutvecklingsverket, NUTEK). In 1991 also a very radical tax reform, agreed upon two years earlier both by the social democrats and the liberal-conservative parties, was implemented. It lowered the previous extreme progressivity of the Swedish income tax to more normal levels. In principle, the Swede would in the future not pay more than half of a wage increase or an extra income in tax.

In the chaotic situation, the Social Democrats once again left government. After the 1991 election conservative leader Carl Bildt became Prime Minister of a liberal-conservative government. The financial crisis forced a series of costly commitments. Alongside dealing with the unemployment, government had to guarantee bank liabilities to third parties, give subsidizes to support some banks and also nationalize the private bank Nordbanken. In May 1993 government set up a special governmental agency, Bankstödsnämnden, to handle further support to banks in trouble. The crisis weakened public finances and unemployment was widespread. Nobody put trust in Swedish economy any longer which imposed new problems. When the credit market was deregulated the Swedish krona had been linked to the European currency unit ECU at a fixed exchange rate. The Riksbank – Sweden's central bank – tried the longest to stave off the attacks against the krona. The overnight interest rate even rose to improbable 500 percent before the Governor, Bengt Dennis, gave up. The krona was allowed to float, which in reality meant that it sank like a stone.

The European Union was realized in November 1993, and in January 1995 it was extended to include Finland, Sweden and Austria. EU's so-called convergence criteria facilitated the consolidation of the Swedish economy during the first half of 1990's. During reasonably broad political consensus there was a relatively consistent austerity policy. It led to cutbacks and changes in the welfare system. International confidence in the Swedish economy was restored. The krona was appreciated and interest rates were reduced to historically low levels. Inflation ceased almost completely, but a larger decline in the unemployment rate was slow in coming.

Televerket and Ericsson are divorced

Sweden started to liberalize its telecommunications in 1980 with a parliament decision to open the market for terminals attached to the public network. Previously Televerket had sole right to attach equipment to the public network. In fact previously, if your telephone broke down, you free of charge got a new phone from Televerket. It was Televerket who owned the phone – not

the subscriber. This became more tricky when new equipment, such as fax-machines, were connected to the network.

Even if you could sense the startup of a liberalization movement already in 1980 a very close cooperation between the monopoly Televerket and Ericsson continued throughout the 1980s. In fact a gigantic development project was started in 1987 in the jointly owned development company Ellemtel, which had previously developed the very successful AXE system. The new project was named AXE-N, where N stood for Network. AXE-N was intended to use ATM (Asynchronous Transfer Mode) technology to construct one single, universal communication system for all telecommunications – speech, data and various broadband services in packet-switched form. It really was a visionary dream for all engineers. But the benefits from a successful project would to a high extent be substituted by internet that simultaneously began to take form in the early 1990s.

Skilled employees in Ellemtel, Ericsson and Televerket were dedicated to the project, which also hired more than a thousand consultants. The AXE-N project was to be the one of most expensive industrial project in Sweden ever. Estimates say that Ericsson alone invested over 10 Bsek. The project was stalled in 1994 and completely closed down on December 8, 1995. This was a chock not only for 700 employees but also for a number of R&D related ICT consultancy companies who almost overnight were out of job. The project must be considered a total failure, especially since Ericsson had completely focused on ATM- technology instead of working with IP-routers, which could perform similar tasks at a lower cost.

Towards the end of the AXE-N project the marriage between Televerket and Ericsson ended up in a divorce. They had been a developing couple for about 70 years but the time to separate had come. Already in 1990 government had taken some steps on a liberalization journey by transforming Televerket into a public company. In 1993 the new company Telia AB was formed and a new Telecommunications Act was launched. This initiated a first significant liberalization effect. When Telia was to become a competitor in the telecommunication industry and not a state-owned domestic monopolist a lot of things changed. In 1994 Ericsson bought Teli, Telia's equipment-manufacturing units, which meant that the domestic AXE manufacturing was transferred to Ericsson. In 1995, just after the AXE-N project was terminated, Ericsson also bought Telia's holding in Ellemtel.

On June 13, 2000 a partial privatization of Telia AB through an initial public offering (IPO) on the Stockholm stock exchang. The government received 76.5 Bsek in exchange for 30 percent of the state-owned telecommunications company. The offer price was 85 sek per share, which valued Telia at about 255 Bsek. It was a huge interest among Swedes in general. Government decided that all investors who applied for 100 shares or 400 shares would get them, while those who applied for more only got a fraction. The Minister of Infrastructure made adds about the "people's share" and 954,000 Swedes actually became shareholders in Telia AB.

The IPO was done just before the third generation mobile standard, 3G or UMTS (Universal Mobile Telecommunications System), was about to be installed in Europe and Japan. 3G was a further development of GSM where it was possible to transfer mobile data at the speed and

capacity needed for multimedia services. Licenses for the new system were issued in the European countries in the late 1990s and early 2000s. Different countries chose different approaches. Finland was the first country to issue licenses. In March 1999, four licenses were allocated without any conditions on the operators regarding coverage or time. Telia and Sonera acquired one license each.

The Swedish Post and Telecom Authority (PTS) chose to allocate the licenses through a "beauty contest". Telia applied but on December 16, 2000 PTS announced that Telia did not receive a license. Telia was the only former PTT in the world finding itself in this position. The licenses were instead allocated to Europolitan (which later became Vodafone and then Telenor), Hi3G (later 3), Orange (later acquired by France Telecom) and Tele2. Telia was in shock but found a solution. Telia and its competitor Tele2 soon announced their intention to create a joint network company, Swedish UMTS Network Company, to utilize the 3G license which Tele2 had been awarded. It was a joint venture on a 50-50 basis, which was approved by the Competition Authority in the spring of 2002.

Several European Countries chose to allocate 3G licenses through auctions. Telia did not participate but the Finnish tele operator Sonera did[85]. In Spain Sonera became a 15 percent partner in the Xfera Movile consortium, which acquired a license for 130 million Euros. In France Sonera and Telefónica received one license for 8.4 billion Euros. The licenses also required massive additional investments to exploit them. The purchases dramatically increased Sonera's debt level. Sonera found itself in a serious financial crisis. Telia was financially strong and saw the opportunity to acquire Sonera. In 2002 Telia acquired Sonera to form a new company Telia Sonera.

Ericsson survived when the bubble bursted

In the year 2000 Ericsson was riding high. Ericsson had 101,553 employees globally (43,193 in Sweden). The number of employees had constantly increased despite the fact that Ericsson had winded up Ericsson Component and closed down their own production of processors and other components. Some plants, for instance a large manufacturing plant in Karlskrona, had also been outsourced to Flextronic in the late 1990s. Still Ericsson was a very large employer in Sweden and abroad. The skills and competence of employees had change over time. The number of blue collar workers had decreased over the years and they were replaced by engineers and technicians of various kinds.

In the year 2000 the turnover in Ericsson was close to 300 Bsek, the profit above 20 Bsek and more than 40 Bsek was spent on R&D. Ericsson’s share of Swedish GDP was two percent. Ericsson shareholders were also happy. Share price had increased from 20 sek to more than 800 sek during the last decennium. Ericsson was in the very center of a worldwide hype around the potential of the internet. Ericsson had around 200 million AXE lines in place in 120 countries. But the success was very much linked to a fast penetration of GSM systems in the late 1990s. Ericsson held an estimated 40 percent share of the world’s mobile market. GSM had almost become a de facto world standard in recent years but Ericsson still held a strong position also in

[85] Jansson, K (2015)

other mobile standards. The amount of GSM subscribers increased extremely fast at the end of 1990s. In 1998 the number was 100 million. At the turn of the millennium, two years later, the number of GSM-users was 465 million and the total number of subscribers to mobile phone systems around 760 million. The number of GSM users alone outnumbered the number of internet-users, which were approximately 400 million. At the turn of the millennium Ericsson was on top and expecting to deliver a lot of brand new 3G-systems, especially to tele operators in Europe. But the market failed.

One important reason why the market failed was, as mentioned earlier, that several European countries chose to allocate the 3G licenses through auctions. European tele operators spent around 130 billion Euro to buy licenses for 3G-networks that were supposed to give people the freedom to virtually live from their mobile phones, reading e-mail, browsing the Internet, placing video calls, enjoying music, buying products and services, making reservations and so on. The nature of the auctions was designed to increase competitive pressure on bidders by offering fewer licenses than the number of operators likely to bid. The tele operators were put in a difficult position, because if they lost the auction they were out of business in the next phase. They took risks and made high bids and ended up with large debts. But when they got the licenses they could not afford to buy and install the systems.

The tele operators went into serious trouble. When the trouble leaked out to the public the hype on the stock market was put to an end. On March 6, 2000 the index on the Stockholm stock exchange had been all time high. The total value was 4,800 Bsek and Ericsson alone was valued to 1,709 BSek. The next day the bubble started to burst, but Ericsson still showed good figures in 2000 and coped rather well initially. The share value of tele operators on the other hand fell quickly all over Europe. They had no choice but to reduce their investments sharply. This of course also hit Ericsson and on October 20, 2000 the share price went down drastically. Still the figures for the full fiscal year 2000 were quit ok, which also is reflected above.

In Ericsson the crisis was a fact on March 12, 2001[86]. The figures for January and February had been bad, which was not unusual, but March had always been a good month. When no orders turned up, and AT&T wanted to cancel a signed order on a mobile system, management started to realize what was to come. Ericsson announced a first profit warning. In one year tele operators around the world halved their investments in tele systems, which of course hit everyone in the tele vendor industry hard. More than 700,000 employees in the tele vendor industry around the world lost their jobs in a very short time. There also were a lot of consolidations throughout the industry.

People still wanted new mobile phones, so the market for handsets was almost not affected at all, which partly explains why Nokia was not hit that hard. Ericsson on the other hand had great problems with their handsets. Former, when the demand exceeded the supply, Ericsson had done well because the phones were reliable. Ericsson shared the top position with Nokia and Motorola in the late 1990s. But in 2000 people on the consumer market started to ask for more. Ericsson still sold 43 million handsets in 2000 but the business area made a loss of 24 Msek and

[86] The rest of this section draws on Karlsson & Lugn (2009)

it was a burden to the Group. Ericsson decided to concentrate on core business, that is tele system – not consumer products. In October 2001 Ericsson's mobile handset business was moved into Sony Ericsson Mobile Communications, owned fifty-fifty by Sony and Ericsson. 3,000 employees from Ericsson and 1,000 from Sony were moved to the new entity. The new company was operated by Sony management and was completely subsumed by Sony in 2012. After a slow start the company became very successful and profitable for a few years, up until the current smartphone era was initiated with the introduction of Apple's iPhone in January 2007.

Despite cost cuttings and massive layoffs the fiscal year 2001 ended with a very big loss of 18 Bsek. It was Ericsson's first loss in more than half a century. More than 8,000 consultants also lost their customer in 2001. But it was not only a question of profit and loss, but also about the cash flow situation. The lack of orders from the tele operators was one thing but customers also paid late due to bad liquidity. Ericsson was forced to borrow money to pay salaries. The situation was alarming in March 2002. The customers were afraid to put orders because they did not believe Ericsson would survive. The board decided to issue new shares to raise 30 Bsek. The share price was set at 3.80 sek. It was uncertain if Ericsson could make investors put up new money when the prospect was presented July 19, 2002. But they did! According to the CEO, Kurt Hellström, Ericsson was only weeks from bankruptcy when the new money turned up.

Ericsson survived and took off again in 2004. By then global employment was down to 50,534 employees (21,296 in Sweden). Thus Ericsson's global and Swedish employment fell to less than half of their previous levels in only four years. In Sweden, the ICT sector outside Ericsson was also hit. Via its external networking and partnering, Ericsson had contracted tens of thousands of Swedish companies in ICT-related development, consulting, manufacturing and maintenance. In the successful attempt to return to profitability, Ericsson slashed this spending. With this multiplicative effect and Ericsson's own layoffs, a huge volume of ICT-expertise was re-deployed in Sweden. And that is still the case. Ericsson's employment worldwide has increased since 2004, but employment in Sweden is continuously decreasing. Ericsson is no longer only a manufacturing company exporting goods, but also a global service provider that operates telecom system worldwide on a contractual basis.

A diversified ICT sector is born

Not only Ericsson made layoffs in the turn of the millennium. In parallel a lot of .com companies and internet consultancy companies, which had been valued to fantasy figures during the hype, were in deep trouble. They lay off people or went into bankruptcy. It was a complete turmoil, but out of the ashes raised a dynamic new ICT sector, which is described in the chapter named "The Swedish ICT Sector today".

When Ericsson no longer absorbed most of the ICT competence in the country people had to turn elsewhere. Ericsson's former employees looked for job elsewhere, but thousands of ICT consultants also had to look for new customers. That development actually started on a massive scale already in the mid-1990s when Ellemtel decided to close down the AXE-N project, one of the largest projects in Swedish industry so far. A lot of competent engineers working with R&D

related software development turned to other employers or customers in different sectors, for example the engineering industry and the banking industry.

Other more application oriented developers and entrepreneurs benefitted from the fact that Sweden and particularly Stockholm, much thanks to Telia and Ericsson, had a well-functioning infrastructure and citizens who were early adopters of new internet services. Especially in Stockholm a lot of very successful new ventures have been born in the segment Software and Net Services. Some of them are spun off from universities like KTH, but many are also spin offs from industry. In some sub-segments, such as the gaming industry, new ventures seem to have a strong foothold among students. Most new ventures in the segment Software and Net Services seem to have one thing in common. They have not been reliant on contacts with Swedish incumbents or Swedish agencies.

In March 2000 the bubble bursted. It seems as if the explosion spread a lot of seeds which found good soil for new businesses and new ventures. But at the same time it changed the conditions for governmental efforts to support demand-driven research and new innovations in Swedish industry. Before 2000, incumbents like Ericsson, Televerket and ABB could set the agenda for both higher education in engineering sciences and applied research in technical universities as well as in sectorial research institutes. But when companies like ABB and Ericsson decided to concentrate their business and close down their factories the existing research in fields like microelectronics and optics were left without their former demanding "customers", who set the agenda for demand-driven applied research. Research institutes like Acreo than became more of an incubator than an institute partly financed by Swedish incumbents with a common research interest. Governmental funding was also partly transferred to help the establishment of new ventures.

EU influences innovation policy and regional growth policy

When Sweden joined the European Union the Social Democrats had returned to government. In 1994 Ingvar Carlsson put together his third Cabinet. Göran Persson was appointed Minister of Finance. He implemented welfare cuts and tax increases to place Sweden in a position to qualify for the European Economic and Monetary Union. The job was done and the budget deficit went down but unemployment rose considerably. When Ingvar Carlsson announced his retirement in 1996 Göran Persson became the new Prime Minister. One important policy issue was to lower the unemployment rate.

Research and technology-based new ventures were regarded as important potential growth engines in Swedish policy. Around the turn of the millennium scientists and politicians pointed out that in Sweden we invested more in R&D than most other countries. Sweden was also ranking in top in terms of new patents. Yet we lay in the bottom of the OECD list when it came to new ventures and entrepreneurship. Many heavy commentators claimed it was due to an inability to commercialize research, so that we could reap the benefits of our outstanding research in the form of new enterprises in the country. As a consequence great policy interest was concentrated to research – both in universities and in research institutes – in fields like ICT, biotech and energy. Seed capital, venture capital, incubators, patent counselling and the like were included in a new policy agenda.

The new agenda also made the social democratic government form a new Swedish governmental innovation agency, VINNOVA (Verket för innovationssystem), on January 1, 2001. The new agency, which is sorting under the Ministry of Enterprise and Innovation, replaced part of the former governmental agency Nutek. VINNOVA got the assignment to administer state funding for research and development. The agency's mission as defined by the government is to promote development of efficient and innovative Swedish systems within the areas of technology, transportation, communication and labor. The agency should accomplish this by giving financial aid to research-focused companies for research, development and legal costs. VINNOVA have contacts with and supports universities, research institutes and public sector organizations as well. VINNOVA also acts as a National contact agency for the EU framework programme for research and innovation, which has in a way increased the funding.

You can argue that the public funding of research and innovation was increased when Sweden joined EU. An active policy to support the development in all regions in Sweden was even more boosted when Sweden joined the EU[87]. A broad political consensus came to prevail that Sweden should regain its share of the money paid to the common funds. Politicians and researchers, and representatives of business and trade unions, both at national and regional level, joined forces to make sure Sweden would be able to gain a rightful share of the common cake. Sometimes the discussions on development started rather in the availability of EU funds, than in discussions about actual needs and possibilities in the region. On the national level Nutek initially played a central role in helping the regions in this context. But when Nutek was closed down in April 2009, the responsibilities were transferred to a new government agency, Tillväxtverket (The Swedish Agency for Economic and Regional Growth).

The Swedish Agency for Economic and Regional Growth is sorting under the Ministry of Enterprise and Innovation. The main task is to distribute EU funding to promote entrepreneurship and regional growth. The mission is to strengthen the competitiveness of Swedish small and medium-sized enterprises or future entrepreneurs directly and work to improve the general framework for doing business. The agency also has the ambition to build networks for cooperation and investment initiatives that hopefully will strengthen the business sector in the region.

Ambitions on the regional level have to some extent removed national policy focus from productivity issues. Former right-wingers among the Social Democrats, such as Kjell-Olof Feldt, had left. They made room for other ideas. A similar reversal was also made within the liberal-conservative block, which was to some extent manifested already when they regained power in 1991. Within both the two political blocks the key policy areas have lately to some extent been formed on the basis of other considerations than economic growth on the national level. The taxation emphasizes justice not incentives, labor law stresses security not mobility, and regional policy stresses equality in all parts of the country and so on. Growth policy does no longer permeate all policies on the national level. Instead growth policy has been looked upon

[87] Nilsson (2008)

as a separate policy area. Economic growth is no longer regarded a concern of general policy but the concern of a separate innovation policy and a regional growth policy.

Entrepreneurship is the name of the game

A few years into the 2000s a consensus grew on the desirability of a broad widespread entrepreneurship[88]. Not only an increased number of super entrepreneurs that would drive new technology-based companies. Entrepreneurship and business creation is an equally important ingredient to increase efficiency in different parts of working life – including domestic and local services. Fragmentation of organizations and companies into smaller units, and a subsequent streamlining of operations, could have significant impact on the pressure for change and growth. The emergence of a rich flora market funded, entrepreneurial enterprises can be of equal importance for economic growth as a single new company with high growth potential.

The wish to support new ventures and entrepreneurship made government introduce some changes in regulatory systems, for example in the tax systems. Swedish laws and regulations were in the beginning of 2000s still very much inspired by Harvard economist John Kenneth Galbraith, who advocated policies and regulations that favored existing incumbents. He argued that individual efforts and individual incentives had become less important. That thinking was still reflected in the Swedish regulatory system in the beginning of the millennium. Something had to be done.

Sweden, compared to other countries, had a very high inheritance tax and gift tax, which were also taxed progressively. The inheritance tax and gift tax in Sweden caused many serious problems in connection with generation shifts because private assets were often locked up in the companies. When assets were shifted, the heirs were often forced to either sell the company or take out a substantial private loan to cover the taxes. For several decades, the inheritance and gift taxes in Sweden, combined with a wealth tax – which also imposed taxes upon working capital in companies – forced many business owners to either sell their firm before transferring it to the next generation, or to move outside Sweden. Many financial advisors in Sweden had since the mid-1970s recommended successful Swedish business owners to take up residence in another country. All those taxes were repealed in the beginning of the new millennium. The inheritance and gift taxes were repealed on January 1, 2005 and the wealth tax on January 1, 2007. This not only pawed the way for new entrepreneurs but also made successful Swedish entrepreneurs move back home to Sweden.

Globalization has during the last fifteen years fundamentally changed the rules and action opportunities for politicians. The financial market is global, both manufacturing and service companies operate in a global market. The companies that supply services to the infrastructure are international. Questions on corporate localization of the development, production and back-office business is constantly up for discussion, as well as the exchange of labor in an increasingly open economy. It has opened for efficiency improvements and structural changes, which in part can be conceived as conflicting with an increased entrepreneurship. Economies of

[88] See Braunerhielm, Eklund & Henrekson (2012)

scale are utilized and small companies are acquired and merged when industries are consolidating. In many mature industries there are only a few companies left, which compete with one another in the global market. Alongside will the new large international companies are being increasingly more specialized. Many companies concentrate on their core business and choose to procure services that they previously ran in-house.

A growth policy of tomorrow must not only – or even primarily – be about individual innovations or export companies with a high growth potential. Equally important – perhaps – is a policy which improves efficiency and productivity in different service sectors that today accounts for 85 percent of all jobs in Sweden. Better quality and service with the same resources in the service sector is almost certainly of vital importance to grow the economy in Sweden. From a societal perspective, the main measure in this context might not be to get existing enterprises to employ more. Perhaps it is even better to support the establishment of more market-funded enterprises that continue to finance their operations through revenues from services delivered on a competitive market.

6 The Finnish ICT sector today

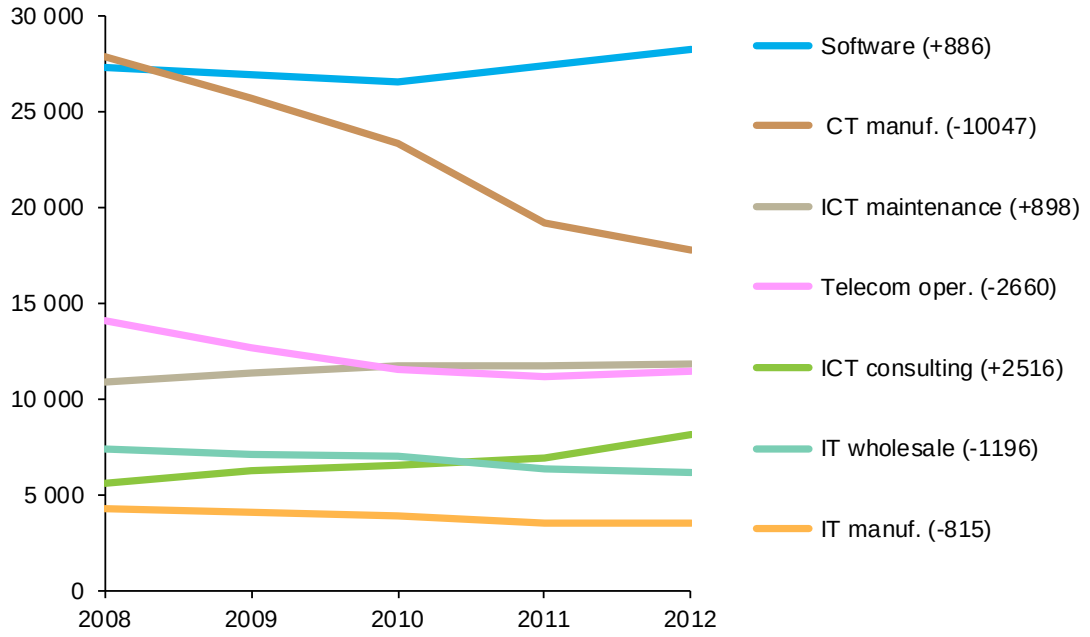
Mika ***Pajarinen*** *and Petri* ***Rouvinen***

The Finnish ICT sector has experienced exceptional turmoil since the 2008 financial crisis. *Nokia*'s downsizing is what first meets the eye and without Nokia the sectors employment in Finland would have remained about the same. There has been a wave of mergers and acquisitions – in particularly *Tieto Group* has been heavily molded. ICT in Finland has grown more international and has become more consolidated.

6.1 ICT companies in Finland

ICT companies employed in Finland 87,000 workers in 2012. From 2008 the employment in the ICT sector has decreased by 10,417 workers. As shown in Figure 6.1, the employment has decreased most remarkably in CT manufacturing, which is largely due to restructuring of *Nokia*. The number of workers has decreased to a lesser extend in Telecom, IT wholesale and IT manufacturing. In contrast, the employment has increased in Software, ICT consulting, and ICT maintenance. Software is nowadays the largest ICT sub-sector in Finland. It employs about one-third of the workers in the ICT sector.

Figure 6.1: ICT employment by sub-sector



Source: Statistics Finland. In the parentheses are reported the changes in employment from 2008 to 2012.

In this section we discuss the companies in the Finnish ICT sector. We will mostly use the definition of an enterprise, rather than an enterprise group/conglomerate. Since many enterprise

groups active in the ICT sector have rather complicated structures and they have multiple enterprises within the same group – in part because of a lengthy series of mergers and acquisitions –, members of the same group frequently come up. Our analysis also shows that the ICT sector is exceptionally international: virtually all major multinational companies are active in the Finnish market via a locally operating subsidiary. As far as larger companies are concerned, the same ones tend to be active both in Finland and in Sweden.

The 10 largest ICT companies in Finland in 2012 were Nokia, Nokia Solution and Networks, Tieto Finland, TeliaSonera Finland, CGI Suomi, Elisa, Fujitsu Finland, DNA, Accenture Services, and IBM Finland.

The *Nokia* group was clearly the most significant employer; it employed more than three times more workers than the second largest company *Tieto*, a IT services provider with a considerable market share in the Nordics but with operations in more than 20 countries. *Tieto*'s main business areas are consulting and system integration services, application management and transformation consulting, IT infrastructure and cloud services, enterprise platform services and end user solutions. It also sells industry-specific software products and productized solutions.

TeliaSonera provides network access and telecommunication services. It is one of the largest Telecom operators in Europe. It operates in the Nordic and Baltic countries, the emerging markets of Eurasia, including Russia and Turkey, and in Spain.

CGI Suomi (former *Logica*) is a Finnish subsidiary of CGI. It sells IT consulting, systems integration services, application development and management services, infrastructure services and business process services both to private and public sector.

Elisa is the second largest telecom operator in Finland by employment. It supplies tele-communication and online services for over two million consumers and organizatios.

Fujitsu Finland is a subsidiary of *Fujitsu group* headquartered in Japan. Until 1990s, it was a part of *Nokia* group selling personal computers (brand name *Mikromikko*) and office software (*ToimistoTiimi*). Nowadays it supplies both IT services and hardware to clients in the Nordic and Baltic countries. *DNA* is the third largest telecom company measured by employment in Finland. It was founded in the end of 1990s and its current form was created in 2007 by a merger of several local Finnish telecom firms. It has about 2.5 million mobile subscriptions and over million fixed line subscriptions. *Accenture Services* is a Finnish subsidiary of Accenture group. It offers ICT consulting services both to private and public sector. *IBM Finland* is a part of the *IBM group*. *IBM* has operated in Finland since 1920s.

Besides the afore-mentioned ten companies, Table 6.1 shows the remaining forty biggest ICT companies in Finland. In total, they had 48,830 employees in Finland, accounting for 56% of the total ICT sector employment in the country. Sixteen of the top 50 were software companies; there were 4–7 companies in the other six sub-sectors.

Table 6.1: Top 50 ICT companies in Finland in 2012 by employment

Rank	Company	Industry	Employment in Finland
1.	NOKIA OYJ	CT manuf.	8 379
2.	NOKIA SOLUTIONS AND NETWORKS OY	CT manuf.	6 378
3.	TIETO FINLAND OY	ICT maintenance	4 429
4.	TELIASONERA FINLAND OYJ	Telecom	3 667
5.	CGI SUOMI OY	Software	3 238
6.	ELISA OYJ	Telecom	2 902
7.	FUJITSU FINLAND OY	ICT maintenance	1 689
8.	DNA OY	Telecom	1 157
9.	ACCENTURE SERVICES OY	ICT consulting	1 113
10.	OY IBM FINLAND AB	Software	988
11.	DIGIA FINLAND OY	Software	773
12.	SIEMENS OSAKEYHTIÖ	CT manuf.	682
13.	HEWLETT-PACKARD OY	IT wholesale	666
14.	CAPGEMINI FINLAND OY	Software	622
15.	OPUSCAPITA GROUP OY	ICT maintenance	599
16.	ISOWORKS OY	IT manuf.	549
17.	F-SECURE OYJ	Software	497
18.	BASWARE OYJ	Software	482
19.	TIETO HEALTHCARE & WELFARE OY	ICT maintenance	475
20.	TELLABS OY	CT manuf.	463
21.	ANVIA OYJ	Telecom	449
22.	IXONOS FINLAND OY	Software	411
23.	TELESTE OYJ	CT manuf.	374
24.	NICE-BUSINESS SOLUTIONS FINLAND OY	Software	359
25.	TEKLA OY	Software	349
26.	CASSIDIAN FINLAND OY	CT manuf.	348
27.	TATA CONSULTANCY SERVICES	ICT consulting	348
28.	ATOS IT SOLUTIONS AND SERVICES OY	ICT maintenance	347
29.	ACCENTURE TECHNOLOGY SOLUTIONS OY	ICT consulting	336
30.	AFFECTO FINLAND OY	ICT consulting	336
31.	OY SAMLINK AB	ICT consulting	330
32.	INSTA DEFSEC OY	Software	327
33.	ROVIO ENTERTAINMENT OY	Software	316
34.	TIETO-TAPIOLA OY	ICT consulting	305
35.	ATEA FINLAND OY	IT wholesale	301
36.	TIETOKARHU OY	Software	288
37.	ALSTOM GRID OY	IT manuf.	276
38.	DIGITA OY	Telecom	275
39.	SCANFIL EMS OY	CT manuf.	273
40.	ENFO OYJ	ICT maintenance	265
41.	CYBERCOM FINLAND OY	Software	262
42.	MICROSOFT OY	Software	259
43.	PKC ELECTRONICS OY	IT manuf.	257
44.	ALSO FINLAND OY	IT wholesale	254
45.	SOLTEQ OYJ	Software	254
46.	STANLEY SECURITY OY	IT wholesale	253
47.	TDC OY FINLAND	Telecom	245
48.	CSC-TIETEEN TIETOTEKNIIKAN KESKUS OY	ICT consulting	234
49.	KEMET ELECTRONICS OY	IT manuf.	228
50.	ORACLE FINLAND OY	Software	223

Source: Statistics Finland's business registry.

Table 6.2: Top 25 ICT companies by headcount growth in Finland in 2008–2012

Rank	Company	Industry	Empl. growth 2008-2012
1.	TIETO FINLAND OY	ICT maintenance	2 888
2.	DNA OY	Telecom	1 102
3.	ACCENTURE SERVICES OY	ICT consulting	972
4.	IXONOS FINLAND OY	Software	324
5.	CGI SUOMI OY	Software	309
6.	ROVIO ENTERTAINMENT OY	Software	290
7.	KEMET ELECTRONICS OY	IT manuf.	215
8.	FUJITSU FINLAND OY	ICT maintenance	186
9.	BASWARE OYJ	Software	156
10.	ELISA OYJ	Telecom	155
11.	TATA CONSULTANCY SERVICES LIMITED	ICT consulting	150
12.	DESCOM OY	Software	136
13.	INNOFACTOR SOFTWARE OY	Software	131
14.	NICE-BUSINESS SOLUTIONS FINLAND OY	Software	119
15.	TIETO HEALTHCARE & WELFARE OY	ICT maintenance	119
16.	WAPICE OY	Software	109
17.	VAKKA-SUOMEN PUHELIN OY	Telecom	100
18.	F-SECURE OYJ	Software	96
19.	APPELSIINI FINLAND OY	ICT maintenance	87
20.	MEDBIT OY	ICT consulting	86
21.	TEKLA OY	Software	79
22.	FUTURICE OY	Software	79
23.	CSC-TIETEEN TIETOTEKNIIKAN KESKUS OY	ICT consulting	78
24.	MIKKELIN PUHELIN OYJ	ICT consulting	78
25.	SIILI SOLUTIONS OYJ	Software	76

Source: Statistics Finland's business registry.

Table 6.3: Top 25 ICT companies by headcount de-growth in Finland in 2008–2012

Rank	Company	Industry	Empl. change 2008-2012
1.	NOKIA OYJ	CT manuf.	-7 597
2.	TELIASONERA FINLAND OYJ	Telecom	-2 093
3.	NOKIA SOLUTIONS AND NETWORKS	CT manuf.	-1 605
	NOKIA SOLUTIONS AND NETWORKS BRANCH		
4.	OPERATIONS OY	CT manuf.	-641
5.	IXONOS OYJ	Software	-481
6.	OY IBM FINLAND AB	Software	-419
7.	SCANFIL EMS OY	CT manuf.	-276
8.	SIEMENS OSAKEYHTIÖ	CT manuf.	-265
9.	DIGIA FINLAND OY	Software	-262
10.	INCAP OYJ	IT manuf.	-213
11.	TRAINERS' HOUSE KASVUSYST.OY	Software	-199
12.	SIEVI CAPITAL OYJ	CT manuf.	-176
13.	ENFO OYJ	ICT maintenance	-163
14.	HEWLETT-PACKARD OY	IT wholesale	-143
15.	KYMEN PUHELIN OY	Telecom	-134
16.	NOKIA INTERNATIONAL OY	CT manuf.	-127
17.	SANMINA-SCI EMS HAUKIPUDAS OY	CT manuf.	-125
18.	TIETO-TAPIOLA OY	ICT consulting	-106
19.	NEUSOFT MOBILE SOLUTIONS OY	Software	-104
20.	AINACOM OY	Telecom	-97
21.	DIGITA OY	Telecom	-95
22.	COMPTEL OYJ	Software	-92
23.	SELMIC OY	IT manuf.	-90
24.	CYBERCOM FINLAND OY	Software	-88
25.	WIPRO LIMITED, SUOMEN SIVULIIKE	ICT consulting	-87

Source: Statistics Finland's business registry.

Table 6.4: Top 25 ICT entries by employment in Finland in 2012

Rank	Company	Industry	Empl. in Finland, 2012
1.	ATOS IT SOLUTIONS AND SERVICES	ICT maintenance	347
2.	ISTEKKI OY	ICT consulting	187
3.	INNOFACTOR BUS. SOLUTIONS	Software	166
4.	NOKIA SALES INTERNATIONAL OY	CT manuf.	149
5.	SASKEN FINLAND OY	Software	149
6.	SCHNEIDER ELECTRIC FIRE & SEC.	IT wholesale	112
7.	KAISANET OY	Telecom	111
8.	KYMP OY	Telecom	111
9.	POHJ.-KARJ. T.TEKNIIKKAKESKUS	ICT maintenance	109
10.	NEBULA OY	ICT maintenance	92
11.	EMPOWER IM OY	Telecom	92
12.	ADP DEALER SERVICES FINLAND OY	Software	90
13.	HCL TECHNOLOGIES LIMITED	Telecom	88
14.	KARTTAKESKUS OY	ICT consulting	74
15.	OY HEDENGREN AB	IT wholesale	73
16.	OY ANGLO-NORDIC AB	IT wholesale	71
17.	TELECA FINLAND OY	Software	68
18.	KUNTIEN TIERA OY	ICT maintenance	67
19.	STRÅLFORS OY	ICT maintenance	66
20.	QENTINEL QA OY	ICT consulting	64
21.	SAAB SYSTEMS OY	Software	64
22.	SOGETI FINLAND OY	Software	56
23.	HUOLTOVERKKO OY	IT manuf.	53
24.	SMARTRAC TECHNOLOGY FINLAND	IT manuf.	52
25.	SUPERCELL OY	Software	51

Source: Statistics Finland's business registry.

Table 6.5: Top 25 ICT exits by employment in Finland in 2008

Rank	Company	Industry	Empl. in Finland, 2008
1	TIETOENATOR PROCESSING & NETWORK OY	ICT maintenance	-1,220
2	TIETOENATOR GMR OY	ICT maintenance	-1,003
3	DNA PALVELUT OY	Telecom	-765
4	OY ENIRO FINLAND AB	Telecom	-583
5	TIETOENATOR FOREST & ENERGY OY	ICT maintenance	-391
6	TIETOENATOR BANKING & INSURANCE OY	ICT maintenance	-380
7	TIETOENATOR DIGITAL INNOVATIONS OY	ICT maintenance	-299
8	POWERWAVE COMTEK OY	CT manuf.	-231
9	EVOX RIFA OY	IT manuf.	-229
10	INFOCARE FINLAND OY AB	IT manuf.	-227
11	TKP TIETO OY	Software	-214
12	DNA FINLAND OY	Telecom	-208
13	TELECA FINLAND OY	Software	-194
14	ETTEPLAN TECHNICAL INFORMATION OY	Software	-158
15	PRIMASOFT OY	Software	-152
16	SANOMA DATA OY	ICT maintenance	-149
17	ADITRO FINANCIALS OY	ICT maintenance	-139
18	VANSCO ELECTRONICS OY	Software	-122
19	ALMA MEDIA INTERACTIVE OY	ICT maintenance	-116
20	TIETO BROADCASTING IT OY	Software	-107
21	SUN MICROSYSTEMS OY	ICT consulting	-106
22	ADP DEALER SERVICES (FINLAND) OY	Software	-105
23	KOKKOLAN PUHELIN OY	Telecom	-97
24	ATBUSINESS OY	Software	-91
25	SPECTRICO OYJ	Telecom	-77

Source: Statistics Finland's business registry.

The importance of the 50 largest in employment declined from 2008 to 2012. This is mainly due to layoffs of the few largest companies. For instance, the largest employer, *Nokia*, fired over

7,500 workers during these years. As can be seen in Table 6.1, the size of the companies in the sector drops quite rapidly. The 30th largest firm in 2012, *Affecto Finland*, employed 336 workers and the 50th largest, *Oracle Finland*, 223 workers in Finland. In 2008, the 30th largest firm, *Digita*, employed 370 workers and the 50th largest, *GNT Finland*, 266 workers in Finland.

In Table 6.2 we look at the 25 companies that increased their Finnish employment the most. In this respect, the top companies were *Tieto Finland* (+2,888), *DNA* (+1,102) and *Accenture Services* (+972). Most growers among the largest employees have been software companies. The only manufacturing company on this list was *Kemet Electronics* (former *Evox Rifa* producing mainly capacitors). In total, these 25 increased employment by 8,120 workers.

Table 6.3 looks at the 25 largest ICT downsizers in 2008–2012. The top three were *Nokia* (-7,597 workers), *TeliaSonera Finland* (-2,093) and *Nokia Solutions and Networks* (-1,605). In total, the top 25 downsizers reduced employment by 15,678 workers.

As can be seen in Table 6.4, the largest entering company were *ATOS IT Solutions and Services* (a subsidiary of *ATOS* group headquartered in France), *Istekki* (a software firm focusing on information, communication and medical technology), and *Innofactor Business Solutions* (a software firm focusing on providing solution for *Microsoft* platforms). Most of the top entrants provide business services. The 25 top entrants employed 2,562 persons in 2012.

The largest exiting companies between 2008 and 2012 were *Tietoenator Processing and Network* (a subsidiary of *Tieto Group*), *Tietoenator GMR* (a subsidiary of *Tieto Group*) and *DNA Palvelut* (a subsidiary of *DNA Group*), all of which relate to corporate restructurings (Table 6.5); among the top exits, six related to *Tieto Group*. Most exits were in software firms and in ICT maintenance. In 2008, the 25 top exiting companies had 7,363 workers.

6.2 Largest ICT firms by subsector

In this section we report top10 companies by ICT sub-sectors, although we mainly comment on top 5 firms. Table 6.6 depicts 10 largest employers in CT manufacturing. After *Nokia* group the third largest is *Siemens*, which a part of a German diversified company with the following business areas: *Power and Gas*, *Wind Power and Renewables*, *Power Generation Services*, *Energy Management*, *Building Technologies*, *Mobility*, and *Digital Factory and Process Industries and Drives* (nevertheless classified as a CT manufacturing firm at Statistics Finland). *Tellabs* (former *Martis*, since 2014 *Coriant*) is a CT manufacturer that was bought in 1993 by US-based *Tellabs group*. *Teleste* was founded in 1954 and it develops and offers video and broadband technologies and related services. Its clients are cable and telecom operators and public sector organizations. It has manufacturing facilities in Finland and in China.

Table 6.6: Top 10 companies in CT manufacturing in 2012

Rank	Company	Employment in Finland
1	NOKIA OYJ	8 379
2	NOKIA SOLUTIONS AND NETWORKS OY	6 378
3	SIEMENS OSAKEYHTIÖ	682
4	TELLABS OY	463
5	TELESTE OYJ	374
6	CASSIDIAN FINLAND OY	348
7	SCANFIL EMS OY	273
8	SANMINA-SCI EMS HAUKIPUDAS OY	197
9	NOKIA SALES INTERNATIONAL OY	149
10	LAUKAMO ELECTROMEC OY	101

Source: Statistics Finland's business registry.

As can be seen in Table 6.7, the largest IT manufacturing firm in Finland is *Isoworks*, a subsidiary of Japanese *Fujitsu*, although nowadays most of its business deals with CT and maintenance services. *Alstom Grid* (a part of *Ahlstom* group since 2010; before *Schneider Group* and *Nokia Kondensaattorit*; originates from *Suomen Kaapelitehdas*) engineers and manufactures products and systems for reactive power compensation and harmonic filtering and sells and markets new equipment and solutions for power transmission. *PKC Electronics* is a contract-manufacturer of electro mechanics products. It also supplies testing solutions for testing of, e.g., mobile phones, tablet computers, vehicle infotainment systems and displays. Moreover, it sells power control products for telecommunication and energy industries. *Kemet Electronics* is US-based company that manufactures electronic components, especially capacitors. It has manufacturing facilities in Finland in Suomussalmi. *Aspocomp Oulu* is a production unit of the group. It manufactures a variety of circuit board products.

Table 6.7: Top 10 companies in IT manufacturing in 2012

Rank	Company	Employment in Finland
1.	ISOWORKS OY	549
2.	ALSTOM GRID OY	276
3.	PKC ELECTRONICS OY	257
4.	KEMET ELECTRONICS OY	228
5.	ASPOCOMP OULU OY	155
6.	OY DAREKON LTD	140
7.	INCAP OYJ	133
8.	GENELEC OY	110
9.	SCF HUOLTO OY	97
10.	HUOLTOVERKKO OY	53

Source: Statistics Finland's business registry.

In top 10 IT wholesale companies foreign-owned firms dominate the list (Table 6.8). Of the top 5, only *Hewlett-Packard* was originally a greenfield entry to Finland, the other four have been targets of mergers and acquisitions. *Atea Finland* was originally known as *Facidata* and was established in 1985. Eleven years later it was acquired by Swedish-owned *WM-Data*, and 2001 the name of the group changed to *Atea*. *Also Finland* was before operating as a name of *GNT Finland* and since 2009 it has been a part of German-based *Also Holding*. *Stanley Security* distributes security related technology. It was founded in 1986 as a name of *STW Security*. In 1993 it was acquired by a Swedish firm *Securitas*, and in 2011 *Stanley Black & Decker* bought

the firm. *Cygate* was founded in 1989 and since 2007 it has been a subsidiary of *TeliaSonera*. The only still Finnish-owned company among the top 10 IT wholesalers is *Hedengren Security* (6th), which sells products related to security systems, including camera surveillance, intruder alarms, access control, personal alarms and emergency light systems.

Table 6.8: Top 10 companies in IT wholesale in 2012

Rank	Company	Employment in Finland
1	HEWLETT-PACKARD OY	666
2	ATEA FINLAND OY	301
3	ALSO FINLAND OY	254
4	STANLEY SECURITY OY	253
5	CYGATE OY	149
6	OY HEDENGREN SECURITY AB	119
7	SCHNEIDER ELECTRIC FIRE & SECURITY OY	112
8	FOXCONN OY	103
9	SAS INSTITUTE OY	89
10	TECH DATA FINLAND OY	80

Source: Statistics Finland's business registry.

The largest telecom company in Finland is *TeliaSonera*, which was founded in 2002 by a merger of *Sonera* and Swedish firm *Telia*. It was the first to operate mobile telephony networks in Finland, followed some years after by *Radiolinja*, which was eventually acquired by the second largest telecom firm *Elisa*. *DNA* was founded by a merge of several local telecom firms in 2007. *Anvia* is the fourth largest telecom firm in Finland. It is based in western coast of the country and known earlier as *Vaasan Läänin Puhelin*. *Digita* maintains radio and television networks as well as wireless data communication networks in Finland. It was established in 1999 when *Finnish broadcasting company* (YLE) decided to divest its distribution network unit. Nowadays it is owned by an Australian investment company.

Table 6.9: Top 10 companies in Telecom in 2012

Rank	Company	Employment in Finland
1	TELIASONERA FINLAND OYJ	3 667
2	ELISA OYJ	2 902
3	DNA OY	1 157
4	ANVIA OYJ	449
5	DIGITA OY	275
6	TDC OY FINLAND	245
7	CORENET OY	195
8	AINACOM OY	169
9	SSP YHTIÖT OY	152
10	VAKKA-SUOMEN PUHELIN OY	117

Source: Statistics Finland's business registry.

The largest software company by employment is *CGI Suomi*, a subsidiary of Canadian based group. *CGI Suomi* was established in 1972 as a name of *Kunnallistieto Oy*. It has also operated under names of *KT-Tietokeskus* and *Novo Group*. It was acquired in 2004 by *WM-data* and then in 2012 by *CGI*. The second largest software company, *IBM*, has a long history in Finland. It has done business in the county since the 1920s. *Digia* is a Finnish company listed in Helsinki Stock Exchange. Its current form was created in 2005 when *SysOpen* and *Digia* merged. *F-*

Secure offers cyber security solutions to both individuals and organizations. It was founded in 1998 and nowadays has 6,000 resellers and 200 operators in over 40 countries.

Table 6.10: Top 10 companies in Software in 2012

Rank	Company	Employment in Finland
1	CGI SUOMI OY	3 238
2	OY IBM FINLAND AB	988
3	DIGIA FINLAND OY	773
4	CAPGEMINI FINLAND OY	622
5	F-SECURE OYJ	497
6	BASWARE OYJ	482
7	IXONOS FINLAND OY	411
8	NICE-BUSINESS SOLUTIONS FINLAND OY	359
9	TEKLA OY	349
10	INSTA DEFSEC OY	327

Source: Statistics Finland's business registry.

Accenture Services is the largest ICT consulting firm in Finland – over three times bigger that the second biggest *Tata*. *Tata* has headquarters in India, and like *Accenture*, it has also done large IT outsourcing deals, e.g., with *Nokia*. The third largest ICT consulting company, *Accenture Technology Solutions* , is also a part of *Accenture Group*. *Affecto Finland* was known until 1999 as *Enator Finland*. Its roots relate to the outsourcing of IT functions of several large Finnish manufacturing firms, like *Wärtsilä*, *Rauma-Repola*, and *Rosenlew*. When *Tieto* and *Enator* merged in 1999, competition authorities demanded that *Enator Finland* had to be excluded from the new group. As a result, the management together with venture capital funds bought *Enator Finland* and its name was changed to *Affecto Finland*. *Samlink* is a software firm that has been specialized to developing and producing software used in financial sector.

Table 6.11: Top 10 companies in ICT consulting in 2012

Rank	Company	Employment in Finland
1	ACCENTURE SERVICES OY	1 113
2	TATA CONSULTANCY SERVICES LIMITED, FILIAL I FINLAND	348
3	ACCENTURE TECHNOLOGY SOLUTIONS OY	336
4	AFFECTO FINLAND OY	336
5	OY SAMLINK AB	330
6	TIETO-TAPIOLA OY	305
7	CSC-TIETEEN TIETOTEKNIIKAN KESKUS OY	234
8	ISTEKKI OY	187
9	MEDBIT OY	160
10	VISMA SOFTWARE OY	154

Source: Statistics Finland's business registry.

In the ICT maintenance, the biggest company is *Tieto Finland*. Also two other entries in the maintenance top 10 belong to *Tieto group*: *Tieto Healthcare and Welfare* and *Tieto Oyj*. The second largest firm in this sub-sector is *Fujitsu*'s Finnish subsidiary. The third largest firm, *Opuscapita*, has been specialized in providing outsourcing services related to financial administration functions of firms. It also develops cash flow processes, which the firm calls as "purchase-to-pay" and "order-to-cash" processes. In addition to Finland, it has businesses in eight other European countries and has over 11000 clients. *Atos IT Solutions and Services* is a

Finnish subsidiary of *Atos Group*. It was formed in 2011, when French firm *Atos Origin* and German *Siemens IT Solutions and Services* merged.

Table 6.12: Top 10 companies in ICT maintenance in 2012

Rank	Company	Employment in Finland
1	TIETO FINLAND OY	4 429
2	FUJITSU FINLAND OY	1 689
3	OPUSCAPITA GROUP OY	599
4	TIETO HEALTHCARE & WELFARE OY	475
5	ATOS IT SOLUTIONS AND SERVICES OY	347
6	ENFO OYJ	265
7	TIETO OYJ	217
8	APPELSIINI FINLAND OY	170
9	REAKTOR INNOVATIONS OY	169
10	YIT INFORMATION SERVICES OY	115

Source: Statistics Finland's business registry.

6.3 Remarks

The above analysis reveals exceptional turmoil of the Finnish ICT sector in 2008–2012. *Nokia*'s downsizing is what first meets the eye and without *Nokia* the sectors employment in Finland would have remained about the same. Particularly *Tieto group* has been heavily molded in this window. Through fairly intense mergers and acquisition activity, and to a lesser extent through entries and exits, the Finnish ICT sector has grown more international and has become more consolidated.

Arguably changes in the composition of the sector and of its companies reflect a shift from "craft ICT", with customer-specific and at least partly hand-coded solution, to more "industrial ICT", in which solutions are more modular and a fitting collection of them is employed in each instance, which reduces employment in segments of the sector.

7 The Swedish ICT sector today

Eric ***Giertz***

This chapter presents a unique study that divides the ICT sector into new business logic segments that reflects a modern ICT industry. The resulting picture provides a significantly better position to understand the composition and development of the ICT sector in Sweden.

7.1 Introduction

After the massive structural changes around the year 2000 a radically different ICT sector developed in Sweden. This new sector differs significantly from a historically more traditional computer and telecommunications industry. Formerly the ICT sector in Sweden as well as abroad was dominated by companies that developed and manufactured goods, such as computers, electronic components, peripherals, telecommunications systems, telephones, consumer electronics and the like. It was complemented by software companies that developed and licensed different software to their customers, as well as companies that managed the computer systems. Today, however, the ICT sector consists – even in a narrowly defined definition – of a variety of companies with completely different business logics and business focus.

This chapter provides an overview of how the whole ICT sector in Sweden is divided among companies with different business focus. The quantitative starting point is in a unique analysis of the ICT sector in Sweden, conducted on behalf of VINNOVA in 2013[89]. All limited companies with more than five employees who have ICT as their core business were reviewed. A uniqueness of this study is that it divides the ICT sector into business logic segments that are not present in traditional statistics. This provides a significantly better position to understand the composition and development of the ICT sector in Sweden, but it provides limited opportunities for comparison with the situation in other countries, such as Finland, as the corresponding statistics do not exist outside of Sweden.

The information and communication technologies are basically impregnating every single industry and every single business. That means that the definition of the ICT sector is by no means simple or obvious. In the study, that is the base for this chapter, all included companies have ICT as their main activity. However all sales companies, wholesalers as well as retailers, are excluded as are call centers and education and training companies, even though they can build their competence and business model on ICT. In addition all companies with less than five employees were excluded. Despite this delimitation, the study involves a total number of 2,740 companies with 132,142 employees distributed over 4,332 different workplaces around

[89] Giertz Eric, Levén Per, Sörensson Robert & Lougui Monia: *Företag inom informations- och kommunikationsteknik i Sverige 2007-2011*, VINNOVA Analys VA 2013:07

Sweden. Given that the study uses the full-time equivalent as a measure to quantify the number of employees, the number of physical persons employed in the sector is considerably higher – approximately at least, 160,000. Despite the important economic recession, the companies register an almost 13% increase in employment during the five years period. The expansion is most notable among the consultancy and the software companies.

The ICT sector in Sweden is thus in itself a rapidly growing sector of the Swedish economy. But the ICT sector as a whole is also characterized by structural changes, sectorial shifts and great dynamics. Many companies have been acquired by foreign corporations. Indeed, during the period 2007-2011, the number of employees belonging to foreign-owned companies increased from some 40,000 employees to reach almost 50,000. The dynamics is also manifested in a relatively large number of companies registering a loss during a single year. This mainly concerns software, utility and hardware companies that are in the early stages of their product life cycle. Moreover, the loss also involves firms being unable to handle the rough competition in later phases of a life cycle.

The ICT sector in Sweden is dominated by different kinds of software and service companies. Less than one quarter of the employees is employed in a hardware company among which Ericsson occupies a very dominant position. In addition, the majority of these hardware companies, like Ericsson, are becoming more likely to include software and services in their deliveries, which of course even more underlines the importance of software and services in the Swedish ICT sector today. The number of employees working in companies delivering different kinds of software and services are divided almost equally on three different segments with different business models; Software & Net Services, IT operations & Maintenance respectively ICT Consultants.

Figure 7.1: Employees in the ICT sector in Sweden 2011 divided on the eight different sub-segments used in this chapter

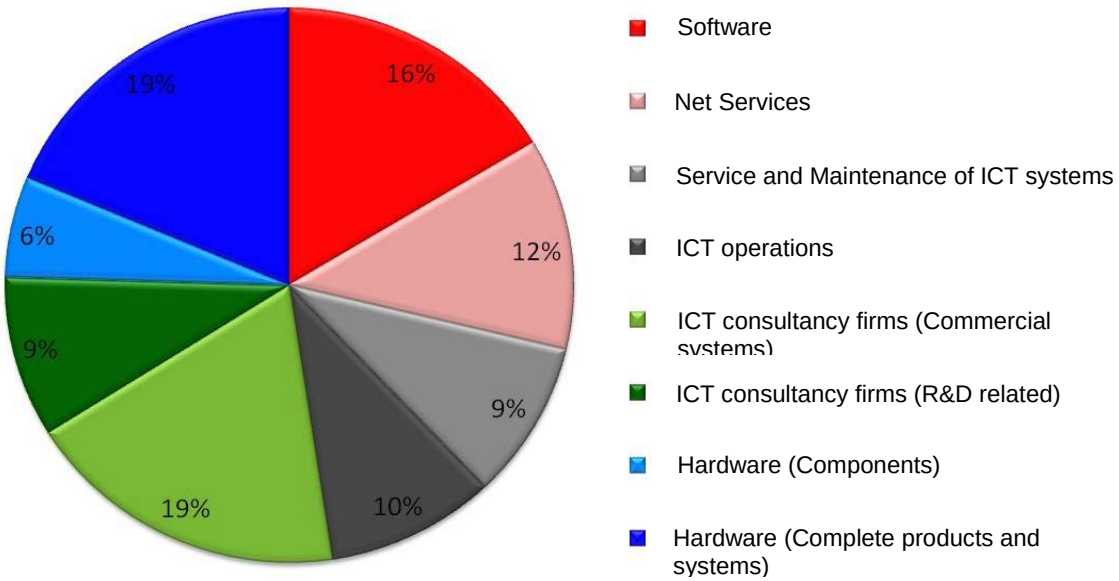


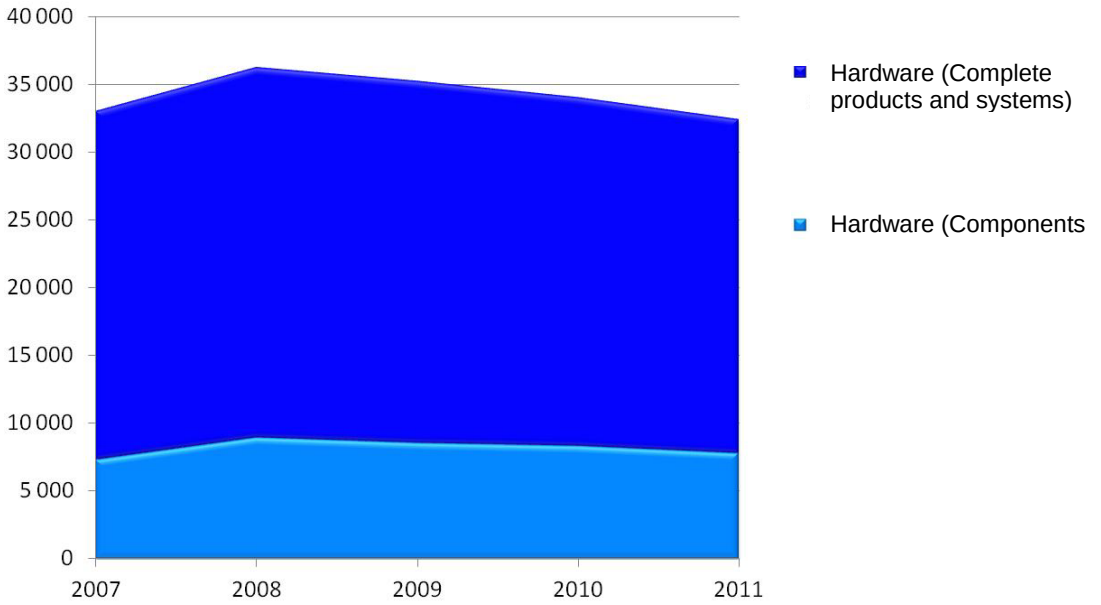
Table 7.1: Number of employees, work places and companies in different sub-segments in the Swedish ICT sector 2011

BUSINESS SEGMENTS	EMPLOYEES	%	WORK PLACES	%	COM-PANIES	%
SOFTWARE	22,193	16,8%	981	23,2%	744	27,3%
NET SERVICES	16,067	12,2%	568	13,4%	223	8,2%
SERVICE AND MAINTENANCE OF ICT SYSTEMS	13,428	10,2%	418	9,9%	106	3,9%
ICT OPERATIONS	14,402	10,9%	299	7,1%	132	4,8%
ICT CONSULTANCY FIRMS (COMMERCIAL SYSTEMS)	24,746	18,7%	1,091	25,8%	775	28,4%
ICT CONSULTANCY FIRMS (R&D RELATED)	12,710	9,6%	482	11,4%	370	13,6%
HARDWARE (COMPONENTS)	24,152	18,3%	198	4,7%	194	7,1%
HARDWARE (COMPLETE PRODUCTS AND SYSTEMS)	4,444	3,4%	196	4,6%	185	6,8%
SUM	**132,142**	**100,0**	**4,233**	**100,0**	**2,729**	**100,0**

7.2 Hardware companies within the ICT sector

The segment Hardware Companies is the only segment within the ICT sector in Sweden that shows declining employment. In 2011, it covered 382 companies with 32,418 employees in Sweden. The reason for the decrease in employment in the hardware segment is not due to fact that many manufacturing companies now are producing a large share of services. All employees in companies that develop and/or manufacture physical products in the computer and electronics field and in the telecommunications industry as a whole have been included in the hardware segment, despite the fact that many of these companies now include a growing share of software and services in their customer offerings. The hardware segment is declining since, similar to the trend in many other European countries; the volume-oriented manufacturing of hardware has left Sweden. In Sweden there are no longer any companies manufacturing products for expanding global volume markets such as semiconductors, displays, computers or consumer electronics. This production did to a very large extent move to Asia in the 2000s.

Figure 7.2: Number of employees in the hardware segment 2007-2011



Hardware companies making complete products and systems

In 2011 there were 187 companies with a total of 24,652 employees at 223 workplaces in Sweden who developed some kind of complete ICT products or systems. The very dominant company was Ericsson who then had over 17,000 employees in Sweden, i.e., over 70% of all employees in companies within this business segment.

Ericsson has its foundation in the development and manufacturing of telecommunications systems. The customers are mainly telecom operators around the world. However Ericsson no longer defines itself as a mere supplier of products, but more as a service provider. Ericsson manages outsourced operations for telecom operators in many countries. Nowadays, around 40% of Ericsson's revenue comes from such services. Service output is now engaging over half of Ericsson's approximately 100,000 employees worldwide. Technological development, coupled with Ericsson's business reorientation, has led to Ericsson's direct employment in Sweden continuously declining during the 2000s, although the number of employees in the global Ericsson group has in the past decade fluctuated around 100,000. During 2007-2011 the number of employees in Sweden decreased with over 800, which accounted for over 70% of the decline in this business segment as a whole. Ericsson's cutbacks in Sweden have also continued in recent years.

However, Ericsson does not only play an important role in the ICT sector in Sweden through its direct employment. As noted in the previous chapters, Ericsson's development and manufacturing of telecommunications systems have had a major indirect impact on the entire ICT sector development in Sweden. Ericsson is still a major supplier, partner, customer and contractor for many other ICT companies in Sweden, i.e. telecom operators, manufacturers of parts and components, contract manufacturers and not least technology-oriented ICT consultants involved in the development of future telecommunications systems.

Ericsson has also contributed to early and rapid penetration of new ICT communications in the Swedish society. Ericsson's existence has meant a lot to the very early adoption of new technology at Swedish-based companies in various industries, as well as in infra service providers, government agencies and for the fast penetration of new ICT solutions among the Swedish people in general. So Ericsson has contributed to a flourishing environment and the birth of an interesting test market in Sweden, which attracts foreign, global companies in the ICT sector to establish in Sweden. Ericsson's presence has also been of great importance for the establishment and development of research and education in universities and research institutes. Ericsson is still a very important node in the ICT clusters formed in Sweden, especially in Kista.

Alongside Ericsson there are a handful of major companies in the ICT sector, with a few hundred employees each in Sweden, which manufacture complete products and systems. It is mainly companies that are spun off from the Swedish engineering industry, particularly Saab, and are now parts of different foreign-owned corporate groups. These relatively high-tech and development-intensive companies appear to be largely retained and developed in Sweden even after the acquisitions. There are also a number of relatively newly established Swedish companies, which have been successful players in their respective markets. This applies e.g. to a number of med-tech companies, which have developed high-tech products in close connection to different research environments; Hemocue AB with 300 employees, Sectra Medical Systems AB and Tobii Technology AB with 100 employees each in Sweden.

In Sweden there are also some research-based companies that develop and manufacture complex machines and equipment for the global ICT industry. The deep expertise in microelectronics and photonics, which was built up during the 1900s in cooperation between universities, research institutes and manufacturing companies as Ericsson, PEAB, Saab and ABB, have survived in various research environments. This expertise has also formed the basis for new, more or less successful companies that develop, manufacture and market machines and equipment for the electronics industry mainly in Taiwan and South Korea. One example is the listed company Mycronic, which was formed by merging Micronic and Mydata. Mycronic is engaged in the development, manufacture and marketing of production solutions to the electronics industry. It has two business areas; Pattern Generators, including mask writers and direct writers, LDI and Surface Mount Technology equipment including pick&place and jet printing solutions. Mycronic has around 300 employees in Sweden. Another example was Replisaurus which was established in 2001. The latter company introduced a new technique to manufacture semiconductors. Their potential customers were supposed to manufacture the top conductor layer on integrated circuits using electrochemical replication instead of optical lithography. However Replisaurus did not manage to convince the producers in Taiwan and South Korea to abandon their proven technology, and the company went bankrupt in November 2011.

Most companies in this sub-segment are fairly stable and profitable. A few slightly larger companies with losses are relatively newly established and development intensive, e.g. med tech company Tobii Technology. Other development-intensive companies, such as Mycronic are extremely cyclical and are interspersed large profits with large losses.

Hardware companies making components

In 2011 there were 195 companies with 7,766 employees at 221 locations in the ICT sector in Sweden that manufacture various kinds of hardware components. This sub-segment is dominated by many small independent companies, each with around ten employees, but there are also some larger companies with a few hundred employees.

The majority of the slightly larger manufacturers of components are however contracting manufacturers. Several are local Swedish manufacturing facilities in major foreign corporations who own many manufacturing units in different countries. The Swedish facilities were often acquired by these foreign corporations when Swedish companies decided to outsource their own manufacturing. There are also some independent Swedish companies among the contracting manufacturers in Sweden. In total there are barely a dozen contract manufacturers in Sweden with between 100 and 500 employees each. Among the relatively large companies manufacturing components you can also find spun-off entities that develop and manufacture components for specific applications, e.g. Autoliv Electronics AB with around 300 employees in Sweden. The larger companies that manufacture components are generally speaking profitable. This applies both to Swedish-owned companies and companies spun off to foreign corporations. Large contract manufacturers in Sweden are, with one exception, profitable.

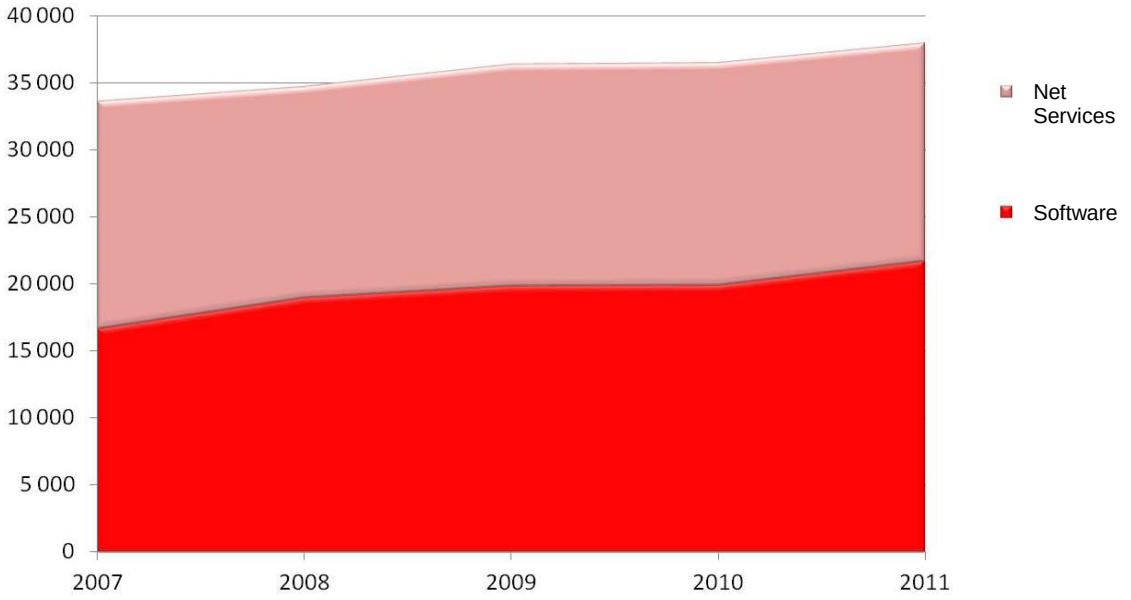
But as mentioned this sub-segment is dominated by a number of small independent companies with around ten employees each. Many of these small companies originates from research environments linked both to research institutes, such as Acreo, and universities like KTH, Chalmers, Linköping and Lund. Most companies are fairly recently established high-tech companies in research fields like fiber optics, nano electronics, power electronics or printed electronics. They develop e.g. control equipment, equipment for measurement and calibration, antennas, power transistors, alarms, lasers, sensors or actuators. A few of these fairly new research based companies have emerged on the international market and gained a position in their specific niche market. Some have been able to develop prototypes and show a proof of concept. Some of the latter have been able to attract potential buyers and successfully sold their company to larger foreign corporations at an early stage. Other companies have flared up around a new technology, such as optical fiber or solar cells, and expanded temporarily for a brief period in the early phases of product lifecycles but then declared bankruptcy a few years later.

The profitability of larger and more established manufacturer in this sub-segment is a contrast to the unprofitability of the smaller companies. Half of the smallest companies with five to nine employees, which develop hardware components, showed a negative result after financial items in 2011. Among these companies you will find many start-ups, development-intensive and venture capital financed companies with a high burn rate and negative cash flow. Some of them are potential acquisition targets for larger companies and some may develop into larger independent companies. But it is hardly likely that they will be the foundation of a Swedish industry producing standard electronics in large volumes. That kind of mass production has probably moved to Asia to stay.

7.3 Software & net services

Companies within the segment Software and Net services covered 965 companies with 37,963 employees in Sweden in 2011. Overall, it's a segment characterized by increasing employment, but also by great dynamics. The companies are becoming more and more specialized to different application areas. In established markets there is an ongoing consolidation but parallel to this new companies emerge, that exploit new business niches based on either new technology or new application areas. Overall larger firms are becoming less dominant in this segment. Employment in the largest companies is declining, but the number of companies and total employment increases.

Figure 7.3: Number of employees in the segment Software and Net Services 2007-2011



Software companies

In 2011 Software companies accounted for just over 27% of companies in the ICT sector but only for 16% of employment. There is no single company that dominates, but the business segment is characterized by the existence of a large number of relatively small companies. Among these software companies are included companies that develop and make available basic programs which have many end users and covers broad application areas such as operating system and database management systems. In Sweden there are a disproportionate number of innovative companies of this type, but overall, these companies account for a relatively small part of the employment in this business segment. This sub-segment is characterized by acquisitions and consolidation. When a particular application matures there is also gradual development of worldwide oligopoly markets or de facto monopoly.

The software companies with the most employees in Sweden are Swedish based companies that develop ERP, finance and payroll systems, CRM systems and the like. Historically, the development of systems for business administration has laid the foundation for many new software companies, which has licensed the use of software programs dealing with for example accounting or payroll systems. For many people such applications are probably still today a kind

of archetype for software products in a software company. But in recent decades, there has been a very powerful consolidation in this sub-sector, which has resulted in a fast declining number of companies, who develops and licenses for example ERP systems, CRM systems or document management systems. The barriers to entry these mature oligopoly markets are now very high.

Overall the software sector is dominated by a very large number of companies with a few dozen or exceptionally a few hundred employees, who develop and make available programs for a variety of specific applications. The programs can be aimed at both the consumer and the producer market. For example this sub-sector includes companies that develop and grant the right to use computer games. It also includes companies that develop and license advanced calculation and simulation software to distinct groups of professionals. This sub-segment also includes a rapidly growing pool of companies that generate revenues by launching apps of various kinds.

Among software companies, it is natural that start-up companies have large upfront development costs and shows red numbers before a complete software program generates sufficient revenues to generate a profit. This is also reflected in figures showing that small firms with five to nine employees are heavily overrepresented among software companies making a loss. 33% of the smallest software companies made a loss in 2011. But also relatively large software companies are making a loss. About 25 of the largest companies, with more than 50 employees, had a negative result after financial items in 2011. Some of them were in an expansive phase and funded by venture capital. Some were rather embryonic and had a turnover of only a few tens of millions, but losses of several tens of millions. Other, previously profitable companies had started to expand their market. In some cases it resulted in a dramatic increase in sales but in the short term it led to negative cash flow.

A number of unprofitable larger software companies, who were in the later stages of their life cycle, were also identified. They were losing market shares and showed declining revenues when their respective industry was consolidating. Several software companies with Swedish roots have been in business one or more decades and previously conducted a sustainably profitable business that catered to corporate customers, primarily in the Swedish and Nordic markets. Among these companies are companies offering ERP systems, payroll systems or purchasing and inventory systems. There are also companies offering specific systems for different industries, such as trade companies, transport industry or financial markets. There are also companies who have sold operating system or software systems for interactive entertainment or publishing. Many domestic companies who have worked on these maturing markets have in recent years have lost market share, significantly reduced their turnover and turned unprofitable.

Net Services

This business segment includes the telecom operators' main activities. In accordance with the selection criteria used in the referred study operators' stores and outlets were excluded, which has reduced the number of employees. Despite this the business segment Net services covered a total of 224 companies with 16,275 employees in Sweden in 2011. Total employment remained stable over the period 2007-2011 but there was a shift from traditional telecom to a variety of

companies with different specialization. The focus is still the telecom operators, and traditional telecom operators are the largest companies. Alongside the traditional telecom operators there are operators originating from TV distribution, broadband and IP telephony. There are also operators with different backgrounds, e.g., Skype who already from the start in 2003 offered free IP telephony over the internet.

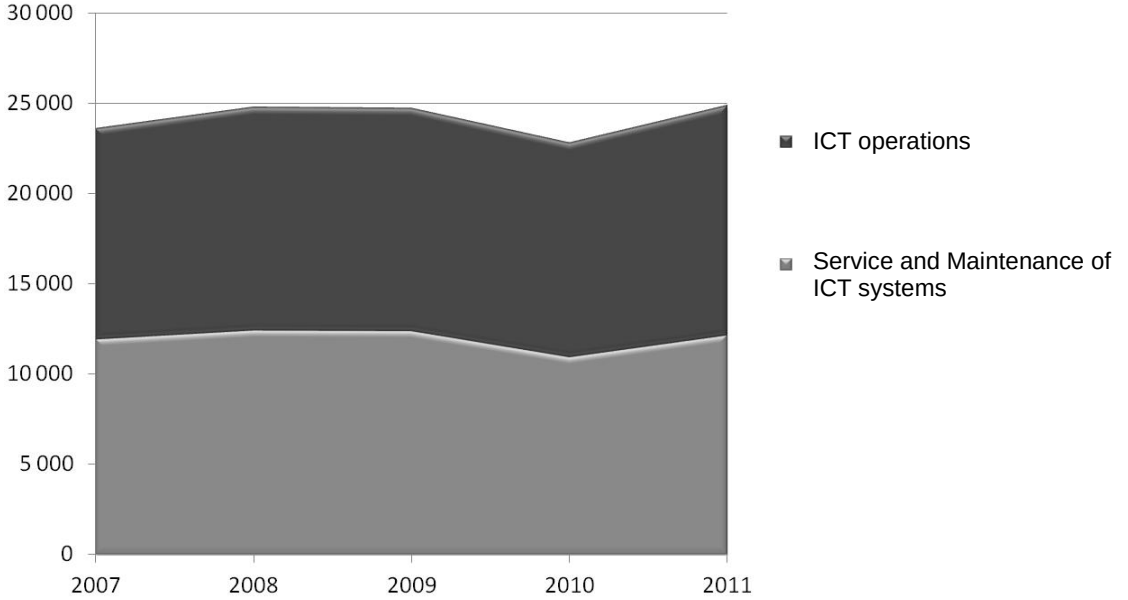
This business segment also includes companies who provide various forms of online search services as well as companies that provide music services. It also includes companies which develop and operate advanced technical platforms for various web-based applications, e.g. platforms for poker or casino games used by several competing poker rooms and gaming operators. A general trend in this business segment is an increased diversity of companies, which provide various forms of specialized network services. The time when one operator alone was responsible for end-to-end communications in a network is definitely over – at least in democratic parts of the world.

This is truly a very dynamic and turbulent business segment. On the one hand you have traditional and new international telecom operators who are competing on different deregulated national markets. The number of employees in that sub-sector has been declining for many decades in Sweden. On the other hand you have new companies delivering different kinds of public net services on domestic or international markets. Blocket is an example of a domestic (but foreign-owned) player while Spotify is an example of an international player. Generally speaking companies that deliver network services only on the domestic Swedish market are generally viable, whereas those around 15 Swedish-based companies that also have substantial exports still showed a negative result after financial items in 2011. Relatively new but already well-known companies offering global technical platforms for music services, poker games, electronic payments and such all showed negative profit margins in 2011. The losses ranged from a few percent up to about 30% of sales.

7.4 Maintenance & computer operations

In 2011 the segment Computer Operations and Maintenance comprised 230 companies with 24,893 employees at 738 locations in Sweden. This segment is characterized by a relatively constant employment. This whole business segment is, compared to other parts of the dynamic ICT sector, very stable when it comes to revenues and profits. The large majority of companies that specialize in delivering service and maintenance of ICT systems and infrastructure or in managing outsourced operations were profitable in 2011. This industry is, however, working with small margins and there was more companies generating smaller losses during the recession the years before. Within the pure service business there has been some consolidation, which also means that some major corporations today deliver similar service at many different locations in Sweden. This is reflected in a relatively high number of workplaces per company, despite the fact that computer operations are concentrated to fewer and larger work places. In total there are 3.2 times more workplaces than companies in this segment, compared to a factor of 1.4 for all other segments.

Figure 7.4: Number of employees in the segment IT-operations and maintenance 2007-2011



Service and maintenance of ICT systems

This business segment includes companies providing installation, maintenance and updates as well as repair and maintenance of their clients' hardware and software systems. In 2011 there were 107 companies with 12,152 employees at 423 locations with this business focus in Sweden. Some of the companies are fairly large corporations with many similar branches in different parts of Sweden and, in some cases, also in other Nordic countries and the Baltic States. Many of the companies offer a wide range of products and services in order to build and maintain their customers' entire ICT infrastructure. Among the companies engaged in the servicing and maintenance of ICT systems you also find specialized companies providing service and maintenance of their costumers' physical networks. These companies can in some cases be geared towards servicing both telecom and electricity networks.

Outsourced computer operations

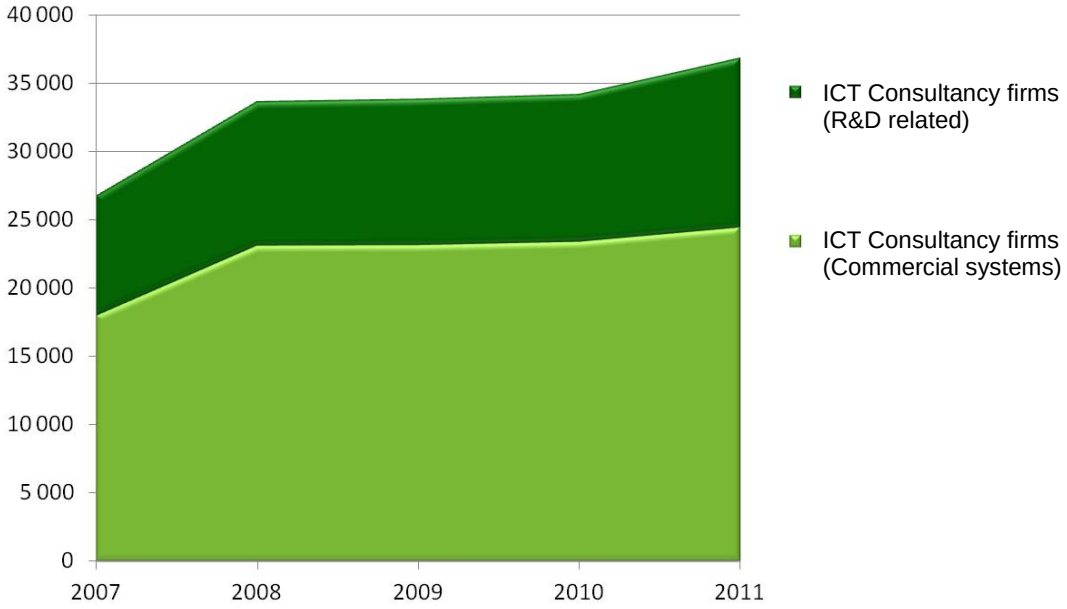
This business segment includes companies that are spun off from larges groups in different industries. Those former computer departments are often responsible for the parent group's entire ICT operations but can also have customers outside the group. This segment also includes a relatively large number of network operators, data service bureaus and data centers with slightly different business focus. In 2011 there were a total of 123 companies in Sweden with this business focus. In total, they had 12,741 employees at 315 different locations. In a way this business segment is in fact even larger than is shown by these figures, since many corporations in different industries have not spun off their ICT operations to separate companies. ICT departments that are not separate companies do not show up in the statistics and are of course not included in the study. This means that ICT departments at companies like SEB and H&M, with approximately 1,000 employees each in Sweden, are excluded.

7.5 ICT Consultancy Companies

ICT Consultancy is in terms of employment by far the largest and the fastest growing segment in the Swedish ICT sector. In 2011 there were 1,127 ICT Consultancy firms, with more than 5 employees. Only companies working exclusively with ICT as their main business focus were included. This means that the number of consultants dedicated to ICT-related work was deliberately greatly underestimated. There are a substantial number of large consultancy corporations with a diversified business focus. Some of them have subsidiaries or separate business units dedicated to work in the ICT business segment, which were not included in the study (see chapter 12.1). There are also a lot of small consultancy companies with less than 5 employees that were excluded. Still the identified companies had a total of 36,868 employees on 1,600 different locations in Sweden. During the period 2007-2011 the number of employees in those companies almost increased by 40 %. Generally speaking the ICT Consultancy segment has undergone heavy consolidation and globalization during the last decades, but there is a great difference between the majority of ICT consultancy companies engaged in developing commercial or management systems and R&D related ICT consultancy companies developing embedded systems in their costumers' products or production systems.

ICT consultancy is the business segment with the highest percentage of profitable companies. It is not surprising given that they do not make large investments in the development of their own programs, products or systems, but instead they charge their work to the customers. The low percentage of companies making a loss is surprisingly stable over the entire period 2007-2011. The vast majority of consulting firms seems to be able to adapt the number of employees, so that the billing rate can be kept high also in economic downturns.

Figure 7.5: Number of employees in the ICT Consultancy segment 2007-2011



ICT Consultancy firms engaged in developing commercial or management systems

In the study 764 ICT consultancy companies, which primarily offer services related to commercial and management software solutions, were identified. In total they have 24,471

employees at 1,101 different locations in Sweden. The number of employees in this segment is constantly increasing, but below the surface there is a great turbulence. During the last decades the segment has undergone heavy consolidation and globalization. In fact today the consultancy sector as a whole is the most international industry in Sweden and the segment of commercial ICT-consultancy firms is no exception. On the contrary the segment is nowadays dominated by around ten international corporations, which employ more than half of all employees in Sweden. Most of them have foreign owners and their corporate head quarter is located abroad.

Among these consultancy giants you will find international groups that have established themselves in Sweden through acquisitions, i.e. Finnish Tieto, Canadian CGI and French Capgemini. They have acquired Swedish companies that originated from the Swedish IT-department outsourcing movement that was initiated in the 1960s. One example of such an outsourcing activity was the creation of Datema, by the Johnson Group. Datema swiftly added external projects to its previously strictly internal order bookings. The remains of Datema now belong to the Finnish ICT company Tieto, which also acquired many other Swedish ICT consultancy companies. In 1999 Tieto acquired Enator, which was a merger of numerous outsourced IT departments from both public and private sector. Tieto also acquired Entra Data in the same year.

At present Tieto has some 14,000 employees, of which 3,400 are employed in Sweden. The forming of CGI in Sweden has many similarities with Tieto. CGI acquired Logica in 2011, which in turn previously had acquired WMdata in 2006. WMdata was founded in 1969 and grew extensively by acquisitions during the 1990s. CGI is a global Canadian company with some 68,000 employees worldwide.

The French consultancy company Capgemini, including the subsidiary Sogeti, has also established itself on the Swedish market by acquisitions. Data Logic was acquired in 1988, Accept Data in 1989, Sypro in 1990 and Programator in 1992. Sogeti has more than 20,000 employees, of which 1,125 in Sweden. Furthermore the Group has about 1,300 employees in Sweden working under the Capgemini brand. Today Capgemini is one of the largest ICT consultancy companies in the world with around 110,000 employees.

Gradually, the consolidated companies have shifted their business focus from computer operations and in house software development towards more generic consultancy services and configuration, installation and integration of different software from vendors like Swedish IFS, SAP, and nowadays also Microsoft. Thus the consolidated companies' business models have become less and less reliant on computer operations or licensing of software and increasingly reliant on consulting and software development services. In some cases this shift in core business and the following refinement has led to divestments. For example, in 2005, Sogeti sold its business area within outsourced ICT operations to Norwegian EDB.

The Norwegian ICT group EVRY, which was formed in 2010 by the merger of EDB and ErgoGroup, today has substantial business in Sweden. The group was formed through mergers and acquisitions of 70 ICT companies mainly in Norway. EVRY was established in Sweden in 2001 through the acquisition of SJ Data and has subsequently made further acquisitions in

Sweden. Today, the British private equity company Apax owns the EVRY Group. EVRY has more than 10,000 employees, of which about 1,000 in Sweden.

Other major players in the ICT consultancy sector emerged when hardware and software companies integrated forward and formed specialized consultancy companies. Hence companies like Tieto, CGI and Sogeti nowadays compete with for instance IBM Consulting, which also includes former PWC Consulting that was acquired in 2002. Currently IBM has more than 420,000 employees, including roughly 2,700 in the Swedish consultancy operations. Another American consulting group with significant operations in Sweden, Accenture, has more than 200,000 employees in 120 countries, of which about 900 in Sweden.

One interesting question is related to the possibilities for large international consultancy corporation to build some kind of structural capital that increases the efficiency and quality of an individual consultant. Can large corporation invest in common methods, models and data bases that supports the efficiency, quality and competitiveness in the whole group and gets all consultants to reuse good work done by colleagues around the world and also work in the same manner wherever they are located. So far surprisingly little seems to be done in large groups that have mainly grown by acquisitions. Acquired subsidiaries often seem to be allowed to work in more or less an unchanged manner also after the acquisition. American corporations, which have mainly grown organically, seem to be on the front of this development. Arguably Accenture is the ICT consultancy group that has invested the most in building structural capital.

In 2011 there were still a small number of independent Swedish ICT consultancy companies in this segment with approximately 1,000 employees each in Sweden. They still had their main activities in Sweden but had started some internationalization. These included Acando, Knowit and Connecta. In 2014 however Acando merged with Connecta to form a new consultancy company with around 1,900 employees.

There are a large number of independent smaller companies, providing similar services in local markets, alongside with the major companies mentioned above. Consultancy companies with a partly different origin and orientation have been included in this specific segment of ICT consultancy companies. Some of them are Swedish consultancy companies with their roots in the production of websites during the late 1990s. Some of them have developed into professional digital agencies, with a few hundred employees each in Sweden. On behalf of their customers' they develop strategies and digital communications solutions. One example is the Norwegian company Creuna, which established its operations in Sweden through the acquisition of Razorfish’s (formerly Spray’s consultancy operations) remains after bankruptcy in 2002.

R&D related ICT consultancy firms

Alongside ICT consultancy firms working with different kinds of commercial or management systems there are ICT consultancy companies more focused on pure technology, such as the development of embedded systems in their customers’ products or production processes. ICT consultants with this business orientation are a kind of external R&D departments to their customers. Larger companies in this sub-system have several locations and typically each

location is specialized on specific applications and customers. The specialized workplaces are also typically located close to major customers. In many cases consultants are working extensively in their customers' physical environments.

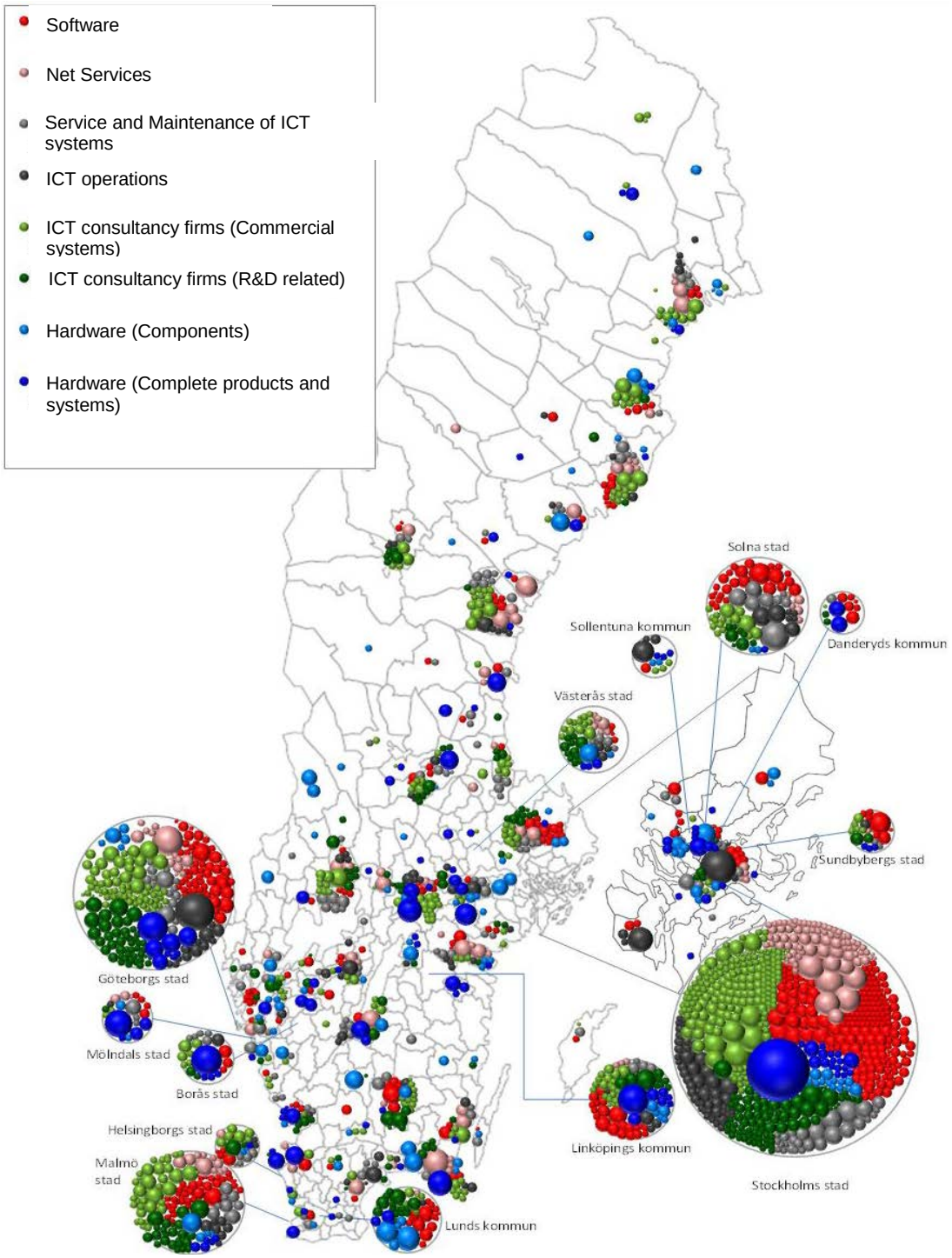
In 2011 there were 363 companies with 12,397 employees at 499 locations in Sweden, working with ICT consulting in pure technical applications. In addition there are a number of large consulting companies with a different main business focus that also compete on this market, but they are not included in this study (The R&D related ICT consultancy segment is presented in chapter 12.2-12.4).

A handful Swedish owned companies dominates this sub-segment, but there are also many small companies with this specialization. They have developed embedded systems and Internet of things in many Sweden-based groups in various technology-intensive industries. Most of them still have most clients in Sweden even if the larger companies are becoming more Nordic. But this sub-segment is, in contrast to the ICT consultancy segments dealing with commercial or management systems, not characterized by an international consolidation. The number of consultants within this technical field is considerably less than in the commercial field. But they have played, and still play, a very important role in the technological shift that Swedish industry has undergone in recent decades. They are involved in the development of embedded systems and machine-to-machine applications (Internet of Things). This important development, as well as the role of the consultants, is therefore dealt with in detail in two separate chapters in this report (chapter 12 and 14).

7.6 An extreme concentration to the Stockholm region

The ICT sector is represented in almost all regions of Sweden, but the concentration to the Stockholm area is remarkably high. Companies in Stockholm County account for almost half of all employees.

Figure 7.6: Companies and work places distributed on different municipalities in Sweden



Note: The volume of a ball is in proportion to the number of full time equivalents at one work place.

The concentration to the Stockholm County is remarkably high for almost all different business segments. Six out of eight business segments have 50% or more of their employment in the county. The most divergent business segment is Hardware companies manufacturing components. Only 23% of employees in that segment are found in the Stockholm County. This

is mainly because contract manufacturers are evenly distributed to smaller cities across the country. Another segment with slightly less concentration to Stockholm is R&D related ICT consultancy companies, with 35% of employees in the Stockholm county. Most major R&D related consultancy companies have many specialized offices located close to their customers in different industries, such as automotive, aerospace, defense, automation and food processing industry. It is therefore hardly surprising that that business segment is more represented in industrial centers in other parts of the country.

The strong concentration of the ICT sector to the Stockholm area is even more prominent when comparing the number of employees relatively to the number of residents aged 16-64, where the county of Stockholm has a ratio twice as high as any other county. Approximately 6% of the inhabitants in the county of Stockholm are employed by companies in the narrowly defined ICT companies. Other counties with a relatively high proportion, just over 2%, are the counties Östergötland, Blekinge, Västra Götaland and Västernorrland. These are counties, who like the Stockholm, has a natural connection to universities and/or research institutes with a strong focus on ICT. The employees in these institutions are not included in the current data but they represent essential components in the local ICT clusters.

8 Nordic gaming

*Kent **Thorén**, Annu **Kotiranta**, and Bryan **Pon***

This chapter describes the video game sector as a subcategory of software and net services. It covers the development in the Nordic region, including brief accounts of the origins and history of the industry in the different countries. Mobile gaming apps are studied in a way that enables direct comparison between Finland and Sweden. This chapter also mentions the key companies and their role in shaping the industry we see today. Sweden and Finland are the main video game exporters in the Nordics. The balance was originally that the Swedish industry was about twice the size of the Finnish in terms of aggregated revenues. However, recently tremendous growth in Finland has led to a shift in leadership, where Finland is now the bigger player. The Finnish industry revenues are extremely dominated by *Supercell* with mobile game hit titles like *Clash of Clans* and *Hay Day*. The Swedish industry is also quite concentrated, but there is a larger number of big firms and a much greater share of revenues coming from console and PC games.

8.1 Setting the scene

Games and entertainment may not be the first thing associated with the ICT sector. However, in some Nordic countries video games are actually the fastest growing subsector within the ICT sector as well as within the economy as a whole. It represents a fairly new and commercially promising application of software and net services. Targeting a global export market, video games sales are today growing fast and quickly increase in economic importance.

This chapter examines the emergence of a thriving video game industry in the Nordic region and its background. Particular attention is being paid to the dominating nations, Sweden and Finland. In addition, the Swedish industry will be examined further in the next chapter, which goes into deeper analysis of the mechanisms behind its long standing success on the international scene.

8.2 Definition, structure and history of the sector

Video games can be defined as electronic games that generate visual feedback on a video device. The industry ecosystem contains three main types of actors: hardware providers, game (software) developers and publishers.[90]

The hardware systems for playing video games can be organized into three platform categories: hardware specialized for games (referred to as consoles), generic PCs, and mobile, handheld devices. The consoles have always been supplied by handful of global companies based in Japan or in the US, e.g., *Sony*, *Magnavox*, *Atari*, *Sega*, and *Nintendo*. Similarly, PCs and mobile

[90] Dymek and Rehn (2003).

phones are typically provided by very large firms in more or less the same countries. However, the actual manufacture of video game hardware tends to be located to low cost countries, in line with general global manufacturing trends.

Publishers have two roles, they help market the games and they can help finance the development efforts. Like the hardware business, publishing is also dominated by a small number of global firms, but geographically it is more diverse with a larger European presence. In Europe there are significant publishers in France and UK. Sweden, Italy and Hungary also have publishing business but to a smaller extent. Since the publishers deal with digital products, they normally have a global market scope. The focus in this chapter is nevertheless game development, because in the Nordic region the publishing business is very small and game hardware production is non-existing.

The early history of video games has been well described in books, academic theses[91] and even documentaries like *Video Games: The Movie*.[92] Building on technical breakthroughs and early experiments on computers in scientific environment, the first commercial videogames emerged in the early 1970s. *Pong* is considered by most game historians to be the first successful game title. It was released by *Atari* in 1972 on coin operated arcade machines.

In the mid-1970s, arcade games started to penetrate the household market with consumer machines. This was an important milestone for the industry as the home consoles came with a separation of hardware and software, making it possible to play several games on the same machine. Instead of being programmed into the console, like for coin-operated arcade machines, each game was stored on a cartridge that could be bought separate from the main hardware. To change game users simply switched cartridge in the console and could continue play using the same infrastructure for video and sound. With this separation it also became possible for other companies than the console manufacturers to provide the software, triggering the establishment of independent game developers.

However, the most important enabler for a global growth of demand and supply probably came with the personal computer, in particular when it became more common in consumer segments. It meant both that the market for games broadened enormously with several new customer groups, and that anybody with programming skills could attempt to make games. Gaming became a wide-spread pastime, primarily among young men. Another important milestone was the introduction of rewritable software storage in the early 1980s. With a home computer, magnetic tapes and discs could be used to share games with friends and at informal copy-parties. The number of people playing grew dramatically, but the number of titles played by each consumer even more so. It became possible to own hundreds of games, which was not realistic when people were limited to the consoles. New games emerged making game play appealing for more or less everyone.

[91] For example: Kline et al. (2003), Sandqvist (2010), and Wolf (2015).
[92] Snead (2014).

8.3 Nordic Video Games

With the separation of hardware and software, rewritable software storage and an early spread of home computers in the late 1980s and early 1990s, came attempts of creating video games in the Nordic region. It was in this environment that the first significant game companies were established, e.g., *Atod, ITE Media* (Denmark), *Funcom* (Norway) and *Digital Illusions*. Some of these managed to achieve longer term survival, in contrast to nearly all the earlier firms who managed to make a small number of games at best. An industry slowly emerged as a handful of additional firms got established each year.

Given today's success of games such as *Minecraft*, *Battlefield, Wordfeud* (Norway), *Ground Control, Candy Crush Saga, Angry Birds* (Finland) and *Clash of Clans* (Finland) it may be surprising to hear that the Nordic contries were late at entering the global game industry. Except for a few small companies active in the 1980s (mostly discontinued), the first major releases came almost three decades after the pioneering efforts in USA and Japan by console and arcade game produces, e.g., *Atari*, *Magnavox*, *Activision*, *Taito*, and *Namco*. Instead, Scandinavian and Finnish enthusiast in digital entertainment were mostly active in informal groups, producing hobby multi-media software "demos" that were advanced for that time but did not allow user interaction.

In the early 1990s the Nordic studios mostly created games for home computers, such as the *Amiga*, rather than for consoles. This gradually changed, possibly because the release of globally successful games, and increasing publisher attention, made a wider range of platforms reachable. During year 2000 the first Scandinavian megahits were released, *Hitman: Codename 47* (*IO Interactive*, Denmark) and *Europa Universalis* (*Paradox Interactive*, Sweden). These are believed to have had a big impact, inspiring young people to try to become game developers as they learned that international success was possible with a global mindset.[93] In 2002, the Swedish company DICE launched *Battlefront 1942*, which was their first big hit, although it was preceded by a number of popular pinball and racing games. These games had a number of sequels and the game *Hitman* was also made into a Hollywood movie. These megahits were probably instrumental for the Nordic game industry, as they inspired nascent studios and latent entrepreneurs. Many wanted to make AAA games (those having the largest development budgets and most promotion) and they were supported by foreign investments and acquisitions. This international involvement also helped making the industry more professional.

Sweden and Denmark were initially the leading Nordic countries in game production, even though Denmark has not been able to sustain its early foothold in the AAA segment. Overall growth has therefore also been much slower than in Sweden, but some praised artistic games like *Limbo* (*Playdead*) have helped Denmark to stay significant on the international scene.

The Norwegian industry is still very small, with revenues about 1/20 of Sweden's, but it has generated some internationally appreciated games, like *Age of Conan* (*Funcom*), kickstarter-backed *Among the Sleep* (*Krillbite*) and *Fun Run* (*Dirtybit*).[94]

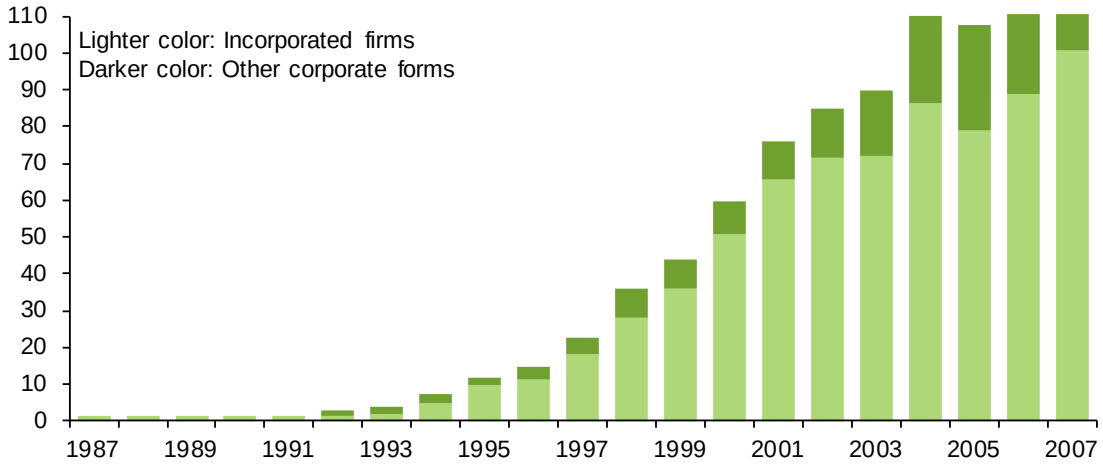
[93] Konzack (2015).
[94] Virke Produsentföreningen (2015).

While the Swedish game development industry has received a lot of attention, it is still rather small, in absolute size, as compared to the main countries. Its workforce is about one tenth of that in the UK industry, and about a quarter of that of the American publisher *Electronic Arts* alone. And while the top Swedish firms like DICE sells tens of millions of copies of the *Battlefield* series, *Nintendo* has sold 4 billion games to date.[95] Still there is little doubt that Sweden has an exceptional video game industry. Not only is it large relative to the country's size, it is also internationally admired for its creativeness and high-quality.[96] In many ways, the persistent international success of Swedish video games mirrors the country's music industry: Sweden doesn't have the largest number of artists, but it has many of the great ones.

Before the formation of an industry in Sweden, it appears that some of the few Swedes who actually were game programmers got employed in British companies, where industry formation happened about half a decade earlier.[97] The early development in Sweden follows the same patters as in the rest of the Nordics with independent demo groups like *the Silents* forming game development companies, in this case *Digital Illusions Creative Entertainment*, or DICE.

In 1997–1998, things started to gain momentum. A much larger number of firms were launched at this time (Figure 8.1). For instance, what would become well-known game companies like *Avalanche Studios*, *Starbreeze*, and *Aniware*. In 2000–2001, nearly 20 companies were started in the Swedish industry per year, doubling the number of game developers. However, from 2004 until about 2007, the development was less dramatic with growth rates comparable to similar industries like software, film and video.

Figure 8.1: The estimated number of Swedish video game companies



Source: Sandqvist (2010).

Generally the industry was not yet profitable.[98] In 2008–2009, the industry was affected by the financial crisis.[99] The demand for games decreased, especially in the US, and because of the

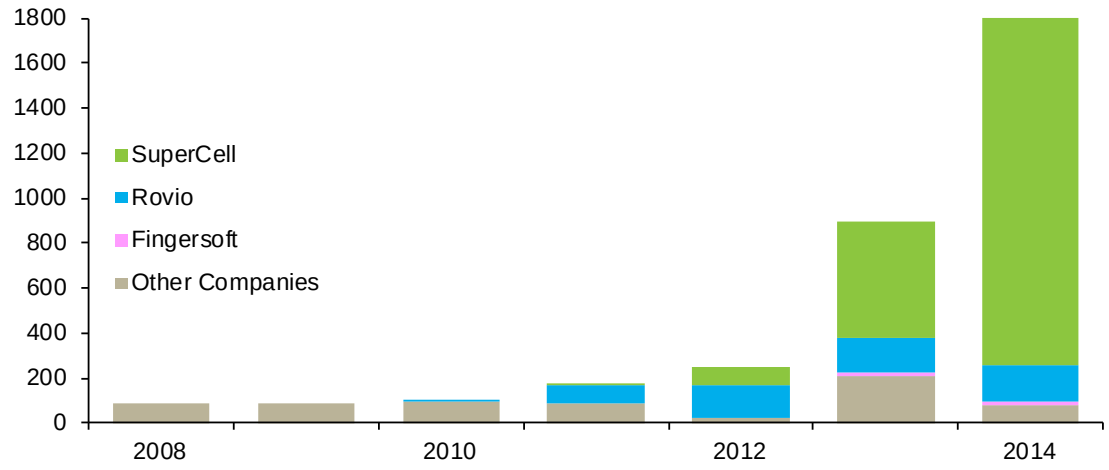
[95] Sweden.se (2014).
[96] Alexander (2014) and Arnroth (2014).
[97] Sandqvist (2010).
[98] Sandqvist (2010).
[99] Leijonhufvud (2009).

falling financial markets several development projects were unable to maintain sufficient funding. The turnover, number of firms and number of employees decreased somewhat. Among others, the renowned developer *Grin* went bankrupt. Since 2010 the industry has been growing.

Among the Nordic countries it is primarily Finland that has a development that is similar to Sweden's. *Supreme Snowboarding* (*Housemarque*), released in the end of the 1990s was the first Finnish game reaching international best-selling level. In early 2000s, Finnish companies had some success in PC and console games. The largest game-like online success was *Habbo Hotel* by *Sulake*, a social network and online community for teenagers opened in 2001. Another big hit was the *Max Payne* shooter game series (*Remedy Entertainment*), winning multiple game of the year awards and being released as a movie in 2008.[100]

But the Finnish gaming industry really started to take off with Rovio's *Angry Birds* launched in 2009. However, the origin of mobile games in Finland was probably Nokia who in 1997 included *Snake*, a simple mobile game, to its phones. Then, around year 2000, Nokia started to develop *N-Gage* which was a mix of a phone and a handheld gaming device. Despite its support for games from e.g., *HouseMarque* and *Remedy*, *Nokia* was arguably more focused on international companies such as *Activision* (e.g., *Tony Hawk's Pro Skater*) than local developers for the *N-Gage*. The device nevertheless aroused local developers' interest in mobile gaming and several experiments were conducted in the early 2000s both in relation to *N-Gage* and the then heatedly debated WAP protocol. *N-Gage* was released in 2003 and updated in 2004; with only two million sold devices, *N-Gage* was a commercial failure and it was discontinued in 2005. It nevertheless managed to plant an important seed in Finland.

Figure 8.2: Turnover in the Finnish video game industry



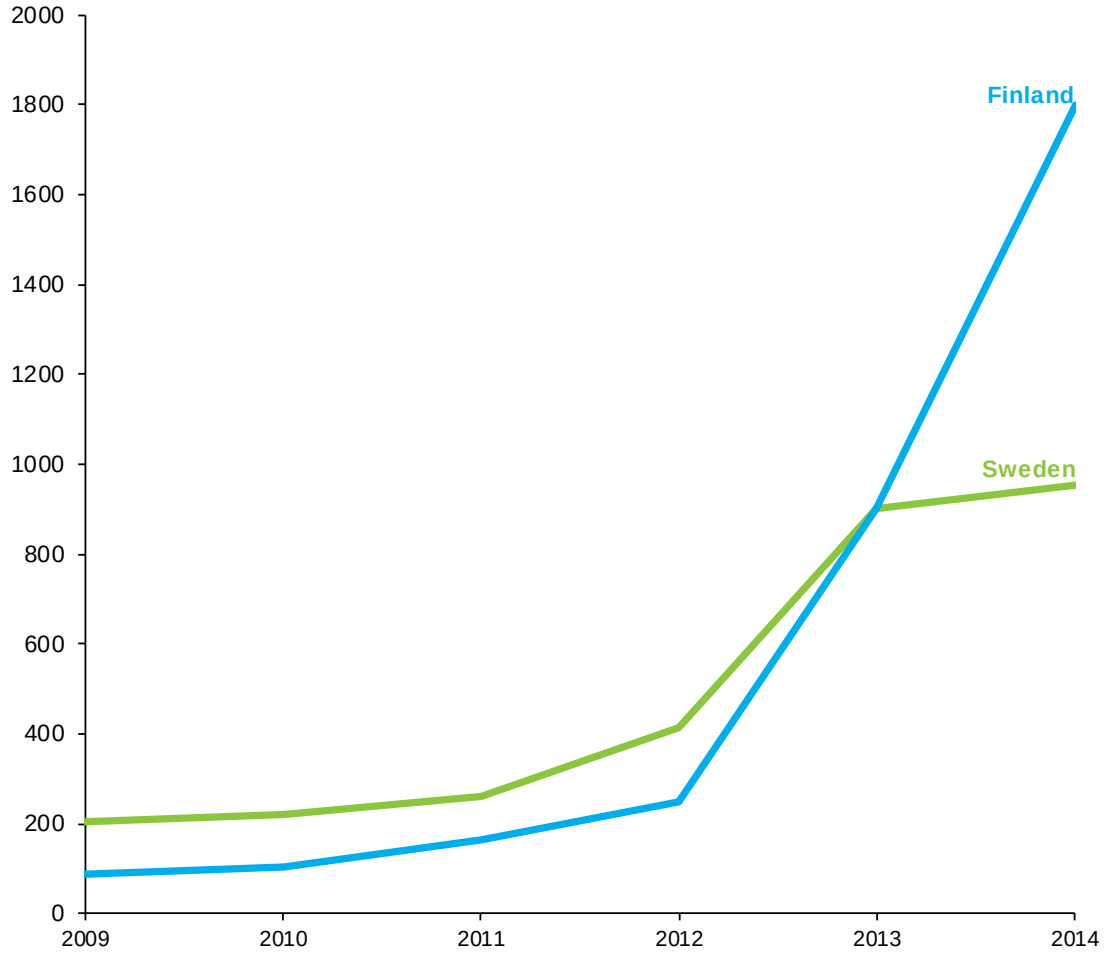
Source: Neogames.

Lately, the Finnish fame revenues have grown enormously, particularly because of the best-selling mobile games from *Supercell* and *Rovio* which account for approximately 95% of the turnover (Figure 8.2). These giants are among the global leaders in the mobile sector, but there are also numerous other Finnish developers, like *Fingersoft* and *Frogmind* that are much

[100] Mäyrä (2015).

smaller but make many interesting games. Most Finnish firms are young; 69% of the 260 companies active in the end of 2014 were less than five years old.[101] During these five years the number of employees in the sector has doubled and the turnover increased with almost 18,000%. Consequently Finland has caught up with Sweden and now has higher game revenues (Figure 8.3).

Figure 8.3: Turnover of video game companies in Finland and Sweden (millions of Euro)



Source: Neogames for Finland. Mojang's turnover 2014 estimated by previous year's market share. When discussing Finland's catch-up with Sweden, it should be noted that the games of publisher-owned companies like Massive and DICE has much larger actual sales figures than what is indicated in annual reports. For example, Dataspelsbranschen (2015) estimates the sales of Battlefield 3 (DICE) to be 11 times higher than the studios total reported turnover of about 85 million euro.

Despite the fast growth of the sector, the gaming industry remains to be a minor component in the Finnish national economy. Currently, there are about 260 Finnish game companies employing 2500 persons.[102]

[101] Tekes (2015).
[102] According to the industry association *Neogames*: http://www.neogames.fi/en/

Tekes has played an important role in supporting the gaming industry through funding and providing networking opportunities. Since 1995, *Tekes* has funded the games industry by some €60 million. The volume of the currently running *Tekes* programme *Skene* is roughly €70 million, of which €30 million is directly funded by *Tekes*.[103] The public infrastructure includes also more than 20 educational institutions that provide education in game development.

The Nordic game studios have received much positive attention for their high game quality.[104] A number of world-class games are made in the region and it more or less dominates the specific subsector of mobile games. Five of the ten most downloaded mobile games in 2014 were from Nordic game companies and four of the seven richest game millionaires made their fortunes from them.[105] At the time of writing, Norway, Finland, and Sweden have the highest average user scores on PC games reviewed at metacritic.com in 2015 and 2014 (compared to the renowned video game nations USA, Japan, Canada, France, Germany, and Australia).

8.4 Finnish and Swedish success in mobile gaming apps

Since video games are not well-captured in the current industrial classifications,[106] global comparisons of national gaming industries are difficult. For the purposes of this report, Bryan Pon, at the University of California, provided a Nordic outlook on the global mobile gaming scene.

Because complete industry data is not available, Pon used published rankings from the major app stores to identify successful game developers worldwide. The dataset included game developers for both the *Apple iOS* (including *iPhone* and *iPad*) and *Google Android* platforms, across the world's ten highest revenue national app markets – the United States, Japan, China, South Korea, the United Kingdom, Germany, Russia, France, Canada, and Australia – as well as the Finnish and Swedish national markets.

From each national market, Bryan extracted the top 400 highest-grossing apps and the top 400 most-downloaded apps on 10 July 2015. He then cross-referenced this extensive data against a list of Finnish and Swedish gaming companies, finding 30 Finnish and 28 Swedish developers that had made it into the top ranks. While these numbers obviously don't include all the Finnish and Swedish companies making mobile games, they likely include the vast majority those who have achieved commercial success, as any app that has not broken into the top 400 in at least one market is probably not earning significant revenue. This is due in part to the "winner-take-most" nature of the app economy, where the most popular apps earn the vast majority of the revenue, followed by a long tail that earns very little. For example, one analysis of this "power law" curve estimated that the highest ranked app earns 150-times more than the 200-ranked

[103] http://www.tekes.fi/en/programmes-and-services/tekes-programmes/skene/services/
[104] Clarysse (2014), Reed (2015). and Wolf (2015).
[105] Ewait (2015) and Reed (2015).
[106] Class 5821, *publishing of computer games*, exists, but even "pure play" electronic gaming companies fall under half a dozen other classes, such as Class 6201, *computer programming activities*.

app.[107] Therefore the data provide a good proxy of a nation's commercial success in mobile gaming, even if they do not capture the full size of the underlying industry.

To put these results regarding Finland and Sweden into context, Bryan compares these results to his earlier work concerning 23 countries, and makes the following observations:

- Both Finland and Sweden have a high per-capita count of top mobile gaming companies. While the absolute numbers seem low, Finland ranked third – behind only Hong Kong and South Korea – and Sweden eighth in terms of population density of successful studios.
- Both countries show a strong international or "export-oriented" capability. Another way that Finnish and Swedish gaming firms outperform the average is in their ability to develop games with international appeal. The average Swedish company entered 4.5 national markets, while the average Finnish company entered 4.0 markets. In this respect, Sweden ranked the first and Finland the second among the compared countries.
- Finland has a larger, but less diverse, footprint in the app markets. The sum of a company's apps, on both platforms, in each of the national stores, comprises its market presence or "footprint." If these footprints are aggregated at national level, Finland's footprint is larger than Sweden's (288 vs 193), but the vast majority of Finland's success is due to one company, Rovio, and its Angry Birds franchise. Sweden's total footprint is more evenly distributed among its developers, and therefore it is more resilient to any one company's success or failure.
- Both countries show the ability to enter markets in all regions internationally. Finland and Sweden are both well-represented in the top app markets across North America, Europe, and East Asia. While their presence is lower in East Asia compared to other regions, all foreign developers have less of a presence there.
- Finland appears to have stronger domestic demand compared to Sweden. 37% of Finnish but only 18% Swedish companies were "domestic-only" (not present in other national markets). The observation may be interpreted in several ways. Swedes may simply have more international orientation. Or Finns may have unique gaming preferences that do not extent to international markets. Or perhaps the Finnish market is simply less competitive, which enables globally uncompetitive games to enter the top ranks.

8.5 Concluding remarks

The success of the Nordic game industry is impressive. Games from *King*, *Mojang*, *Supercell*, and *Rovio* are at the very top on the mobile side, followed by smaller developers like *Toca Boca*, *Mediocre*, *Krillbite*, *Dirtybit*, *Playdead*, and others who acquire many of the positions on the prestigious top 100 list for game downloads.

Cross country collaboration occurs. For instance, *Rovio* decided to develop *Angry Birds 2* in its Stockholm studio, rather than back in Finland. It will be interesting to see the coming strides of competition and collaboration between these two nations and what dynamics that will cause.

When it comes to dominance in the Nordic game industry, it was initially Sweden that was about twice the size of Finland for many years in terms of game revenues. Nevertheless, Finland managed to catch up and is, at the moment, possibly even bigger than Sweden. But it should be

[107] Garg and Telang (2013).

noted that Sweden has a richer long term video game history with many successful titles on the PC and console market, leading to a relatively large number of renowned AAA studios in the country. As a result, the Swedish industry is less concentrated than the Finnish, which is heavily dominated by only two giants in the mobile sector.

9 The Swedish game development sector

*Kent **Thorén***

While the history of Nordic game production was summarized in the previous chapter, we here deepen the investigation of the region's video game success, with particular attention paid to Sweden. The research is based on interviews with journalists, industry experts, educators and leaders at a broad selection of game development firms. This primary data has been supplemented and cross-examined using industry reports, databases and other sources of information. To deeply understand the mechanics of development in the industry, it is nevertheless first necessary to complement the picture with some information about its current state.

9.1 The Current Video Game Industry

The last two decades, a number of major changes have reshaped the circumstances for both video game creation and consumption. When it comes to game creation, at least two of these changes signal that the industry is maturing.[108] First, the emergence of firms specialized at certain aspects of game development, such as middleware, graphics engines, audio, design of 3D structures etc., has occurred as technical standards has made it possible to divide game development in tasks that can be performed independently from one another. Such outsourcing allows game development studios to increase development speed while also balancing costs and risks better. In some cases the specialization is almost extreme, like the American company SpeedTree that only sells digital trees and plants. Already in 2008, 86% of studios used outsourcing for some aspects of game development.[109] (The least mature sector of the industry appears to be the production of mobile games, which tend use outsourcing to a rather small extent.) A second sign of maturity is the increasing availability of production tools. For example the game engine Unity, developed by Unity Technologies (Denmark) was released as free to use in October 2009, substantially lowering the threshold for small "indie" firms that want to develop full quality games.

Another change having dramatic impact on the industry was the Internet. It gave game developers new ways of distribution and new channels for customer interaction. In the console sector, digital distribution became a cheaper way to provide customers with software and facilitated the forming of more substantial customer relationships. It also enabled downloadable content, so that games could be patched or expanded directly from the device. In combination with micro transactions, downloadable content allowed for new business models, where small repeated revenues could be added to the upfront payment from purchase of games. In the

[108] Christensen et al. (2004)
[109] Game Developer Research (2009)

extreme form, the game itself can be for free and all the revenues come from players making in-game purchases. This is currently the dominating business model for mobile games (sometimes combined with revenues from advertising). PC games enjoy additional benefits of the all-digital distribution possibilities. Open online distribution platforms, like Steam (available for third parties since 2005), meant both a reduction in piracy and the chance to profitably offer customers smaller and cheaper games by bypassing traditional publishers and retailers. Digital distribution has thus led to the PC sector unexpectedly coming back after facing gloomy prospects in the beginning of the 21st century.[110]

Trough the Internet game experience could be enhanced by player-to-player interaction and the new game mode of remote multiplay. This was incorporated in many types of games, but also led to new games with profitable business models. The most illustrative example is perhaps massive online games like World-of-Warcraft that previously only existed as text-games called multi-user dungeons. In the action and strategy genres, remote multiplay quickly became popular and thus a standard feature in most games. Around such games, a competition culture has emerged with professional and amateur players engaging in huge “e-sport” tournaments streamed live to over 130 million viewers.[111]

With the Internet came social media which brought video games into the life of mainstream consumers. Video games have become a normal pastime for the majority of people of both gender and all ages. Games are among the most successful applications on Facebook, which some attributes to gameplay as being a social human activity.[112] People want to have fun with their friends and on Facebook they can play anytime with any friend online. Moreover, social media also supports sharing, which can aid the diffusion of games. Game recommendations and critique often spread by twitter and Facebook, sometimes having an enormous impact on the game sales. Being noticed in social media by Yogscast or an influential trendsetter like Felix Kjellberg aka “PewDiePie” with 40 million followers on Youtube, is extremely valuable for small games with limited marketing budgets. Game developers often try to exploit social media as a means of achieving a viral spread of their game releases. Incorporating incentives for sharing in the games, pre-launching them with Youtube videos and being active in communities and other social media is common marketing practice today.

But perhaps the most dramatic change was the breakthrough of smartphones starting with the iPhone in 2007. This opened up a new technical platform for video games for the first time since the PC. However, the appmarket innovation is probably of even greater importance, as it practically eliminated key entry barriers on the supply side. The mobility of games made it possible to play in new contexts, activated new audiences, and prompted the emergence of a new genre of games aimed at filling “micro sparetime” rather than providing an immersive and interactive multimedia experience.

The new types of games occurring in response to these changes have led to massive supply-side growth. But since they brought new audiences to the market they have also caused demand to

[110] Cf. Dymek & Rehn, 2003)
[111] Superdata (2015)
[112] Kirkpatrick (2011)

grow. Often, early-moving developers have been able to capture opportunities for dramatic profits by being among the first to offer quality games to these new audiences. For instance the American developer Zynga successfully brought its games to Facebook early making more than 500 m$ in 2010,[113] while the Norwegian company Bertheussen (Wordfeud) and Swedish developer King (Candy Crush Saga) have built strong profitable positions through rather early entry on the mobile platform.

Technical entry barriers are now lower than ever.[114] But despite the large inflow of new entrants in the industry there is considerable concentration, where a small number of firms manage to launch series of popular games and hire more and more people while the majority of firms remain small. Industry complexity has also increased as numerous specialist actors have found positions in the value chain, as described above. Some of these are development studios that have narrowed their scope to assume specialist consulting roles. Other studios have broadened their activities for instance by entering the publishing business as a way to further exploit their contacts and digital channels (for example Paradox Interactive and Coffee Stain Studios). The old categorization of hardware-software-publisher can still broadly describe the value chain, but has become less applicable for labeling individual firms.

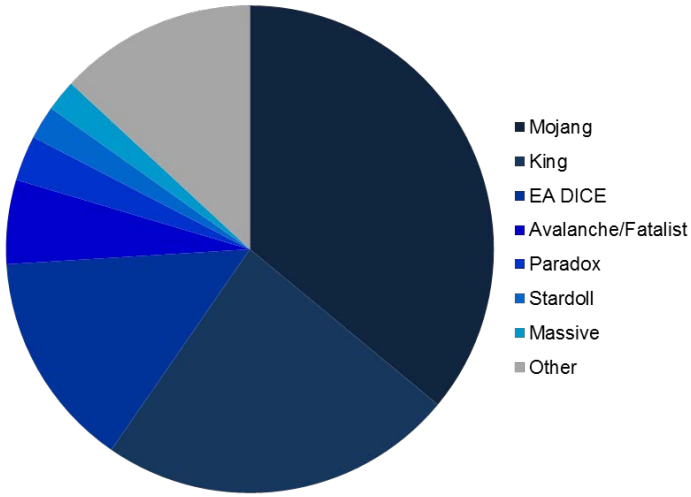
9.2 Sweden's performance and position

Today, video game development is the fastest growing industry in Sweden, growing 522% in revenues from 2010 to 2013.[115] According to interviewed industry experts, similar growth rates are expected for 2014 and 2015. For instance, Paradox Interactive's revenues in Mars 2015 amounted to 160 million Swedish kronor, or 68% of the whole fiscal year 2013. In 2014 the industry had aggregated revenues of 955 million euro and employed 3100 people.[116] The revenues do not include the commissions to sales channels (30% on Appstore, Google Play, and Steam). They are also probably severely underestimated because some of the larger firms have activities in many countries and the sales of Swedish games may not all be reported through the Swedish business unit. The industry also expands in terms of workforce, but there is a significant unevenness in gender (only 20% women), which a number of recent joint efforts aim to address.

Regarding the industry structure, it is clear that even though some 20-30 firms are started every year, a handful of firms completely dominate the industry. In fact, the three largest firms represent more than 70% of the total industry turnover, see illustration below.

[113] Boyd Meyers (2010)
[114] Wolf (2015)
[115] See Retz (2014), Dataspelsbranschen (2014) and Sweden.se (2014)
[116] Based on Dataspelsbranschen (2015). Mojang's number not being available at the time of publication, it was estimated in this study that they maintained its 2013 market share of 31,6%. Dataspelsbranschen's estimate holds the turnover for Mojang as constant.

Figure 9.1: Revenue share distribution among Swedish game developers 2013



This skewness raises questions: Is this an exceptionally fast growing industry, or is it a rather normal industry with a few outliers distorting the picture?[117] Exploring industry data from 2010 to 2013, excluding top and bottom outliers, shows that the 'typical'[118] firm has 16 employees, 16,5 million SEK in revenues and grows 47% per year. In addition, most of the firms are profitable, even the smaller ones. It is hence safe to say that this industry performs remarkably well.

In international comparison, there is a consensus among the respondents that Sweden is outstanding when it comes to video games. While it is difficult to quantify and validate this assertion, it is has also been reflected in various media.[119] Some even use refer to the industry development as a "Swedish game wonder" (e.g. Danielsson, 2005).

Estimating the global video game market through a meta-study of reports from five different international industry research organizations (Statista, Gartner, PWC, SuperData and Video Game Sales Wiki) suggests an approximate market size of around 100 billion dollars. Sweden's share can be estimated to around 1,5% in 2014. When it comes to the global position it is therefore more correct to argue that Sweden, as a producer and exporter of computer games, is prominent among the world's smaller nations. However, looking at the growth distribution reveals something very interesting. After the latest financial crisis in 2008 to 2013 the collective turnover of Swedish developers grew in average 64% per year. The corresponding figure for global revenues on the other hand is merely 6%. This means that the Swedish industry grows more than 10 times faster than the global! Even in the worst year 2009, Sweden's output grew with 22%.

Internationally, Sweden appears to hold a stronger position than its Scandinavian neighbors. In addition to successful mobile games and acclaimed indie productions, there are also a handful of famous AAA developers. The latter generate a lot of visibility since their games are promoted

[117] Cf. Sandqvist (2010)
[118] Excluding firms with less than 3 employees and 1 msek in revenues.
[119] For example Alexander (2014), Arnroth (2013), Clarysse (2014), Deppert (2013), Reed (2015)

by large publishers such as EA, Sony and Microsoft and backed by substantial marketing campaigns. Currently, a number of really strong titles are under release or final development including Star Wars Battlefront (DICE), Magicka 2 (Paradox Interactive), Mirrors Edge Catalyst (DICE), Need for Speed – Rivals (Ghost), Just Cause 3 (Avalanche), Tom Clancy's The Division (Massive), Mad Max (Avalanche), Wolfenstein: The New Order (Machine Games), Minecraft on Hololens, and Warhammer Vermintid (FatShark).

Sweden's position has been corroborated by interviewed industry experts, who often compare Sweden and to some extent Finland with international game development "hubs" in USA, Korea, Japan, and regions in Canada like Quebec. In addition, in 2015 Sweden was elected the leading game developing country in Europe in for the second year in a row, in surveys connected to the European Game Developers Conference.[120]

The structure of the Swedish video game industry is somewhat different from the major nations like USA, Canada and Japan, where most of the largest developers (in turnover) also are publishers and/or hardware providers (Newzoo 2015). Perhaps there would be larger similarity between countries if these global giants active in multiple business areas were disregarded?

9.3 Drivers of success in the video game industry

Given that Sweden's game developers appear to stand out in international comparison, it is relevant to examine the roots of their success. Ohame argues that an industry's key success factors (KSF) determine the competitiveness of firms vis-a-vis each other.[121] The KSF are those few things that enable a company to win over competitors if executed really well, even if the performance in other less crucial areas is mediocre. So if Swedish firms perform well compared to firms in other countries, they should be stronger at such KSF. If these KSF are identified, and relatable to circumstances forming a differentiated technical innovation system for game production in Sweden, it explains why Sweden has become a world class video game exporter. The search for a common denominator of success that is applicable to all the competitors, have a decisive relevance and is possible for firms to influence, led to the identification of two KSF. To have success with video games it is necessary to i) make really good games *and* ii) reach through the market noise.

KSF 1: Producing really good games

> *"The success of the industry … depend on the successes of individual companies, and those successes will depend on the creation of video games that consumers want to play."*
> (Wolf, 2015, p5)

But what makes a game good? One reason it may be difficult to specify success factors for games, according to Tobias Andersson CEO at Turborilla, producer of Mad Skills Motocross 2, is that they tend to be successful for reasons that vary between the titles.[122] Each game has its own unique combination of attributes that influence its fate. However, Andersson maintains that

[120] Dataspelsbranschen (2015)
[121] Ohame (1982)
[122] Andersson (2014)

the critical issue is the game experience, to provide the player with value and joy. When discussing this issue with respondents, a few aspects tend to come up especially often. First, the game must provide a balanced challenge level. If games are too easy they become boring. On the other hand video game players tend to be impatient, so games need to be interesting rather quickly. The worn-out cliché that games should be easy to learn but difficult to master still holds true.

The second aspect regards how well the game presents the challenge as a series of interesting choices and how well it enables the player to tightly control their activities in the pursuit of those choices. Developers and critics often refer to "gameplay", a concept that appears to be broad and hard-to-define, when trying to express the quality of experience with a game. One aspect of game play is the game design. This refers to the specification of systems for set-up, game mechanics, level architecture, design of objects and interactions etc. These form governing structures that frame game goals and objectives and the means available for the player and his or her enemies to reach them. Game design also includes specifying the user interface and controls, as well as the "physical" and visual effects connected to player actions, like making a hole in a certain surface by shooting at it with a weapon. A credible sense of cause and effect is essential to gameplay and players get frustrated when it is lacking.[123] But gameplay is broader than design; it only occurs when a player actually engages in the systems of a game world.[124] Optimally the interaction between user and game is flawless and smooth, where game design manifests the activities of the user in a nice flow. Game design also needs to avoid spoiling the suspension of disbelief created by the story and audiovisuals, which may happen because of inconsistent application of game world rules or logical conflicts between scenarios. Experience shows that gameplay is more important than audiovisuals, as proven for instance by the enormously popular but awful-looking sandbox game Minecraft.

Under sufficient synergy between the motivator, game design, challenge levels, audiovisual aesthetics, and a compelling story or adventure, players may form an emotional bond to the game. Examples of feelings targeted by game designers are thrill and sympathy. These are often utilized in combination, like in the forthcoming title Hunger by Tarsier Studios. The plot of Hunger is to help a little girl named Six escape a labyrinth full of monsters. Artistic and original audiovisuals enhance the impression of her vulnerability and the threatening world is consistently portrayed from small person's point of view. It's easy to become engaged in helping Six and the interesting problems arising from clever level design make the game promising.

If the customer has an experience that is satisfying enough to create delight, which is a positive emotional reaction, he or she may aid market noise penetration by recommending it to other users. This is where the two KSF are connected; a really good game that delights customers can benefit from word-of-mouth support, which under the right circumstances can cause a much desired viral spread of a game.

[123] Streitfeld (2013)
[124] Björk et al. (2005)

But it is hard to get a word-of-mouth "buzz" around a game that isn't innovative in some way, so creativity also needs to be included as an aspect of game quality. Gamers love when developers come up with something novel and unique, and they love telling their peers about it. So game quality is linked to creativity, it helps games to exceed expectations and excite customers. Extraordinary games benefit from good audiovisuals but do not rely on them. Instead the value of game play and emotional affinity is so high that they can compensate for technical shortcomings under the right circumstances, if the game is unique.

KSF 2: Reaching through the market noise

In the current market, where industry insiders claim that 500 games are launched per day on iOS alone, it is even more unrealistic to expect great sales from an underdeveloped game.[125] On the other hand, a good game is not sufficient; a criterion for volume sales is that millions of consumers become aware of it. Unfortunately, the amount of market "noise" appears to be higher than ever before.

So what options do developers have to get players' attention? A number of different non-exclusive approaches have been observed in the industry. One group of approaches aims at *penetrating* the noise, either by enormous marketing spending and/or by trying to stimulate positive word-of-mouth spreading in social media. The former option is feasible primarily for very large publishers such as Ubisoft and Electronic Arts. They promote their premium titles with massive release campaigns comparable to those before a major movie premiere. Market campaigns consist of elaborate trailers placed in purchased spots online and on TV, big billboard campaign, in-store promotion at retailers, pre-ordering campaigns, and much more. The latter option, however, trying to get the user community engaged in promoting the game, is what is available for smaller studios. Pre-launch trailers can be used to create awareness around a game and evaluate customers' interest in it. For instance, after spending two weeks on doing a trailer for the *Goat Simulator* idea, Coffee Stain released it on Youtube where it quickly got several millions of views. This overwhelming response made the studio feel that they more or less "had" to finish the game. Once a game is released it is desirable to get users engaged in seeing, discussing, trying and promoting it. Many creative tricks have been used. When launching *Mirror's Edge*, Electronic Arts put up wanted posters for the main character "Faith" at university campuses in an attempt to create attention and engage the public, as a part of the viral marketing strategy. Given the scalable nature of social media reach, however, some trend setters have a disproportional influence and reach enormous audiences. If someone like Markus "Notch" Persson, founder of Minecraft tweet about a game to his over 2 million followers, or PewDiePie plays it in a fun Youtube clip, chances for success are extremely good.

Another way to draw attention to a title is to have it praised by established experts. Favorable reviews are valuable and getting many good reviews can lead to a high ranking at important sites like Metacritic. Many gamers check such reviews before buying games so it is important, especially for AAA game sales.[126] When good reviews appear in mainstream media, it may lead to spontaneous downloads also by customers outside the games normal fan base. Developers,

[125] Graft (2015)
[126] Arthursson (2015)

especially start-ups, also often submit their games to competitions and awards, like the Swedish Game Awards. Winning awards gives the developer attention and credibility. However, game developers' benefit from awards primarily by building a case for publishers or venture capitalists, rather than to increase sales.

In parallel to penetrating the market noise, there are also a number of approaches by which developers can try to *bypass* it. One way to do this is by establishing channels for direct communication with the players. Once a studio has launched an appreciated game, they can start stimulating a fan base and engage in interaction with it. As these fans already like the game in question, it is probable that many of them will be interested in a similar but better game in the future. This way of "farming" a community of users and then sell them a succession of games over time is perhaps the most common strategy for established developers including King, Starbreeze, Paradox Interactive and many others. If sales are good enough, the margin might allow for diversification projects, but often developers prefer to stay rather focused trying to improve the size of the core audience and use cross-selling to maximize the yield. While it is necessary to already have an audience to pursue this strategy, it is rather inexpensive and mitigates risks when launching sequels. There are other advantages too. Paradox Interactive actively cultivates their game communities, let users create their own modifications of some games and use forums to create a platform for listening to them. CEO Fredrik Wester argues that this helps the studio to stay close to customers and create games with high value. In this manner, interaction platforms can be useful for collecting suggestions and testing new ideas.

Another way to reach through the noise is provided by digital distribution, which is the dominating way to sell games today. All the digital channels (Steam, GamersGate), mobile marketplaces (Google Play and Apple AppStore) and console platforms (PS4, Xbox One, etc.) have solutions to sell both games and supplementary content for download. However, because there are thousands of games available at any given time, the chance that buyers will pick a particular game at random is very small. Distributers therefore "feature" certain games, which mean that they get a premium highly visible placement either on the first page or at the top in some category. Some time after launch it is also common that games have temporary price reductions, which can give them attractive spots on in sales or bargain sections. With some luck, games might also get picked for the distributers' own campaigns, like Steam's Christmas Sale. The volume curves for mobile game downloads show very clear peaks when games are featured, updated, and on sale. To seize, and hold for as long as possible, favorable placements is thus extremely valuable and the difference in sales volume compared to a regular placement is enormous.

9.4 Innovation system circumstances that influence KSF

A way to understand the development in the industry is to view it as an evolving technological innovation system (TIS). This is appropriate for the video game sector since both product development and most of major changes affecting the industry concern technical progress. The performance of a TIS, in turn, depends on how well its key functions are carried out by the evolving set of processes in the system. Bergek et al. proposes that the functional patterns of TIS can be described by seven different components, or functions, synthesized from a large

number of reviewed innovation frameworks and system approaches.[127] The functions that are most relevant for the developments in the Swedish video game industry appear to be: market formation, legitimation, knowledge development and diffusion, and resource mobilization.

Market formation

Market formation refers to the process of going from the very first nascent market to a mature mass market. For the video game industry, in Sweden and globally, the steady increase in demand is most likely an important factor for the massive growth. This demand in turn is fueled driven by the macro trend of steadily increasing standard of living in nearly all countries, allowing more and more people to own suitable hardware and get connected to the Internet.

All the different platforms have mature markets today, despite emerging at different times and in different pace. For example, the early Swedish developers could benefit from an existing game demand in the PC segment, but then had a breakthrough into the console game mass market after the introduction of PlayStation and Xbox. The market formation for mobile games, on the other hand, was quick with Nordic developers taking lead positions early on.

One reason for Nordic developers' success in the global game market may ironically be their small home markets. In countries with a small domestic demand entrepreneurs in general have more incentive to think about worldwide export early on. Since the Swedish market only represents 0,4% of the global video game sales,[128] it has been natural for start-ups to take the born-global approach.[129] This is reflected in clear designs that tend to feature universally appealing themes and can be accepted by people in most geographies.[130] It has also been suggested that the small home markets make Nordic firms more likely to focus on growth and scalability than what is common in larger countries.[131] Benefiting from a global demand, with online delivery services making it easy to reach out, may have been fruitful for producing big hits in the Nordic region.[132]

Even though the demand is global it does not mean that the local market is unimportant. The Nordic markets, while small, are populated by knowledgeable and demanding users, providing an excellent test-bed and source of early feedback for development projects.[133] This can benefit the local TIS, helping firms to produce superior products and thereby grow faster than the world average. In the video game industry, it therefore appears that Swedish firms benefit from the local market, without being impaired by its smallness.

[127] Bergek et al. (2008)
[128] Based on Newzoo (2014)
[129] Sandqvist (2010)
[130] Wolf (2015)
[131] Clarysse (2014)
[132] See Clarrysse (2014), Reed (2015), Wolf (2015)
[133] Arnroth (2013)

Legitimation

Legitimation is a process where a TIS obtains social acceptance and institutional compliance, thereby overcoming its liability of newness.[134] In general, Sweden has a long tradition of success in IT and as a subsector of the IT industry video games production has been easy to comprehend and accept as a viable business activity. Early successes in the 90s drew attention to the pioneering firms that became seen as attractive employers and entrepreneurial role models. Culturally, Swedes also appear to have been less skeptical compared to the Finns, who to some extent viewed video games as unserious or inappropriate.[135] Game development as a profession is not at all controversial today.

When it comes to social acceptance, it can be concluded that video games are now played by all kinds of people and has become a mainstream pastime. For example, a non-traditional group of players, women 25-55 with kids, are the core audience for King's mobile games.[136] Consumers hence seem to be fully accepting video games as a product, but there is still some debate regarding two issues. The first is the striking gender inequality in games, both in regards to games still being predominantly designed for men and also in regards to how women are portrayed in some games.[137] Female developers also face challenges in how they are regarded and treated in the heavily man-dominated world of game production.[138] This has led to initiatives for increased awareness and improved equality in the industry like Diversi, a VINNOVA backed collaboration between game companies, educational institutions and gaming communities. In fact, the region has received international attention for its pioneering efforts in this area.

The other issue concerns business models for mobile games. The mobile games consumers have quickly become used to being able to play games for free, so having success with a game that has a price for download is difficult. This problem is exacerbated by the dependence on online market place positions for reaching through the noise. If a game cost money, it will be all but impossible to get feature on some top lists. In the spring of 2015 49 of the top 50 downloaded games on iOS was play for free, with Minecraft as the only exception (on place 50). As a result, most developers rely on advertising and in-game purchases to get revenue streams. In-game purchases is slowly getting customer acceptance, but still typically only 5% are willing to pay in games. There have also been controversy concerning in-game purchasing in games for children and it has been misused by developers to make customers buy and pay for much more than they were aware of.[139] Interviewed industry actors, as well as discussions in forums and conferences, indicate that customer trust and well-being is very important for Swedish developers and most use in-game purchases reluctantly and carefully.

When it comes to key stakeholders other than customers, it seems that general legitimacy is achieved enough to get work-force resources and normal supplier collaborations. The main

[134] Bergek, et al. (2008)
[135] Mäyrä (2015)
[136] Byrne (2014)
[137] See for instance Barkeman (2015)
[138] See Mellgren (2015)
[139] The industry's concern about in-app purchasing has been discussed by Rylander (2014)

exception is the capital markets actors, who still are reluctant to engage in video games. It may not only be a matter of legitimacy though, making large profits on games requires finding the rare big hits beforehand, which is exceptionally difficult. Mainstream investors have yet to find a way to pick winners and therefore they tend to avoid the industry altogether.

Knowledge development and diffusion

The development of an appropriate knowledge base is a cornerstone in the emergence of a viable TIS.[140] Video game production requires availability of people skilled in IT as well as good education programs that keep training new talent in sufficient numbers. Sweden has a strong reputation for IT competence since its early IT maturity, consistently ranking in the top of the World Economic Fourm's measures of ability to take advantage of ICT.[141] Many writers refer to the fast diffusion of PCs in Swedish homes and the high level of connectivity as important conditions for the emergence of the first generation of game companies.[142] When it comes to education programs there are a number of post-secondary level YH educations committed to teaching practical skills and knowledge in game development. The most well known are: Future Games (Stockholm), The Game Assembly (Malmö) and Playground Squad (Falun). In addition, Gotland University College, Södertörn University, Blekinge Institute of Technology, and University of Skövde all offer higher education programs focusing on, or related to, game development. Among the major Swedish universities only a few give courses in the area, but they do not offer complete programs. With their education students can get hired, primarily by the larger firms. Some choose to start their own studios instead, and others move to work abroad. According to respondents, the output from these schools now more or less matches the volumes needed by the industry. Previously, there was too much junior talent available, but some educations have been shut down. In most respects, these programs have replaced hobby programmers and the former demo groups as a major source of recruitment. However, it is also common for Swedish developers to attract employees, especially more experienced ones, from abroad (Alexander, 2014).

An area of concern is the long term development of knowledge. There is still rather little academic research conducted on video games and the collaboration between studios and universities is very limited. In some cases there are platforms for collaboration where municipalities, industry actors and universities work together, like the network around Sweden Game Arena in Skövde. The outcome of such collaboration have been very positive and led to dozens of new game companies.

However, a solid knowledge base is necessary, but not sufficient, for performing in the KSF of making really good games. Instead, the competence advantage of Swedish studios seems to be that knowledge is augmented with other competence related factors, primarily work culture, business culture, and design.

[140] Bergek, et al. (2008)
[141] Presenting Sweden
[142] Alexander (2014), Deppert (2013), Sandkvist (2010)

First, regarding work culture; respondents with an international background argue that Nordic people rarely get satisfied with mediocre achievements. Instead, Swedish studios tend to over-deliver.[143] Per Strömbäck, spokesperson for the Swedish Game Industry, speculates that, "maybe it has something to do with Jante or Luther, but Swedish developers tend to not get content with their games easily". They have very high standards for quality and focus on getting things right before release.[144] This may also apply to the personal level, perhaps Swedish workers take more responsibility to do well what they are supposed to rather than just following orders?[145] The Malmö based mobile game studio Mediocre Games is a good illustration of attitudes to quality, as the respondent entrepreneur states that they spend far more time on their projects then the industry in general – because they believe in and want to do only very good games.

Second, one of the most frequently mentioned differentiator compared to North America and Asia is the business culture. Swedish video game production benefits from a corporate culture that emphasizes the achievement of teams rather than star individuals.[146] Sweden in general, and Swedish IT-companies in particular, enjoy flat organizational structures and informal corporate cultures. This is proposed to be conductive to creativity and suitable for the cross-functional work of developing games. Business culture in Sweden tends to be inclusive, open and informal compared to other game developing nations like Canada, Japan and USA.[147] Such environments may be favorable for the discussion of creative ideas, facilitating the invention of innovative game attributes. Making games requires creative artists to collaborate well with specialist programmers and game designers, who may have very different personalities and values. It has been suggested that such collaboration benefits from Sweden's consensus-driven management style and culture with high inter-personal respect.[148] Being a relatively young industry, with many firms driven by founding entrepreneurs, formal management is still a challenge. Unsurprisingly the largest firms, especially those owned by international corporations, have the most mature management and strategy practices.

Third, on the product level, it has been argued that Swedish-made games tend to be unusually player-oriented in design and aesthetics, providing a superior game experience. The Nordic design style that embraces minimalism and emphasizes practicality and usefulness is said to contribute to the appreciation of the video games.[149] Similarly, the Swedish Institute argues that domestic developers are "renowned for their diversity and high quality" and former game designer Prof. Richard Learchand has argued that Swedish games seem to be designed with great concern about the players and the game experience.[150] This diversity and creativity has led to an impressive stream of awards, positive reviews and an admirable reputation. It is not surprising that Swedish games have been compared to other exports for which Scandinavia is

[143] Clarysse (2014)
[144] Alexander (2014)
[145] Clarysse (2014)
[146] Alexander (2014)
[147] See Alexander (2014) and Clarysse (2014)
[148] Deppert (2013)
[149] Clarysse (2014)
[150] Arnroth (2013)

renowned for stylish design and usability, such as art, music and furniture.[151] Perhaps there is a Nordic differentiator in terms of a high interest in and talent for novel and tasteful designs that manifest itself in the videogames? Several of the respondents believe this is the case. A nice example is the adorable game *Unravel* by Coldwood where you play "Yarny" a character made of a single thread of yarn that unravels as you solve problems in breathtakingly beautiful environments following a heart felt story to collect the memories of his long lost family.

Resource mobilization

Resource mobilization plays an important role for TIS development. Bergek et al. suggest that the key categories of resources are competence, financial capital and complementary assets.[152]

Given the knowledge development in the TIS discussed above, with training programs in place and a favorable reputation in the international labor market, it appears that the industry attracts sufficient human capital and competence. In addition, it has been proposed that the game industry in Sweden an in Finland have benefited from the ups and downs of large technology-based companies by getting access to additional experienced IT professionals. In particular, there are signs that the decline of Nokia fed the Finnish game industry with talent.[153]

Financial capital is another story. With a generally week seed market in Sweden and venture capitalists being reluctant to invest in the game industry, financial resource mobilization is a challenge (Dataspelsbranschen, 2015). There are some local venture capital firms investing in IT and app companies, like Spiltan and Creandum, but investments in game project appears rare even for them. Also, despite the three decades growth there has yet been few exits where funders made large profits and reinvests as capitalist in the industry. This may be something that is coming though. Markus "Notch" Persson (Mojang) and Tommy Palm (King) are examples on notable recent exits. Mr. Palm has, in collaboration with several other industry leaders, engaged in a non-profit accelerator called "Stugan", a project for helping nascent studios. However, the emphasis for Stugan appears to be on advice and support rather than financing.

But so far the opportunities to get funding are limited, to say the least. With these conditions it may be expected that game developers were getting part of their financing from public support initiatives, but this is also uncommon. One exception is the Nordic Council of Ministers, which supported Nordic developers through the Nordic Game Program. The only other examples of public support revealed during the interviews were Avalanche Studios and PeppyPals, who received money from VINNOVA, and Coffee Stain and PeppyPals, who received some Almi support.

Locally, some municipalities have fruitfully involved themselves in supporting incubators, game companies or collaborations, like Näringslivsstiftelsen in Karlshamn and Skövde komun.

So how are most start-ups funded? There are two common patterns. The first is that experienced developers exit their current studio to start their own, bringing knowledge and some starting

[151] See for example Arnroth (2013)
[152] Bergek et al. (2008)
[153] Clarysse (2014).

cash with them. This is how Machine Games got started by people from Starbreeze and Mojang got founded by people leaving King. Other examples are Raw Fury and Resolution Games. The founding teams are often small, typically 2-6 individuals, with an early stage product and a strong motivation to build their own game studio. The other common pattern is that younger people start a project while still being students in a game education program. These teams tend to be bigger, often 8-12 people, were some of the members may be willing to take the step of joining thanks to Sweden's well developed systems for social security. Respondents at such small indie firms, spun off from game schools, often joke that initially they were "CSN financed" (the Swedish Government authority for financial aid for studies). In addition, many new companies try to win business or game competitions, to get some credibility and prize money.

The most important complementary asset, and also the most important source of advantage for Sweden, is probably provided by the industry itself. From previous success it is now abundant with knowledge, skilled potential partners, and useful contacts with important people around the globe. However, what differentiate Sweden from other countries is the striking generosity and willingness to help others within the game development community. This is a tradition that has not been observed in competing nations like Canada, UK and the USA. An important aspect of this collaborative culture is the substantial cross-firm of sharing and support between companies. Ola Holmdahl, CEO at Tarsier, argues that since the market is growing fast and almost all output is exported, companies gain much from helping each other with insights, contacts and even lending of personnel. It is not uncommon that firms also support each other with ideas and resources. Many new firms help each other by volunteering to test games. Many of the managers in small firms have mentors in the larger once, giving them greater access ecosystem resources than would otherwise be the case. In fact, all the investigated start-ups have given examples of how they received help from other start-ups and/or major studios and publishers. Consequently growth in itself becomes a factor that favorably affects industry circumstances in a way that improve chances of making excellent products.

Bergek et al. argue that collaborations and networks in an industry can be an important structural component.[154] For the Swedish video game producers this definitely appear to be the case. Nevertheless, its driven by the actors' willingness to make efforts for the wellbeing of their own industry. And it is important beyond improved chances of making good games; it also affects the KSF of reaching through the noise. It turns out that many firms in the Swedish game industry also share access to market channels and help each other with distributor contacts. The well-connected players collaborate with others either by just freely giving the contacts or buy actively engaging in a business relationship where they take a publisher role. But, previous success also brings another important benefit; a reputation for good games. Reviewer and journalist Thomas Arnroth, who has decades of international experience from the game industry, argues that the digital channel companies like Apple likes Swedish games. The prevailing image of creative and well designed games help putting new Swedish games on the distributer's radar, increasing the chances of reaching through the noise by being featured. As Arnroth argues: "If you are good in Sweden – you are *really* good. Everyone knows that." A

[154] Bergek et al. (2008)

statement corroborated by venture capital firm GP Bullhound contemplating to open a fund specifically for Swedish video game investments.[155]

Moreover, an active and open user culture combined with tight-knit communities is very favorable conditions for a vital game industry.[156] Such communities exist in many countries, but it appears that both Sweden and Finland have many collaborations, conferences, networks and events around video games. Most notable is the world's largest computer festival Dream Hack, arranged every year in Jönköping Sweden with over 25 000 participants. But there are many other meeting points where friendships can be formed and skills get improved through exchange of ideas. For example, some of the schools also support events, like the aforementioned Sweden Game Arena, which hosts a Microsoft game camp and arranges Sweden Game Conference 2015.

9.5 Concluding remarks

This chapter validates the Swedish success in video games. It establishes that the growth rate in Swedish revenues by far outperforms the global market growth, which means that the Swedish market share is steadily increasing. The average yearly growth has in the last five years has been about 270 M Euro, with several dozens of new companies typically being started each year.

It then attempts to find reasons for such success by identifying beneficial circumstances leading to a strong TIS in the country. These circumstances, or functions, are: market formation, legitimation, knowledge development and diffusion, and resource mobilization. All of these can potentially support Swedish studios in dealing with KSF 1 – to produce really good games. Superior competences like audiovisual design skills, strong Nordic work ethics and user centered game design all contribute directly to perceived game quality. Being a legitimate industry helps attracting talent and hopefully also capital in the future. Swedish business culture, with flat structures and emphasis on teams and collaboration, is believed to have an indirect but significant role in forming companies that can have repeated successful releases and accumulate skills over the long term.

The collaborative spirit within the industry appears particularly important. It does not only aid the development of really good games, it also facilitates reaching the market, which is what is needed to handle KSF 2. The connections, knowledge and reputation generated by previous success thus benefits many actors as a valuable asset. Some, like Simon Lundmark CEO at Pixeldiet, argues that it is really the only advantage with being in Sweden. As far as this study has been able to find out, this remarkably high degree of cross-firm collaboration does not exist outside the Nordics. It is therefore a key differentiator that also is difficult for other regions to imitate, and thus most likely the cornerstone of Sweden's competitive advantage.

The prospects for the future are extremely interesting. On line distribution and off-the-shelf hardware and software tools for game design has made it possible to develop games all over the world. The role of national borders diminishes with increasing cross-border collaboration,

[155] Goldberg (2015)
[156] See Reed (2015) and Konzack (2015)

multinational branch office locations, and franchised intellectual property. So in some sense "the growing shift toward transnational game development is eroding and reconfiguring the very concept of a national industry".[157] It remains to be seen if Sweden can maintain and nurture its competitive advantage under such circumstances.

Major hardware developments are imminent as well. Industry experts expect that the next radical game play enhancement will come with virtual reality interfaces such as Oculus Rift or Samsung Gear VR. Whether this will lead to growth through new audience-game combinations remains to be seen. In Sweden, Starbreeze is currently developing their own "Star VR" gear that will have better performance than Oculus, after acquiring the French company Infiniteye. Aforementioned Tommy Palm has started a new studio in Stockholm (Resolution Games) with capital from Google Ventures that develops games specifically for VR.[158] Another more long term hardware development is the anticipated 5G mobile networks. With much higher bandwidth and expected latencies down towards 1ms, multiplayer action games will become much more feasible on portable devices. It is also possible that new categories of real time multiplayer games may emerge.

A wider application of game design is likely to occur according to authors writing on gamification. Player-generated content and free-form play is increasing and may support the development of game elements being infused in new aspects of our lives. With gamification the application of game mechanics can encourage people to take part in certain activities or maybe nudge them into behaving in a certain way.

Another emerging factor that is expected to have a major impact on the industry is the increased activity in Asia and other BRIC countries. These regions currently have the fastest increase in demand (Dataspelsbranschen, 2014), but there are also massive investments being made. In china, billions of dollars are invested in game companies both domestically and abroad. This can challenge the current balance among leading nations and companies.

[157] Wolf (2015:12)
[158] Dataspelsbranschen (2015)

10 Mergers and acquisitions in the coming-to-age phase of the Swedish ICT services industry

Anders ***Broström****, Monia* ***Lougui*** *and Fredrik* ***Johansson***

Industrial consolidation through mergers and acquisitions has been important for development of the IT sector. M&As constituted a force of creative destruction parallel to the mechanism of exit through bankruptcy. Drawing on new empirical evidence, we argue that M&As also provided new impulses and opportunities for entrepreneurship and stimulated between-firm job mobility of key persons in the sector. We conclude that the intensive M&A-activity of the period contributed to renewal and growth of the ICT software and services industry at large, but did not lead to the creation of new Swedish-based multinationals in the sector.

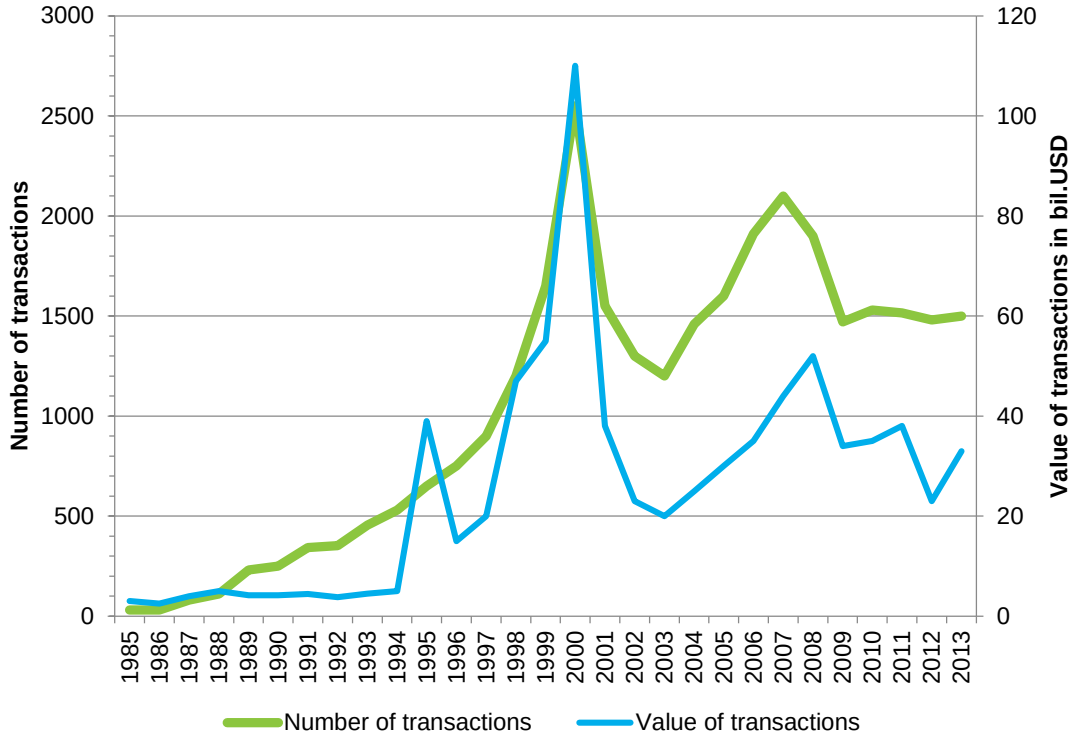
10.1 Introduction

ICT service firms played a prominent part of the "boom and bust" pattern of the Swedish economy around the year 2000. Demand grew rapidly from a low level in the years preceding the turn of the millennium. New entrants were recruiting directly from secondary-level education, the skills of much of the existing workforce considered inadequate and outdated by rapid technological change. A frantic hunt for market share ensued, driven by expectations of rapid industry growth and of significant first-mover advantages and realizable scale economies. With this background, many investors and entrepreneurs considered it natural to sacrifice short-term profits to invest in technical capacity and a large international customer base. Acquisitions became a natural vehicle to pursue such aggressive growth strategies. In the Swedish setting, a series of rapid mergers and acquisitions (M&As) by ICT consultancies such as Framfab, Icon Medialab, Razorfish and Sapient were upheld as prominent examples of how to succeed in what was referred to as "the new economy". After dramatic adjustments of the earnings expectations and market valuation of ICT firms in the period 2000-2001, significant shake-out occurred in the industry. However, as demand for ICT technology continued to grow across the economy, industry employment recovered relatively quickly in a more regular industrial climate of consolidation and exploitation of scale economies.

The Swedish experience reflected a pattern of technological and industrial development found throughout the developed world. Figure 10.1 illustrates the dramatic increase in global M&As in the ICT consulting and services industry in the period around the year 2000, the subsequent drop and recovery in M&As up until 2008. Data for Sweden provides a parallel picture of volatility in M&A activity. In this chapter, we analyse the role of M&As in the industrial

transformation of the Swedish ICT software and services industry during this period of post-boom industrial growth.

Figure 10.1: Announced mergers and acquisitions in the IT consulting and services



10.2 M&As over the industrial life cycle

It is well established that M&A activity fluctuates heavily over time[159]. The notion of "merger waves" is a commonly used jargon in economic history[160]. While such fluctuations are related to macro-economic conditions, industry-specific factors have been found to play a central role[161]. Changes in the pace of technological change, policy adjustments such as regulation and deregulation processes, and shifts in demand or supply affect industry-specific dynamics change the condition for competition in an industry and thereby the appetite for growth through M&A activities among firms.

In the analysis of M&As in new industries, industry life cycle analysis constitutes a useful contextual framework. This perspective, such as presented by Williamson (1975), suggests that there are certain characteristics in common in the development of any newly introduced industry. In particular, a new industry is considered to go through different phases of increasing industrial maturity: an early exploratory stage of introduction, a phase of growth, and a maturity stage – eventually followed by a phase of decline. For the Swedish ICT software and services

[159] See Blair et al. (1991), Golbe & White (1993) and Scherer & Ross (1990)
[160] Sleuwaegen & Valentini (2006)
[161] Nelson (1959)

sector, the period 2000-2008 can be characterized as a period of transition from a late introductory stage to an early stage of industrial maturity.

M&As are typically important vehicles for change through which industries mature and are consolidated. The motivation and wider impact of M&As may however change between the three stylized phases of industrial development. During the introduction stage, M&As are typically motivated by R&D-related objectives and by ambitions of product- and market-extension. Acquisitions often involve the purchase of startup firms by well-established firms in related but more mature industry segments. During the subsequent growth phase, we see several types of acquisitions. Established companies from one industry segment may start entering other segments with greater frequency, looking mostly for proven and growing targets. Industry-convergence acquisitions appear and continue into the maturity stage. We may also expect to see acquisitions driven to some extent by preemptive and "empire-building" motives, where managers and entrepreneurs may opt to acquire a competitor rather than see this firm acquired by another competitor. In the subsequent maturity phase, where industry growth stagnates, overcapacity and consolidation motives dominate the market for M&As.

10.3 An overview of M&As in the Swedish ICT software and services sector

Utilizing register-based data, we are able to study merger patterns in the Swedish ICT software and services sector. Firms are identified as belonging to the sector based on industrial classification codes following the OECD definition of the industry. The detailed list of the industries and their codes can be found in the appendix. 9 341 unique firms with at least three employees which are identified as belonging to the Swedish ICT software and services sector for at least one year in the period 2000-2008. We identify the occurrences of M&As through patterns of employee mobility, following the rule of thumb applied by Statistics Sweden: a merger between two Swedish-registered firms A and B is registered as having occurred when firm A ceases to exist in the following year and a majority of employees from firm A are found to work for firm B in that year. Following this definition, 2 657 ICT software and services firms go through at least one M&A process between 2000 and 2008, the total number of M&As amounting to a full 4 001. The median size of these acquired firms is 25 employees. Interestingly, the mean size of all firms in the industry does not change much throughout the period. Firm growth through mergers is obviously off-set by new entry of small firms and/or by lay-offs and exits among merged firms. In addition, we observe 131 cases of mergers and acquisitions involving foreign owned firms. All in all, approximately 5 percent of the firms are involved in an M&A during the studied period.

10.4 M&As transform industries – but how?

The traditional business motivation for M&As is that of achieving operational or financial synergies and of increasing a firm's market power in monopolistic direction. Both these objectives may potentially lead to transformations in the industry or industries involved. The exploitation of scale economies in novel ways may allow for more efficient production of goods

and services. The creation of monopolies may, on the other hand, reduce supply, push up prices and hamper the speed of innovation in an industry.

Well aware of these effects, public authorities have monitored and regulated M&A activity for decades if not centuries in virtually all countries. The attention of authorities is, however, closely fixed to market power concerns and to upholding competition within an industry. In the context of a growing industry in a relatively early phase of industrial development and characterized by fast technological development, such as the one under consideration here, such concerns are typically not very urgent. This expectation is supported by available data. During 2000-2008, the Swedish competition authorities filed 51 investigations of business concentration consequences of M&As involving firms in the ICT-service sector (corresponding to 6% of all such investigations pursued during the period).[162] Among these acquisitions several cross-border deals are found, as well as activities involving large and well-known actors from the time such as TietoEnator, CapGemini, WM-data and Posten AB. None of these mergers were however considered to threaten the competitive nature of the industry. The authority decided, in each one of these 51 cases, to take no further measure to prevent the merger.

While M&As in the period thus did not give any single firm a dominating position, they helped bring about industrial consolidation. Beyond the traditional efficiency-through-synergy arguments, scholars have highlighted a further industry-transforming mechanism of M&As, which would seem to fit the situation on a growth phase market in general, and the ICT software and services industry in particular. In situations where more effective firms buy less effective firms, the overall productivity of the industry will typically increase[163]- at least when the efficiency advantage of the acquiring firms is rooted in actual superiority in production, and not in market power advantages of any kind[164].

Efficiency perspectives on M&As would suggest that the development of the ICT software and services industry was affected in two major ways. In the short term, lay-offs may occur, e.g. as a consequence of attempts to achieve synergies in operations. The consequences for laid-off employees can however be expected to be limited, as continuous industrial growth created labor market demand for skilled ICT workers and opportunities for self-employment – at least in the major cities. In the long term, the efficiency achieved through M&As may have contributed to the international competitiveness of firms in the Swedish ICT software and services industry.

The mechanisms through which M&As are seen as pushing the development of an industry towards greater efficiency discussed so far are of a static, on-off nature. In a technology-intensive sector such as ICT software and services, dynamic effects of M&As are also expected to play out. Such effects, which arise through the impact of a specific M&A on the industry-wide conditions for R&D, innovation and entrepreneurship, are theoretically speaking often greater in magnitude than static effects, but inherently difficult to estimate ex-ante and to

[162] Source: authors' calculations from source material derived from the public registers of the Swedish competition authority, (http://www.konkurrensverket.se/Diariet/default.asp?nav=2)
[163] Jovanovic & Rousseau (2002)
[164] Braguinsky et al. (2014)

measure ex-post. In the remainder of this chapter, we provide a few illustrations of such mechanisms playing out, focusing on the people most directly affected by M&As.

10.5 The tales of two acquisitions

The "dynamic" effects of M&As arise through e.g. capital transfers within and across borders, change-of-hands of technological assets and the emergence of new networks. As illustrations of how the industry-wide effects of such flows can be both far-reaching and non-dramatic at one and the same time, we next outline two important acquisition events in the Software & Net Services industry from the period under study and their effects on key individuals.

The acquisition of Coding Technologies[165]

In 2007, California-based Dolby laboratories acquired the Swedish firm Coding Technologies for 1,6 billion crowns. The firm, which had been started 10 years earlier by the musician Lars Liljeryd, had developed world-leading technology for audio compression with applications for low-bandwidth transmission such as mobile communication and digital radio. It employed 15 persons in the Stockholm office and a further 50 persons in Nürnberg and Beijing. In 2007, the firm was in need of additional investment to finance further technical development. There was quite some interest in acquiring the firm, whose technology was integrated in several global standards. For Liljeryd, however, the opportunity to have Coding Technologies integrated into the large American firm which for decades had held a dominating position in noise reduction and audio encoding was a preferred alternative. The technological assets of the two firms provided interesting opportunities for synergetic effects, e.g. opening up for technique from Coding Technologies to be implemented in the BlueRay/DVD market.

The merger has been described as relatively successful. Technological synergies has allowed the implementation of technologies from the Swedish venture in a vast array of handheld devices. Many of the developers also choose to stay with the firm. As of today, Dolby maintains an office in Stockholm ("Dolby Sweden"), currently employing some 17 persons. As for Lars Liljeryd himself, he remained with Dolby as senior advisor. After the acquisition, he has also engaged ad co-founder of two firms (Diabetes tools, Biocrine) developing new treatments for people suffering from diabetes.

The acquisition of Ongame[166]

In early 2006, following a dramatic growth in turnover and employment which had earned it the title "IT-company of the year" the year before, the Stockholm-based venture Ongame was acquired by the Austrian company Betandwin. Ongame, an on-line poker platform first launched in 1999, had timed the poker hype of the mid-2000s really well and had in 2005 achieved a margin of 33% on a 137 million SEK turnover. The business, which had started out as a site for on-line poker, had quickly shifted focus into developing and providing technology and a joint database of players for 14 independent sites.

[165] This section draws on an interview and subsequent conversations with Lars Liljeryd in May-August 2015
[166] This sections draws on interviews with Eric Hörnell and Oskar Hörnell in May 2015

The strong financial results together with strong expectations of future growth in what at the time was a strongly growing market for on-line betting motivated an acquisition price amounting to 4.5 billion SEK. An IPO on the London stock exchange was being planned, but the price and expectations on significant synergies that were attached to the deal convinced the four owners to sell. Through the acquisition, Betandwin sought to enter the on-line poker market from a position of offering on-line betting. Synergies in terms of customer-bases were expected, as the acquirer hoped to attract players from Ongames (primarily European) player base to its (US-oriented) betting services. Technical synergies in terms of server use and synergies in development costs were furthermore foreseen. The merged firm set out to become the world's largest player in on-line poker.

The post-merger development was accompanied by some of the traditional challenges of international mergers. In particular, cultural and managerial differences created some frictions in the integration process and combining the poker products of the respective firms proved more difficult than initially foreseen. More importantly, however, market conditions for on-line poker changed. As the poker hype cooled down and new players entered the market, competition increased. New regulation of online-betting by the US government also put pressure on the market. Ongame AB was divested by Betandwin (by then known under the name bwin) in 2012.

The development activities in Stockholm have survived this turmoil. In October 2005, Ongame AB had 230 employees. In 2014, when the Stockholm activities under the name Ongame services were sold to the NYZ Gaming Group, it employed 152 people.

Five people controlled 96% of the stock in Ongame. They have all gone on to launch new ventures. Co-founder Oskar Hörnell stayed in the merged organization as a senior advisor but left in 2008. Today he is involved in Casino room, a firm with 14 employees which offers a web-based platform for online-games. Hörnell also is co-owner/investor in a Chinese technology company that develops mobile games for chines mobile phones and tablet and runs an on-line sport community for fantasy sport. Eric Hörnell and Carl Hörnell have founded the firm KEP games, which has launched a highly successful crossword-app available in several languages. The second co-founder Claes Lidell have continued working with the final major shareholder Bo Johnson to develop a video-on-demand application called Headweb. The app has won the award for Sweden's best video application several times. In 2015 the company, which employed 13 people, was acquired by Film2Home.

Observations

The two histories of the acquisitions and subsequent mergers of Swedish ICT-service firms in the mid-2000nds offer some interesting observations, which may cast some light on what role that M&As may have played during this period of industrial development. Consistent with the received view of mergers, jobs may have been lost in the short term in attempts to realize synergies in sales, marketing, etc. Technology has been transferred, but in both cases development activities are still being pursued from the original location of the acquired firm.

Of particular interest is the observation that key-persons such as the founders of the two firms have left the acquired firms and engaged in the formation of new ventures. As main owners, the

founders of the above two firms carried away significant fortunes from the acquisitions. The fact that they have chosen to invest some of that capital in new ventures suggests a mechanism through which potentially negative effects of acquisitions for a specific region may be offset. More generally, key-persons who leave an acquired firm contribute to localized knowledge spillovers[167]. How common was this pattern in the growth-phase of the ICT-services industry in Sweden? To what extent did employees of acquired firms engage in new firm formation, similar to the founders of Ongame and Coding Technologies? In the following section, we revisit Swedish register-based data to investigate these questions in some detail.

10.6 Post M&A spin-outs in the Swedish ICT-services sector

In post-M&A processes of integration, securing strategic focus of activities through divesture and re-orientation of existing activities is often a key priority in parallel to realizing synergies between related activities. Such strategic decisions are a potential source of new opportunities for entrepreneurship and other forms of entry. In a market characterized by high growth and low physical capital intensity of production, such as the one under study here, post-merger consolidation may be particularly likely to stimulate such entry. For example, a market niche abandoned by a merged ICT consultancy firm seeking to streamline its offering is an opportunity for entry by other actors. An obvious possibility is that existing consultants leave to set up a new firm drawing on their existing customer contacts. Technological re-orientation in a software firm following its acquisition may cause the firm's developers to consider exploiting ideas and projects threating to be abandoned by the new management in a new venture[168].

Our data supports the existence of such a pattern. The entrepreneurial activities of the employees of ICT-service firms involved in M&A activities did indeed increase during the post-acquisition periods. For this study, we limited the sample to firms with at least 50 employees.[169] In this sample, 289-360 new firms are each year making their entry by spinning out from one of the 2 889 concerned ICT software and services films. It appears that M&As increase the frequency of spin-out by 33% two years after the event. Putting this differently, it suggests that on average, with a fusion or an acquisition, there are one to two extra firms launched compared to the absence of any M&A. In other words, there are supplementary opportunities that are perceived by employees of acquired, acquiring and merging firms and that are additional to the opening available on the market. In a growing market with limited entry barriers such as the ICT software and services industry, M&As can be considered as something of a force of creative destruction.

As new firms try to carve out a niche for themselves, e.g. by introducing technological innovation, addressing new customer segments, sometimes even challenging the existing ways to do business in the industry, they potentially change industries. Supporting such notions, entrepreneurship has been empirically found to drive industrial productivity[170]. We note that

[167] Rosenthal & Strange (2001)
[168] Klepper and Thompson (2010)
[169] This limitation has technical motivations: with a minimum of 50 employees, we can exclude concerns related to the employees' involvement in the M&A decision, we reduce the error margin in the definition of an M&A, and we emphasize the impact of M&As on the mobility of the employees.
[170] Andersson et al. (2012)

M&A contributed to strengthen such patterns in the growth phase of the Swedish ICT software and services sector.

10.7 Post M&A executive turnover

We next turn to study the fate of managers of ICT software and services firm acquired during the period. In the two cases of Coding Technologies and Ongame, founder/managers were found to have left their operational positions soon after the respective acquisition.[171] Should we think about this as a general pattern, and if so – what have this implied for the industry?

For acquirers of ICT consultancy firms, retaining staff and reducing business disturbances are key to realizing the potential value of the deal. In acquisitions of software firms, retaining developers and key persons is typically attractive, e.g. to secure further development and technical integration with the acquirer's existing software, to manage relationship to existing communities of users and customers, etc. The retention of managers after an acquisition helps reducing post-acquisition turbulence, and is therefore often desirable – at least in the short run. Does that mean that M&As in the Swedish ICT software and service sector inhibited mobility of key persons?

Register data allows us to investigate the patterns of managerial exodus, albeit only from 2004.[172] One year after an M&A, over a third of the managers have left the merged firms. Adding a further two years, only two out of five managers remained with their previous (merged) employer.

M&A thus seem clearly associated with increased managerial turnover. This effect has implications for industrial development. Mobility of labor causes diffusion of knowledge and ideas, stimulating learning[173]. Inter-firm job switching is also a mean to ensure efficient labor market matching, which theoretical models suggest to have significant influence on industrial productivity and development (c.f. Farber, 1994). There are thus reasons to describe M&As as having contributed to cross-fertilization between firms in a phase of industrial growth, and thereby to the success of the industry.

10.8 M&As as a vehicle for industrial transformation

During the first decade of the 21st century, the Swedish ICT software and services sector developed from a pioneering state of wide-eyed enthusiasm via abrupt adjustments of expectations into a major business sector and an important part of the Swedish economy. Industrial consolidation through mergers and acquisitions played several important roles in this process. As a mean of expansion, M&As allowed for greater scale economies. As a channel for less effective firms to be absorbed by more efficient competitors without total loss of operational assets, M&As constituted a force of creative destruction parallel to the mechanism of exit through bankruptcy. Furthermore, as we have illustrated through new empirical

[171] As described in section 5, Coding Technologies founder Lars Liljeryd maintained an advisory role and relationship with the firm
[172] Occupational codes allowing us to identify managers are not available before 2004.
[173] See Almeida & Kogut (1999) and Agrawal et al. (2006)

investigations in this chapter, M&As provided new impulses and opportunities for entrepreneurship and stimulated between-firm job mobility of key persons in the sector. So what was lost?

While evaluating the impact of potentially "positive" industry-wide effects is notoriously difficult, evaluating negative effects may be even more challenging. The main concern of public authorities, the threat of market concentration leading to reduced competition and industrial stagnation, does not seem to have been a major concern in this phase of development. For each acquired firm, opportunities were probably foregone. Did M&As destroy struggling firms who would have developed into major players, had they not been acquired and integrated into other business activities? Did M&As transfer technological assets and key competences which may have allowed Swedish-based firms to develop into a new Google or Microsoft abroad? Regarding such contra-factual questions, we can only speculate. It should be noted, however, that even if access to risk-willing and "competent" capital for investment in scalable ICT assets had been corresponding that of, say, the U.S. west coast, it is not likely that successful firms would have "stayed Swedish". The case of Coding Technologies provides a good example: at the time of acquisitions by American industry leader Dolby, the Stockholm office accounted for less than a fourth of total employment and the main alternative to an acquisition seems to have been an IPO in London. Most likely, cross-border acquisitions have created outflows of future profits to firms based in foreign countries. At the same time, such M&As have also created inflows of capital which at least partly has been re-invested in an industry by entrepreneurs/ owners who – like the Hörnell family of Ongame – have gone on engage with creating and funding new firms in the ICT software and service sector. Last but not least, it should also be noted that the possibility of exit through M&As provide powerful motivation for many entrepreneurs.

We conclude that the intensive M&A-activity of the period contributed to renewal and growth of the ICT software and services industry at large, but did not lead to the creation of new Swedish-based multinationals in the sector. With technology, demand and business models continuing to develop at a strong pace, it would seem more strategically important for the future development of the local industry as a whole that the dynamics of entry and exit (e.g. through acquisitions) stay vibrant than that Sweden becomes the headquarter of a new major corporation.

11 Swedish entrepreneurial firms and ICT hotspots

*Annika **Rickne***

This chapter takes the perspective of startup companies in the Swedish ICT sector and looks at what positive sides or drawbacks there are being located in Sweden as compared to one of the major ICT hubs in the world: California.

11.1 Introduction

California has been unprecedented successful in a set of ICT related development efforts: semiconductors, personal computing, internet related businesses. There is plenty of literature on what characteristics and resources that single out Silicon Valley as an outstanding region for ICT innovation. Our aim is not to contribute to these analyses of mechanisms and factors, but instead to highlight how Swedish entrepreneurs may perceive their development journey and their locational choices.

Much explanatory power to the secret of Silicon Valley and California lies in the history: the role of Stanford professors, procurement activities, the technological breakthroughs and subsequent growth of the early startups. Also, a rich resource base has been built up with a strong human competence base and high mobility in to the region, intellectual capital, formation of venture capital firms and support organizations. Perhaps most important, a critical mass of companies in many subsectors has provided ample of opportunity for interacting as development partners, or for customer-supplier relations. Indeed, there are several, partly overlapping and partly competing, explanations to why this particular location has proved to manage prosperity over time, ranging from discussions of trust and strong ties, to a performance based culture, early mover advantages and path dependencies or a favorable set up of actors and institutions.

Sweden has an international reputation as a highly ICT productive environment. And especially, Stockholm is seen as a form of hotspot for ICT. In general terms, Stockholm has been ranked as number seven of the world's major capitals and scores particularly high on indicators such as technology readiness, intellectual capital and innovation, sustainability, quality of life, and safety (PwC). In fact, as regards technology readiness - measured by internet access in schools, broadband quality, digital economy and software development - Stockholm ranks third after London and Seoul. The Networked Society City Index 2013 puts Stockholm in top rank, followed by London, Singapore and Paris (Ericsson, 2013). Also, in more popular assessments Sweden is often mentioned: for example, Stockholm was by the US seed-stage fund SparkLabs Global Ventures ranked the second best city for startup ecosystems in the world as regards funding and exits, engineering talent, active mentoring, technical infrastructure, startup culture,

and legal and policy infrastructure. The city grows fast in terms of population, and is expected to be the European city with the fifth largest population increase until 2030.

As we saw in chapter 7, there are significant ICT activities throughout all of Sweden but there is indeed a large concentration to the Stockholm region, with nearly 50% of the Swedish employees, and twice as many ICT business jobs per capita as the country at large. The exceptions are the manufacturing part of ICT where less than a fourth of the jobs are in the capital, and technical ICT consultants (35%).

Table 11.1: The investigated firms

COMPANY	ESTABLISHED	PROFILE	NR OF EMPL
YUBICO	2007	Hardware and service	50
TRUECALLER	2009	Service	70
NEO TECHNOLOGY	2007	Software and service	100
NARRATIVE	2012	Hardware and service	40
VINT	2013	Mobile app and Service	6

With this as a basis, we in this chapter look at the idiosyncrasies of five specific startup firms, and how they have – in this particular time period – experienced the locational issues. They are all rooted in the Swedish entrepreneurial soil, even though in rather disparate manners. What unites them is their decision to move some or all of their operations to another of the global IT hotspots: California. The sample for this study was, thus, five companies founded by Swedish entrepreneurs and now active in the Silicon Valley area. They are what we may call ‘growth companies’, that is, their aim is not to stay as small, livelihood companies, but to grow to international players. They are active in hardware as well as software and service development, and were founded between 2007 and 201x (see Table 11.1). Some of them have already experienced a significant expansion period, while others are just starting up. The chapter dwells on one of these firms in particular – Yubico – to illustrate some issues that several of the firms have experienced. We then conclude with a general discussion pertaining to all studied firms.

11.2 The entrepreneurial journey of Yubico

The underlying business idea for Yubico is that security solutions are in dire need in relation to an Internet designed for sharing. This calls for a simple to use, low cost, device for securing access, independent of device or platform. Today Yubico provides their device to individuals and organizations, and have had success in having their solution implemented within some of the leading Internet companies globally.

The company was established in 2007 by Stina Ehrensvärd as a spinout from Cypak, a company formed by Stina and Jacob Ehrensvärd in 2000, designing electronic modules for compliance monitoring in healthcare. In the development work for Cypak they saw needs and possibilities for using the communication protocol NFC (near field communication) to enable device users to have a secure connection between each of their devices and the internet. This new business idea did not lie within the realms of Cypak’s profile, and a new company was thus spun out with a minority Cypak ownership. With them they brought all the experiences and mistakes from the

first company in how to run a startup, recruit only the best, manage a team, develop fast and with highest standards, not to get caught in too large organizational and economic commitments before the paying customers have signed up on the prospect, and how to build a market.

Early on two Swedish angel investors helped to get the first development under way, and with an office in the incubator Sting and an early loan from the governmental support organization Almi, and support from VINNOVA the process was set in motion. After initial development work Yubico received extensive attention on a rather difficult market. This could be attributed to something of a fluke, when Ehrensvärd caught the attention of a thrifty journalist at an international security conference and the then rather prototype like gadget got a prime marketing push. This lead to massive attention and Yubico had to move fast and started sales to both end users and corporate customers. The fast market penetration was however not a fluke but a result of presenting a solid product leaning on dedicated development work. An open source approach and unmet customer needs meant that sales to individual users started, and this lead to the product being brought to the attention of some major ICT companies in the USA. Discussions of customized development were held with such customer firms, and the prospects loomed promising.

With such main customers in California, Ehrenswärd realized that communication and market penetration would be much improved with geographical proximity. So, they moved the headquarters to Silicon Valley. This has proved crucial to access and cultivate deep relations with world leading companies such as Google, Facebook, and Salesforce. Such customers explicitly said that Yubico impressed them with their gear, and that they were able to deliver fast, building a working prototype within weeks. Not least important, Yubico was local, and they wanted local. As a contrast to other security providers located in Europe Yubico showed that they were in for a serious and long term relation by localizing next to the customers and tending to their needs. Ehrenswärd's assessment is that US companies is more prone to walking into a development collaboration with a small company, being accustomed to a milieu of flourishing startups.

The Yubico team aspires to change the standards for Internet security, and has set up a think tank - the FIDO Alliance – where open standards specifications are discussed. This is indeed not an easy task where many have a stake in the process and outcome and parallel protocols have been on the table for some time. The level of attention has been high given recent US and global desires to increase Internet security, assure personal integrity, and make big data sharing possible. In this, leaning on the prominent historical role of Ericsson in standards, Swedish firms have as good platform and brand goodwill. Discussions with both Swedish and US governmental officials have opened up possibilities for further development projects, and also pave the way for initial talks with other countries. The solutions provided by Yubico can today be used by individual users and corporations, but also has a larger potential implication for how to handle Internet security in specific countries or at an international level.

The decision to move much of the operations to California was neither easy nor unanimous at the time given the expected high costs, unsuccessful experiences within the board from earlier trials in connecting to this market and the given the early stage of the product. Being neighbor

with leading firms as Google does not automatically make them your friends and allies, but in the case of Yubico the move was a fruitful move.

The challenge is to balance the activities in the two countries and get the best out of both environments. Ehrenswärd's view is that Sweden has a great milieu for software and hardware development, in particular as related to mobile apps and games but also many other interesting sub-segments. Spotify, King, Klarna, Skype are but some of the successful companies and she hears very positive Californian comments about Sweden as an environment to invest in, and to recruit from. For Yubico, the gist of the development team is still in Sweden, but is lead from the USA by the founding inventor with all the time management issues such collaboration over time zones entails. Economics operations are based in Sweden, and this reflects that location is mostly a matter of there the crucial human competence are situated. Manufacturing is located in Sweden as well as in the USA.

Recruitment is often tricky when one is a young and unknown firm with little but a vision and hard work to offer. Indeed, recruitment is a key matter and what the USA has is a competent and highly mobile labor stock, whereas the mobility and willingness to take chances with a startup are lower in Sweden. When it comes to skills of engineers Sweden fares at least as well as the US, but the labor cost is extremely high in California. In this context, thus, Swedish developers are well renowned and not as expensive as in Silicon Valley, but there is a scarcity of them. Even given the many foreign students receiving their education in Sweden and the push for a gender equal education system, there is a general volume deficiency and a particular lack of female engineers. A flat organization and a team spirit and culture of consensus is something Ehrenswärd perceives as positive traits of the Swedish milieu, especially when combined with diligent and creative engineering work.

Some well-renowned investors joined in 2014: one of Google's initial investors Ram Shriram, and Marc Benioff of the cloud computing company Salesforce. The company is today owned by the management team and a set of business angels. The competence network obtained in California spans from investors to advisors and partners and customers. Exactly this, to be able to actively and in person build networks and relations to world leading individuals, firms, investors, thought leaders, researchers may be one of the core advantages of the Californian location. This enables a young firm to tap into competence flows otherwise unattainable. In the same vein, access to early and demanding B2B customers is crucial, as is an access point for thoroughly understanding of the large US consumer market.

11.3 Discussion

In this chapter we took the perspective of startup companies in the Swedish ICT sector and looked at what positive sides or drawbacks there are being located in Sweden as compared to one of the major ICT hubs in the world: California.

Sweden has an international reputation as a highly ICT productive environment, and especially, Stockholm is seen as a major hotspot for ICT. Naturally this goodwill builds on a long history of high end research, innovation and business activities, as well as prominent Swedish roles in

standard setting, as has been discussed at length elsewhere in this report. History prevails and Sweden is surely well positioned to entice companies to locate in the country and perhaps especially in Stockholm. Moreover, attracting investors as well as individuals with specialized ICT competence does not seems farfetched.

The interviewed firms are all in agreement that for software and hardware development, Sweden - and predominantly Stockholm - is one of the most favorable locations to be situated at globally. The labor force of engineers is highly educated and experienced, work efficiently and performs at high standards. In addition, a flat organizational set up and consensus models make for efficient hardware and software development, in a sector where speed is everything. As the ICT sector and ICT development in general is flourishing in Sweden, there is however a shortage of programmers, system developers, etc. Moreover, contracts with often three months' time of notice means that it is difficult to recruit swiftly. As an example to solutions, this lack of available development personnel has lead one of the responding firms to recruit from elsewhere, and their staff in Sweden now holds 70% non-Swedish employees.

What Silicon Valley can additionally offer in terms of competence is highly experienced top managers, growth experts and financial officers. Some respondents mean that there are in fact job descriptions in the US that does not exist in Sweden. Based on handling of large data sets – on demographics, customer preferences, medical databases, etc. - growth management aims to understand how a firm can better reach growth goals. Such expertise is now built in Silicon Valley. Similarly, as based on extensive experience some of the most proficient and successful chief executive officers, financial officers and operations managers are located in California. This does not mean that their competence is available to any new startup, but some of the interviewed firms had indeed be able to secure high-end competency.

It is well documented that angel investors and venture capital are highly profuse in California. The respondents witness to how competent investors have guided them not only strategically but also on detailed operational matters that proved critical. With profound experience from failures as well as triumphs angels, fund managers and executives can more readily lead a new venture forward. It seems thus to be a matter of experience, and being a small country Swedish financiers and managers may have a high competence but many do not have as broad experiences in growing ICT companies to global players.

Likewise, there is in California a plenitude of role models to lean on: companies who have already been down the same roads and can give guidance. And this happens continuously. The interviewees reveal that they have often benefitted from learning details of operations from related companies sharing their findings. Most importantly, USA is where there is a large market, in terms of end users as well as businesses. The manager at Narrative stress that to know how to develop a camera for US customers one needs to live and breathe like they do, and thereby understand their needs and how they respond to marketing communication.

In essence, what our cases show is that it is indeed crucial and very beneficial to be located in a ICT focused region: a cluster. This gives access to otherwise unattainable resources: ideas, discussions, human capital, financing, partnerships, intellectual property, customers, market

knowledge, distribution channels, etc. Both California and Sweden can be considered to be such regions conducive to IT innovation and growth. In particular can Silicon Valley versus the Stockholm region be seen as hotspots. Most of the companies wish to remain Swedish, and have a balanced approach to how to get the best out of both milieus. This given, it cannot be denied that in several dimensions, Silicon Valley is the more advanced of the two clusters. Having a foot in each location ensures quick and high quality resource mobilization, tapping into state of the art learning, and having the ear to the market.

It has been repeated time and again that one should not make a business plan on Google buying the firm. That is, a move to California is less likely to be fruitful if the plan is solely to be acquired. Instead, clear goals and targets in terms of favorite customers and partners should be outlined. Importantly, not all IT companies would benefit from having a presence in California. For example, Silicon Valley is a hotspot for software. While there are decidedly a lot of companies developing hardware, such startups are currently a somewhat harder sell to investors.

12 ICT consultancy – Building a foundation for ICT in other sectors

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Sweden has a very large ICT consultancy segment. The lion share of both the companies and the employees offer services related to commercial and management software solutions. This chapter however focuses on ICT consultancy companies developing embedded systems in their customers´ products or manufacturing systems. It was born when the tele and defense industries introduced a disruptive technology into their products.

12.1 Introduction

ICT consultancy companies are in terms of employment the largest and the fastest growing segment in the Swedish ICT sector. In the figures mentioned earlier in this report (chapter 7.5) only companies working exclusively with ICT as their main business focus were included. This means that the number of consultants dedicated to ICT related work was deliberately greatly underestimated in that study. There are a substantial number of major consultancy companies with a diversified business focus. Some management consultancy firms, infrastructure consultancy firms, construction consultancy firms and mechanical engineering firms have subsidiaries or separate business units dedicated to work in the ICT business segment.

In a recent, and yet not published, quantitative study, made for the Swedish Governmental Agency for Innovation Systems, all consultancy companies in Sweden were identified and classified. In this study separate business units and branch offices were identified and classified differently than the head office on group level. The former ICT study (chapter 7.5) identified 1,145 ICT Consultancy firms (with more than 5 employees) with a total of 37,456 employees (2011). The latter study identified 2,083 ICT Consultancy units (with more than 5 employees) with a total of 72,645 employees (2012). In addition there were about 8,806 full time employees in smaller (with less than 5 employees) ICT consultancy companies (2012). Thus there are in total more than 80,000 full time employees working in the Swedish ICT consultancy sector.

In this chapter we are not studying the entire ICT consultancy sector. We are completely focusing on the R&D related ICT consultancy segment, which has played a very important role in the development of software products and automated production systems in the Swedish industry. As a consequence, most ICT consultancy companies are excluded. All companies that primarily offer services related to commercial and management software solutions are not included. The latter ICT consultancy segment has, as mentioned before (chapter 7), undergone heavy consolidation and globalization. This is however not true in the R&D related ICT consultancy segment.

We base our analysis on an overall description of the development of the Swedish R&D related ICT consultancy sector based on both substantial engagement in the field operatively and through additional research. As a complement, the study also rests on qualitative cases from five companies, which all have been successful and substantial players on the Swedish market during different periods since the 1970s. Our selection includes both existing successful companies and previously important companies that do not exist today. The case companies represent, or have represented, R&D related consultancy companies that have been active mainly on the Swedish (or Nordic) market. To learn more about how the R&D related ICT consultancy industry was born and how it initially developed we conducted interviews with key individuals from the startup phases.

12.2 The R&D related ICT consultancy segment in Sweden

As mentioned before there is a segment of ICT consultancy companies focused on developing embedded systems and other IT solutions intended for their customers´ products or production systems. These consultancy companies work mainly with incremental product development on behalf of their clients. ICT consultancy companies with this specialization act as an external research and development department for their clients.

In the quantitative part of this study we used a very narrow definition of a R&D related ICT consultancy firm. Only companies or business units working with the development of embedded systems and Internet of things were included. At the same time the scope was broadened in another way. In this study a lot of separate business units in consultancy groups with main focus on construction, mechanical engineering or design, such as ÅF, Rejlers, Semcon, Etteplan, Sweco, Pöyry, Outotec, I3Tex and Knightec, were included. With this approach 295 R&D related ICT consultancy companies or business units (with more than 5 employees) were identified. Together these companies and business units have 14,491 full time employees in Sweden. In addition there are 2,393 full time employees in this segment working in companies with less than 5 employees. In contrast to the commercial systems segment of the ICT consultancy sector, this segment is dominated by domestic or Nordic companies. Some of the companies have grown organically and some by smaller acquisitions. Furthermore the companies have, with very few exceptions stayed Swedish.

The externalization of ICT related research and development has made it possible for R&D related ICT consultancy companies to work at the very frontier of knowledge in a specific area, to develop attractive professional environments for skilled engineers. Simultaneously competence in a consultancy firm by definition becomes available for other companies. An individual consultant performing work for one client can of course with substantial advantage perform similar work also for other clients. In addition consulting companies with this specialization try to develop efficient methods, processes and databases, which helps consultants to benefit from their colleagues' previous assignments and experiences. In other words consultancy companies in this segment try to build structural capital to systematically improve quality and efficiency rate by exploiting the experiences from previous assignments.

The segment is dominated by a number of domestic or Nordic companies with around 1,000 employees. These larger consultancy companies have multiple workplaces and most commonly each location has its own strategic focus on a specific customer segment and certain technology and application area. These specialized workplaces are typically located near major customers. In many cases an individual consultant work extensively with colleges employed by the client and on the customers' premises for very long periods.

One larger company is HiQ, with approximately 1,400 employees in Sweden, Finland and Russia. The company has extensive expertise in communications, software development and business-critical IT. The foundation of HiQ is the specialist expertise from assignments in the aerospace, automotive and telecom industries during the 1990s. Many customers of HiQ are still in these technology-intensive industries, and advanced technological skills are still the foundation of HiQ's success, but the market and the customer base has broadened when client companies have outsourced more and more of qualified R&D activities in the ICT field.

Another large company with this business focus is Combitech with about 1,200 employees in Sweden. Combitech is seeking its roots to the former Saab-Scania Group's joint technology development, but in the 2000s Combitech also grew through mergers, including TietoEnator Communications, TietoEnator Telub, Celsius Aerotech, Caran Saab Engineering and Sörman Information AB. The company is now fully owned by Saab AB, but has many customers outside the group. Important customer segments include defense, aerospace and telecom industries.

A third representative of the larger companies in this specific group of consultancy companies is Prevas, with roughly 600 employees in Sweden. Prevas specializes in embedded systems and industrial ICT. It was founded 1985 in Västerås and the founder had close links to ABB's automation expertise and good contacts with Volvo's manufacturing of components in Köping and Skövde. Expertise on automation of manufacturing processes was a key ingredient in the company's offerings right from the starting point. In the 1990s, the company established new offices with application expertise that suited the local customer structure. As an example Prevas established an office in Malmö, specializing in the food & beverage and the pharmaceutical industries. In the 2000s, the company also grew through a number of smaller acquisitions.

Cybercom Group AB is a fourth major company with approximately 830 employees in Sweden. Cybercom too is a Swedish company, with the Nordic region as its home market. The company has a clear focus on technical systems and relies primarily on customers in the telecom and financial sectors. The company was established in 1995 and has grown extensively through acquisitions.

The R&D related segment of the ICT consultancy sector is partly dominated by a handful Swedish-owned companies originating from the development of technology-intensive systems for Swedish engineering companies. Another group of large competitors, with main focus on other consultancy business, have also, partly through acquisitions, expanded into this segment. ÅF:s Technology division has about 700 consultants working in this area. Many of Rejlers 1,000 engineering consultants also have specific competence and work in this segment. Another

large player in this segment is Semcon. A rather large part of Semcons 3,000 consultants have specific competence about embedded systems.

Finnish Etteplan has a subsidiary in Sweden, with approximately 450 employees, which partially deliver this type of services to the Swedish industry. Sweco has divisions like Elektronik and Industry that incorporates around 250 employees. Outotec is a mining-oriented service business with 250 employees delivering services in this field. I3Tex with 250 employees is another company that is specialized in this specific ICT services area. Knightec with 300 employees is a product development consultancy company that to some extent focuses on embedded systems services.

All major competitors in this segment still have their main operations in Sweden even if some of the larger companies can be considered Nordic companies. So far very few foreign acquisitions, in contrast to the ICT consultancy segment related to commercial systems, can be observed. An exception, however, is the French Altran Group with around 17,000 employees. In 2001 Altran broke into the Swedish market through the acquisition of Consignit AB. Altran has close to 300 employees at three locations in Sweden.

Alongside with the larger consultancy companies there are a very large number of small consulting firms with this business focus. It is also most likely that there will be new specialized companies focusing on new application areas and new industries. There will be further increase of complexity in computerized industrial systems with the development of embedded systems and machine-to-machine applications (Internet of Things).

We believe that the R&D related ICT consultancy industry in Sweden has played an increasingly important – and so far rather neglected – role in an important technical innovation system in Sweden. The R&D related ICT consultancy industry has been very instrumental when developing improved functionality in engineering products and in production processes in Swedish industry.

Table 12.1: The 10 largest R&D related ICT consultancy companies

POSITION	COMPANY	NUMBER OF EMPLOYEES 2012	PRIMARY OWNERSHIP	HEAD OFFICE
1	Semcon AB	2,891	Sweden	Göteborg
2	HiQ AB	1,326	Sweden	Stockholm
3	Combitech AB	1,164	Sweden	Linköping
4	Xdin AB (now Alten Sverige AB)	861	France	Göteborg
5	Cybercom AB	832	Sweden	Stockholm
6	ÅF-Technology AB	695	Sweden	Stockholm
7	Prevas AB	590	Sweden	Västerås
8	Altran Sverige AB (incl. Altran Technologies Sweden AB)	364	France	Göteborg
9	Knightec AB	298	Sweden	Uppsala
10	Syntronic AB	279	Sweden	Gävle

The consultancy firms can be regarded as a commercial part of an innovative system that really is on the forefront in developing embedded systems for product as well as process development.[174] They work in very close cooperation with their customers, both product developers and production engineers, and they have great possibilities to use experience from one project in one company also in other projects in other companies and other industries. That individual companies could benefit from this is also in line with theories about open innovation,[175] which assumes that firms should use external expertise as well as internal in their R&D.

12.3 Characteristics of the R&D related ICT consultancy industry

When microprocessors and digital electronics made an entrance into the Swedish defense and telecom industries, the R&D related ICT consultancy industry was born. The new ICT consultancy industry was very different from the ICT consultancy business already in place.

In the early 1970s microprocessors made an entrance in former purely mechanical products. Tasks, which earlier were carried out by analogue components, could then be executed in a digital domain. The new 8-bit microcontrollers together with assembly code offered huge possibilities to create new and improved functionality in many different products. But there was also a need for new competence to take advantage of the new possibilities. A new profession – "the computer software developing electrical engineer" – was born.

Most Swedish engineering corporations have consulted external expertise since the very first steps to increase functionality by using microprocessors in their products. Most of the R&D related ICT consultancy firms started out with just a few employees. In most cases expansion started almost instantly, due to high demand and access to qualified young engineers from Swedish universities. These new consultancy firms often took on roles as complementing external R&D departments for their customers.

In the very beginning 4-bit and 8-bit processors performed simple tasks. Soon enough engineers started to add functionality and both source code and system behavior rapidly became more complex. Complexity made it hard to plan the system resources to make the performance predictable over time. Technical solutions with multi-threaded software (sometimes running on several processor kernels) tended to require experienced engineers. Other early challenges were memory management, portability, communication interfaces, display support, sound etc. Such functions are nowadays commonly provided by standard Operating Systems even for very specific hardware platforms. Consultants, with extensive experience from this type of assignments, often perform these specific adaptations.

[174] Laestadius and Rickne (2012)
[175] Chesbrough (2003)

Most engineering companies, that incorporated embedded computer systems in their products, soon came to a conclusion to further improve some principal areas. After the initial projects many customers wanted to accomplish three things:

- Structured ways for multiple developers to work on the same code base
- Ways to reuse and configure software for multiple products from their product line
- Improve testing activities to find problems early in the development projects

These demands caused concepts like object-oriented architectures and model based design concepts to emerge. Crucial resources and experiences were often needed when it came to introducing these new and modern concepts in product development. Sometimes it turned out that consultancy companies, which earlier had helped other customers with similar tasks, had the necessary expertise.

Today R&D related ICT consultancy firms sometimes are empowering and enhancing large-scale R&D departments with special expertise or just plain “doing”. In other cases consultants are forming versatile software R&D functionalities for customers, who completely lack this ability. Assignments can be conducted on customers’ or consultancy firms’ premises, or in a mix.

Understanding R&D related ICT consultancy companies

To develop a deeper understanding of how the R&D related ICT consultancy sector emerged and developed we have examined a number of successful consultancy companies that played important roles during different periods of the new industry´s life cycle. We have chosen two companies that were important suppliers of consultancy services to Ericsson at an early stage. We have also chosen three of the presently large R&D related ICT consultancy firms. The analysis is mainly based on interviews with founders of the five R&D related ICT consultancy firms, public information on home pages as well as articles and reports.

Enea was founded in 1968 by four students from the Royal Institute of Technology. It was one of the first R&D related ICT consultancy firms in Sweden. The first assignment was to design a solution for storing data in an air traffic control system. During the 1970s the customer base grew and Stansaab, ASEA, LM Ericsson and Facit were important customers. During the 1980s ASEA became the largest customer. Enea also worked on a new dispatch system for the Swedish police. Enea advanced to other customers and started new offices in Gothenburg, Linköping and Malmö. Another crucial customer for Enea, when developing embedded systems, was LM Ericsson in Kista. In the late 1990s Enea had about 1,000 employees and several hundred consultants worked on site on Ericsson´s premises.

SoftLab was founded in the early 1980s by two researchers, Jerker Wilander and Kenth Ericson, as a spin off from the department of Computer Science Engineering at Linköping University. SoftLab grew and continuously recruited new employees from the program in Computer Science Engineering. To extend the recruitment base SoftLab started new offices in Uppsala and Stockholm. In the mid-1990s SoftLab had about 90 MSc in engineering employed. Ericsson remained the largest and most important customer but SoftLab also contributed in product

development for other companies in different industries, e.g. industrial robotics, machinery and auto carrier systems. The company was sold to Rational Inc. in 1997.

Prevas was founded by Göran Lundin in 1985 as a spin off from the Swedish electrical company ASEA (today ABB). Prevas was founded in Västerås, a city about 100 kilometers west of Stockholm. Göran Lundin and other young employees had experience from product development in ASEA and from assignments primarily at Volvo in Köping, a city about 100 kilometers west of Västerås. ASEA, Volvo and a machine tool manufacturer, SMT, were important customers at an early stage. Prevas grew rapidly and, based on assignments for the telecom industry, launched an office in Stockholm in 1986. In 1996 Prevas launched new offices in Linköping and Uppsala and in 1997 in Malmö and Skövde. Prevas's customers are found in industries like telecom, machinery, automotive, defense, life science and electricity. At present Prevas have 20 offices in Sweden and a few abroad.

Combitech Software was founded in 1992 when Saab Instruments had successfully delivered integrated control software to the Swedish shipyard Kockums. It was a state-of-the-art software first installed in submarines bound for Australia. After the delivery Saab had an obligation to be of service – when needed – in Australia for some years. Based on this group of software engineers (six persons) Saab-Scania Combitech started a joint venture together with Enea named Combitech Software. The customers included companies in different industries; life science, defense, telecom, machinery and automotive. During the first three years Combitech Software set up new offices in Gothenburg, Jönköping, Linköping and Stockholm. Today Combitech has around 1,200 employees. Combitech has offices on 20 locations in Sweden and 2 locations in Norway.

HiQ was founded in 1995 as a spin off from a more general Swedish IT consultancy firm, Enator, in 1995. The three founders had common experience from prior projects in the field of flight simulators. HiQ opened offices in Stockholm and in the city of Arboga, about 170 kilometers west of Stockholm, to stay close to their main customer. Initially HiQ only focused on defense projects but soon added telecom projects in Stockholm. In 1999 HiQ acquired a business in Gothenburg and launched services to the automotive industry. In 2002 HiQ acquired a consultancy company in Finland, which added the first office outside Sweden. At present HiQ's customers are found in industries like telecom, media, retail, public sector, machinery, automotive, defense and finance. Today HiQ has 1,400 employees. HiQ has eight offices in Sweden and three abroad.

12.4 Common denominators in R&D related ICT consultancy firms

R&D related ICT consultancy firms in Sweden are, with few exceptions, domestically owned and operated companies.[176] It makes this industry different from consultancy siblings in the purebred ICT consultancy sector. This latter industry is much more consolidated. Large international corporations nowadays own former Swedish ICT consultancy firms; while the

[176] Giertz et al (2013)

R&D related ICT consultancy firms so far have remained very “Swedish”. Most of the larger companies also have a lot in common.

Starting point

Most of the larger companies are sprung from either the telecom or defense industry. There is one exception, Prevas, which was a spin off from industrial robotics. Defense and telecom (and industrial robot technology) were early users of the new microprocessor technology in their product lines. Most of the consultancy firms were founded by a small group of skilled engineers, who executed the first assignments themselves. They were well known authorities to their first costumer, who put a lot of trust in them. Thus the business often started on a local market with good personal connections to important R&D managers in large engineering companies. Most of the founders were well-educated engineers from MSc programs like Electrical Engineering. It seems as if Swedish universities taught their students valuable knowledge in the field of digital electronics in the 1970s.

Expansion

The larger R&D related ICT consultancy firms expanded by organic growth during the early years. Basically they all recruited intensively at Swedish universities to find the engineers with fresh competence in this new branch of engineering. The new professionals were to a high extent recruited among young students who had graduated with an MSc in Engineering.

Many Swedish engineering programs teach their students theory for automatic control of systems. This specific skill defines a significant difference between software developing engineers and a “general software developer”. This foundation of theory helps the software developer to design power control systems, regulators for radio hardware, motor control systems, injection systems for engines, torque control on assembly tools, wing control systems for aircrafts, navigational software, control of construction equipment, automatic transmissions, material processing tools, automatic milking systems etc. Furthermore computerized systems are frequently used to create algorithms for encryption, compression of data, modulation for radio transmission, speech emulation, signal processing etc.

The senior engineers provided skill and guidance while the less experienced “rookies” provided speed and new knowledge from academia. After the first few years most consultancy firms founded new offices, in other Swedish cities. The locations of the new offices were close either to the customers´ large R&D departments or to technical universities. Very few offices are found north of Stockholm or outside the Nordic countries. Typically these new offices started up based on a local entrepreneur with experience (and potential business contacts) from product development on a local market. The studied companies have applied a split concept where some crucial values and guidelines are governed from the central office, while other principal matters are left to be defined by local management, on the local market.

The larger consultancy firms have during recent years also started to use mergers and acquisitions to further expand the business in three ways:

- Reach a new local market
- Gain access to a new type of industry (specific domain expertise)

- Expand the offer to an existing customer base

It seems as if very few firms have purchased smaller consultancy companies just to expand faster, achieve savings or benefit from large-scale.

Production engineering – a common ground

Many assignments are in product development, but much of the product development is focusing on the development of more effective production equipment, such as assembly systems, automatic milking systems, tooling systems, industrial robotics and so on. This means that many product development assignments also call for competence in production engineering.

Many of the R&D related ICT consultancy firms also work very close to highly automated factories and some of them are frequently engaged in the development of more effective manufacturing systems in Swedish factories – and Sweden still has a very high concentration of flexible manufacturing systems.

In Sweden big headlines are seen in media when large Swedish corporations, like Electrolux, Ericsson and Autoliv, move manufacturing abroad and close down large work places in Sweden, but it is rarely noticed that many large engineering corporations, like Scania, Volvo, Atlas Copco, Alfa Laval and Sandvik, also close down factories in other European countries and concentrate their highly automated European manufacturing, especially metal cutting (turning, milling, grinding drilling etc.), to Sweden. Thus there is still a very high concentration of highly automated factories for cutting metal located, close to the R&D departments, on a 500 kilometers long and 300 kilometers wide belt from Stockholm on the east coast to Gothenburg on the west coast of Sweden. All larger R&D related ICT consultancy firms in Sweden have most of their offices located on this very belt.

Sticking to the nuts and bolts

Most consultancy firms hold very little (or none) intellectual property rights (IPR). During the 1990s some R&D related consultancy companies, e.g. Enea, developed products of their own. But these companies now have left the industry. Today most successful R&D related consultancy firms stick to their nuts and bolts. There seems to be a common understanding between costumers and consultancy firms that the consultancy firms keep the right to reuse the ways of working, invented in projects, while the customers keep all IPR. Furthermore most consultancy firms are extremely cautious not to raise any suspicion that something, invented in a specific project, ever could be used by the customer's competitors. As a consequence very few patents regarding products are filed directly by consultancy companies.

A mix of business models

The Swedish consultancy industry is in general dominated by companies who charge their customers by the hour. This is also true for the R&D related ICT consultancy firms, but most companies perform a mix of fixed price assignments and charging by the hour. This far neither consultancy firms nor customers have strived to give the consultancy firms a stake in a specific product’s future success. However there are some examples of incentive models involving parameters like production cost of electronic hardware.

It seems as if some companies, e.g. Combitech, who have most of their consultants working on their customers´ premises, are more likely to charge their customers by the hour. Other companies, e.g. SoftLab and Prevas, with more consultants working in house have been more willing to strive for fixed price assignments.

Developing methods and processes

When the first 4 bit and 8 bit processors entered mechanical products, engineers used assembly language to program functionality. In the beginning only few people were involved in rather non-complex projects. But soon the development teams introduced more powerful and efficient approaches to computerize their products. It seems as if a major technological change, and a new generation of technical solutions, has been introduced every decade or so. These technological “milestones” also gave opportunities to introduce new methods, concepts, roles, programming languages, operating systems, development tools and hardware.

Initially many engineering companies suffered heavily from expensive maintenance of existing embedded systems due to delivery-specific versions of software, which required special source code instead of just configuration of data. Many experiences have been drawn from each development project. The larger R&D related consultancy firms seem to be on the forefront in gathering experience. They play an important role when spreading the gained best practice to new industries, new companies and new product areas.

Ever since the introduction of high-level computer languages for embedded computer systems so called cross compilers are required, along with debugging tools to interact with the more generic desktop development environments. Continuously more engineers have been introduced in the development activities and in turn the need for configuration and change management, frameworks for software testing, build scripts and product-line architecture has increased vastly.

Final remark

Ericsson did not choose to rely entirely on in-house competence when the company successfully coped with the transformation to a disruptive technology. As a consequence Ericsson gave birth to a new R&D related ICT consultancy industry, which today is a vital part of the fastest growing ICT sector in Sweden. Our analysis shows that this new industry successively has broadened its customer base. Consultancy companies started to develop embedded systems for engineering companies that still were in a specific phase of their life cycle and with an existing dominant design in their products. One question that we raise is if the externalization of R&D related ICT development gave engineering and manufacturing industries as well as other industries in Sweden a competitive advantage, since the necessary competence to develop both new products and efficient production systems was available to buy on the domestic market. Chapter 14 is to some extent an answer to that question!

13 ICT in other sectors

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This chapter provides an overview of how ICT permeates non-ICT industries. We discuss the cross-industry importance of big data, cloud computing and Internet of Things (IoT). While the ICT sector in and of itself is large and vibrant, ICT as a pervasive technology sifts into and influences, or even revolutionizes, most economic sectors.

13.1 Digitalization in non-ICT sectors

Information and communication technologies are changing products, services and competitive conditions in virtually all businesses and industries. In this way, ICT knowledge permeates activities in many traditional, or previously not digitalized, sectors. Naturally, the ICT sector (as defined in this report) and the sectors using ICT are co-dependent and collaborating as producers and users, suppliers and customer, co-developers. ICT becomes more integrated into products and services in other sectors, and these industries contain a larger share of ICT related knowledge and skill sets, and build their competitiveness to an increasing extent on ICT-related competence. ICT related tools and processes change the way one does business, create new market opportunities and lower costs.

It seems as researchers and companies alike agree that while much innovation and cost cuts have already been achieved, the large potential is still ahead. It is truly difficult to measure the productivity and growth gains ICT has on other sectors. This has been referred to as the Solow paradox.

Swedish calculations show that digitalization contributed to 32% of the country's productivity growth during the time period 1995–2005, and 42% from 2006 to 2013. However, even though there is much investment in ICT technology in a number of sectors, the productivity gain is – as measured in this manner - almost entirely fount in that ICT sector in itself, and not in other sectors of the economy.

This rhymes well with OECD figures revealing that work productivity in general is higher in the IT sector. Sweden has had one of the best productivity increases in the 2000s. In 2012, Sweden's general work productivity was 10% higher than the OECD average (behind e.g. USA, Belgium, France, Germany, the Netherlands, Denmark), and the Swedish IT sector is 60% ahead of the average (behind e.g. USA, Ireland, Belgium, Canada). Finland's productivity figures are close to the OECD average, both as regards the economy as a whole and the IT sector.

Even though productivity advances are difficult to measure in other sectors, there are clear links between innovation and the degree to which organizations use ICT, but the causality between

the two is not obvious. ICT has brought significant changes to how companies do business. ICT comes into all parts of the operations: technological and competence platforms, development processes, process equipment, internal administration, decentralization processes, communications, global networks, service offerings, customer communication, access to global markets, etc. Naturally, to invest in ICT technology or equipment is not sufficient, but associated structural, organizational and operational changes are necessary. New possibilities continuously emerge, and today big data, cloud computing, and *Internet of things* poses new challenges and opportunities.

Changes spurred by ICT technologies and digitalization relate to basically all business sectors. Out of the manufacturing firms, the engineering sector has undergone a change process towards embedded systems linked to *Internet of things*. Since this is such a crucial change process we'll spend an entire chapter on its development in Sweden, and discuss how some main firms have handles these competence shifts and disruptive technological and organizational alternations.

Also, the media sector has faced a profound structural change in this respect. On a positive note, their services are increasingly digitally distributed which has spurred the segment's rapid development. Meanwhile, the development also involves challenges. Through ICT-based consumption patterns (for example, file sharing), in particular the film and music industry's established logic and business models have been challenged. Digitally distributed content has also created revenue shortfalls, particularly for printed news media. In recent years, however, from companies – including some Swedish ICT-based companies such as *Spotify* – demonstrated new functional business and revenue models, often linked to streaming based subscription services. More and more consumers choose to become a subscriber to streaming services, which media professionals must gradually adjust to. Although the music and film industry looks to adapt to new types of subscription models, it is uncertain how the news media, especially originating in traditional print media, will be able to establish effective business models in line with increased digitalization.[177]

Another, quite different type of sector, significantly affected by ICT technologies is the retail sector. Retail increasingly incorporates ICT into its offers. Computers were introduces in the back office for ordering and invoicing in the the 1970s, electronic cash registers and bar codes (such as European article numbers) during the 1980s, and automated bar code reading in the checkout systems during the 1990s. Today ICT is used to capture market shares through increased customer and interaction. In addition, some of the sector has been transformed into web shops.

Yet another area which has captured much attention in recent years involves changes on both the user/patients part and for care givers: e-health – or distributed health – is expected to revolutionize how health care is delivered and to whom. More importantly, it will – and perhaps already has – alter the way we look at health and wellbeing, as well as the role the patient has in

[177] The changes in various sectors, and their increased ICT content, imply that the delineation of the ICT sector as such becomes fuzzier. For example, it is fair to ask whether not the media industry, due to changes in technology and competence base, nowadays could be seen as a part of the ICT sector. We will however leave these issues of delineation aside.

this process. ICT presents opportunities for patients to be involved in all parts of the process. Readily available information access through the Internet makes patients and their relatives knowledge, making them able to pose questions and demands, ask for the latest treatment, or choose between alternative care providers. Information access has also created opportunities for new types of self-care, as has ICT-based instruments for e.g. monitoring heart functioning or glucose levels. In effect, all this means that the basic routines of care are about to change drastically. This places pressures on governments and regions to develop new effective interaction and forms of dialogue between patient organizations and health professionals, to understand how to prioritize resources, and to be proactive in terms of regulations. It also changes the premises for care givers. In addition, patient organizations take on a more central role.

Another industry which has undergone a fundamental change through digitalization is banking. Today banks operate ICT networks which are similar and as complex as ICT networks run by telecom operators. In Sweden, a cash less society is now close to be realized.

The examples above also make it clear that the ICT sector is, naturally, inherently dependent on its customer industries: these other sectors contribute significantly to the growth of the ICT sector. Through their demands on hardware, software, ICT consulting, service and maintenance, operations, cloud services - and by choosing to outsource rather than develop in-house - these customer segments induce an expansion of the ICT sector as such.

Recently, what is popularly denoted as 'the sharing economy' is also on the rise. 'Driven by digitalization, the Sharing Economy involves the peer-to-peer exchange of tangible and intangible slack … resources … However, the elimination of third-party intermediaries means that risks are often borne by the providers and consumers of resources rather than by a central actor.'[178] The sharing economy may have substantial effects not only how we do business, on the competitive landscape and probably on pricing and availability of services. It may also affect productivity – something that is now difficult to discern in public statistics and GDP figures. While the sharing economy presupposes some values of equality, sustainability and good use of resources, the business models of network based increasing returns, means that early movers or firms successfully attracting a large customer base have a clear advantage.

13.2 Recent trends

As mentioned above, some of the recent trends of how ICT integrates into our economies relate to what we may call big data, cloud computing, and *Internet of Things*.

Big data and cloud computing

The popular concept of 'big data' denotes that organization – firms and governments and others – have during latter years found new use for the large sets of structured and unstructured data available. Enormous amounts of data points are collected – through machine communication, sensors, social media, etc. – and as these data now can be stored to a reasonable cost the issue becomes one of how to deal with this data in a timely and accurate manner to create value.

[178] Felländer et al. (2015, p.7).

Technical issues related to speed, real-time collection and analysis, making formats compatible, etc. Careful use of such data resources may help understanding of phenomena, guide in decision processes, or provide a competitive advantage through cost cuts, innovation or market knowledge.

Cloud computing is a way to handle such big data as well as to offer other services. A cloud have been defined as 'a platform or infrastructure that enables execution of code (services, applications etc.), in a managed and elastic fashion' (European Commission, 2010, p. 9), where elasticity refer to load-balance and scalability. There are clouds with different functionality: resources (storage), services, computation and analysis.

One may argue that cloud computing in essence is nothing new but has in its main parts been there all along. Cloud computing is really a model for service delivery, and many sites may be connected to form the cloud and its inherent possibilities. Such high capacity computing can give solutions for many organizations, and for most computational problems. It offers fast and affordable data analysis. With a propensity to outsource ICT capacity and competence this decreases the need for managing some forms of ICT related issues, and instead concentrating on others. Importantly, development times and time-to-market can be reduced when relying on partner organizations specialized in big data analysis and cloud computing. Cloud services offers opportunities to test various solutions and business models, and gives comparably low entry costs in several sectors. In this way, the cloud might be especially serviceable to small firms and start-ups, offering both supple and resourceful ways to access hardware and software. Supercomputing, on the other hand, implies specialized needs and only has a more limited customer base.

To the user it should be indifferent who provides the service as long as it is of suitable quality. The most prominent feature of the cloud is perhaps its scalability. Storage through the network, server time, on demand services, etc., are not only rebranding of previous existing feature but rather signal extensions with immense prospective. Potential concerns relate to security, loss of control over the organizations core information assets and vulnerability to providers' potential failures. Today there are still both technological and organizational or content related elements to be solved, and much proposed potential of the clod is still to be fulfilled.

While the US currently take on a global lead in providing resources for cloud computing, some point to Europe having joint opportunities when it comes to procuring and producing a global cloud ecosystem. This in turn opens up for various new roles, such as cloud hosts, software developers, tools providers and users as data partners.

This relates especially to common research efforts, policies and regulation. As discussed in the other chapters of this report, both Swedish and Finnish firms are active in taking several of these roles.

On the user side, it seems as Swedish firms are switching over to cloud based services at a higher speed than its European counterparts. Hybrid solutions - with part internal operations and part cloud reliance – have been adapted by 63 per cent of the Swedish as compared to the

European average of 45%, and only 36% of Swedish respondents had own server facilities (50% in Europe).

Internet of Things

The term *Internet of things* – or *Industrial internet* – was popularized by *General Electric* in early 2000s. GE's industrial internet scenario was mainly oriented to industrial manufacturing systems or equivalent, efficiency of equipment and systems used in the manufacturing operations (e.g., energy consumption, predictive maintenance, and production optimization).

It has been suggested that *Internet of Things* (IoT) may cause the third industrial revolution. The first revolution machines replaced human labor, revolutionizing the manufacture of the scale, productivity, and improving workers' quality of life products. Another revolution, the Internet, laid the foundation for a new kind of way of doing business regardless of location data. With IoT, smart devices and machine-to-machine communications become an increasingly important part of the virtual world. Cloud computing is IoT's technical foundation. IoT uses big data for intelligent data analysis increases the usefulness of connected machines. The various objects commune not directly with one another, but with a central node where data is analyzed, coordinated and sometimes combined, and then reiterated to the object or objects.

In the current early stage of IoT developments, most industrial companies use their internal platforms and most of collected data stays within companies' firewalls. If so, the main idea is to the company's products and services over their life cycle. Reaching even this stage remains a considerable challenge. For example, in our interview one industrial engineering company in Finland noted that "Some 60% of our products ship with Internet connectivity. In about 40% of these, the product is actually connected to the Internet. Thus, about 24% feed data back to our internal platform." Deploying IoT to provide maintenance and support is a good first step, albeit far from the ultimate vision associated with IoT, which involves all-encompassing and largely autonomous communication between relevant aspects of physical environment in such a way that needs of businesses and individuals are met as they emerge.

Ultimately IoT changes the design philosophy of the products and services: the software is no longer embedded into smart products and services, but the smart products and services are increasingly embedded into software.

13.3 IT using sectors in Finland

To illustrate the trends discussed above both as regards the importance of ICT in a variety of sectors, and the specifics of big data, cloud computing and IoT, in this section we discuss these issues in light of Finnish data. The themes covered are software development, the effects of digitalization on firms' products, big data and related analytics, and IoT.

Our data is derived from on a large firm-level survey which was conducted by ETLA in the late spring 2015. It includes nearly 5000 useable responds related to the ICT use. The results reported in this section have been weighted in order to be representative to the whole business sector. The industry classification we employ is presented in Table 13.1.

Table 13.1: The industrial classification employed in this chapter

ICT MANUFACTURING	See Chapter 3. The categories below **exclude ICT** .
ICT SERVICES	See Chapter 3. The categories below **exclude ICT** .
PRIMARY PRODUCE	Agriculture, forestry & fishing Mining & quarrying
FOODSTUFFS	Manuf. of food products Manuf. of beverages Manuf. of tobacco products
TEXTILES, APPAREL	Manuf. of textiles Manuf. of wearing apparel Manuf. of leather & related products
PULP, PAPER, WOOD	Manuf. of wood & cork products (excl. furniture) Manuf. of paper & paper products Printing & reproduction of recorded media
CHEMICALS	Manuf. of coke & refined petroleum products Manuf. of chemicals & chemical products Pharmaceuticals Manuf. of rubber & plastic products
METAL, MINERAL PR.	Manuf. of other non-metallic mineral products Manuf. of basic metals
ELECTRICAL EQUIP.	Manuf. of computer, electronic & optical products (excl. ICT) Manuf. of electrical equipment
MECH. MACHINERY	Manuf. of machinery & equipment n.e.c. Manuf. of motor vehicles, trailers & semi-trailers Manuf. of other transport equipment
OTHER MANUF.	Manuf. of furniture Other manufacturing Repair & installation of machinery & equipment
ENERGY, WATER	Electricity, gas, steam & air conditioning supply Water supply; sewerage, waste mngnt, remediation activities
CONSTRUCTION	Construction
TRADE	Wholesale & retail trade; repair of motor vehicles/cycles
LOGISTICS, COMM.	Transportation & storage Information & communication (excl. ICT)
HOTELS, RESTAUR.	Accommodation & food service activities
FINANCIAL SERV.	Financial & insurance activities Real estate activities

Source: ETLA.

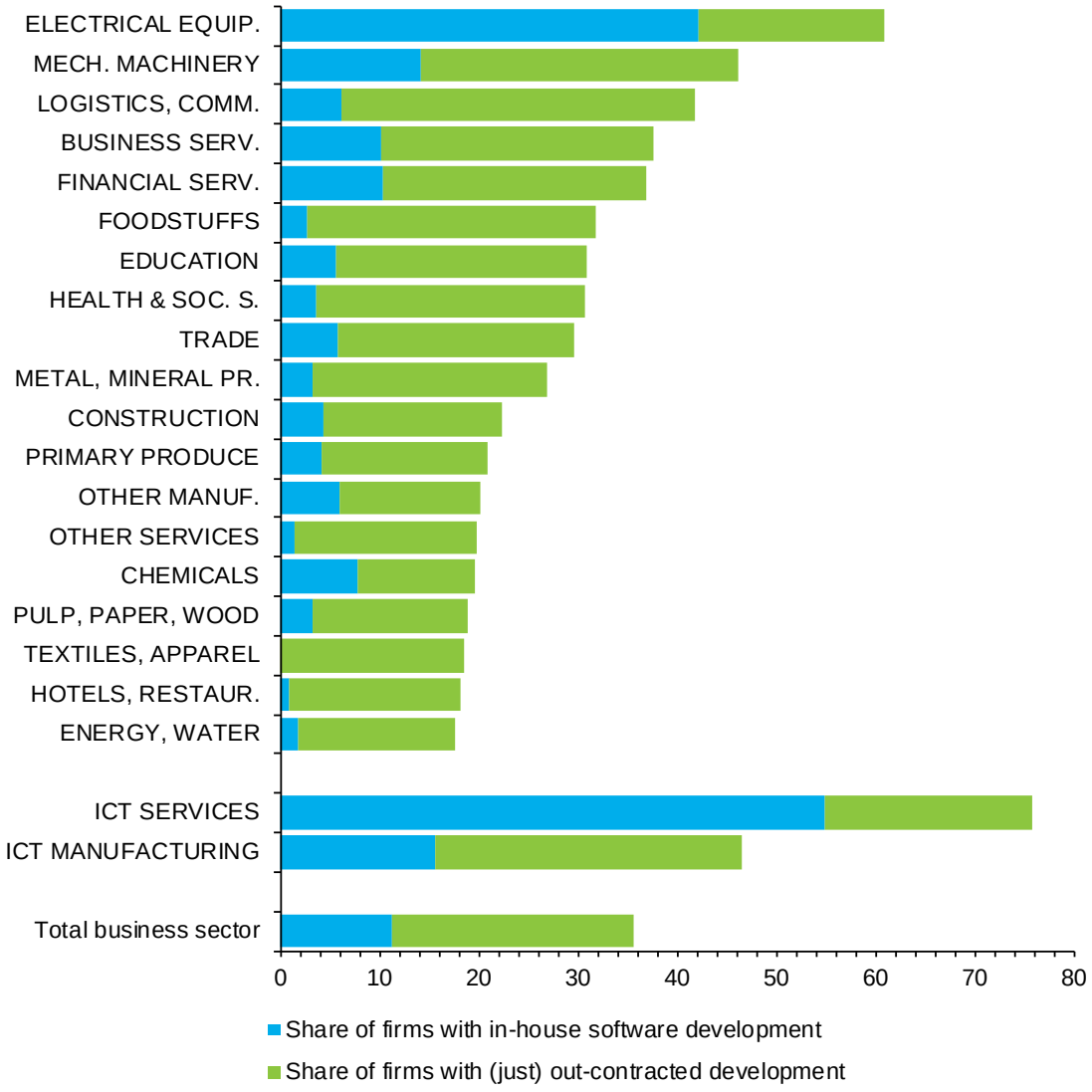
Software development

In total, every third of the Finnish companies have either in-house or out-contracted software development. Software development is the most common in ICT services, in which 75% of the firms have been engaged in software development. Another industry in which over half of the firms have either in-house or out-contracted software development is electrical equipment industry (excluding ICT manufacturing). The share of firms who do software development either in-house or by out-contracting is the lowest in energy and water supply, and in hotels and restaurants, in which clearly less than 20% have such an activity.

Out-contracted software development is more prevalent in the Finnish business sector than doing it in-house. Every fourth of the firms have out-contracted software development but only every tenth do it in-house. By industry, out-contracted software development is the most endemic in logistics and communication (excluding ICT services) and in mechanical machinery, in which about one third of the firms have engaged in this sort of activity. On the other hand, in-house software development is the most common in ICT services in which over half of the firms

are doing this activity. Outside of ICT industries, in-house software development is most frequently observed in electrical equipment industry (excluding ICT manufacturing) in which about 40 percent of the firms have own IT development workers. In contrast, in textiles and apparel, in hotels and restaurants, and in energy and water supply in-house IT development is rare.

Figure 13.1: Software development and related sub-contracting by industry, %



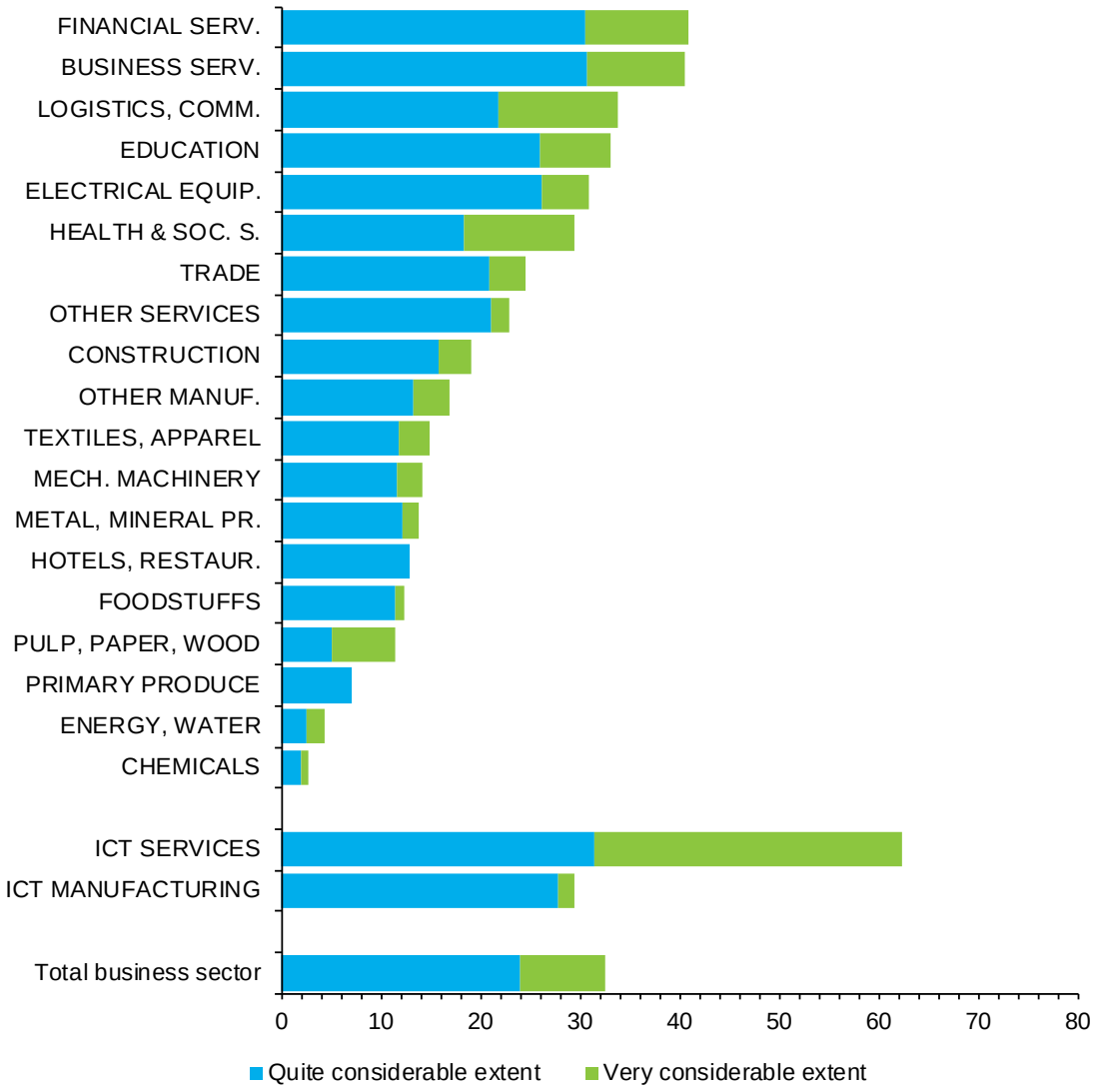
Source: Etla 2015 survey.

Digitally-enhanced products

One third of the Finnish firms see that digitalization is enhancing their products by creating ways to add new features to them. This belief is the strongest in ICT services in which nearly two thirds of the firms agree with this claim. Also among the firms in financial services and in business services there is a great trust in opportunities created by digitalization. In these industries about 40 percent of the firms agree with the statement that their offerings are

enhanced by digitalization to a quite or very considerable extent. The lowest belief in business opportunities created by digitalization is in chemical industry and in energy and water supply in which only 2–4 percent of firms are confident that digitalization is enhancing their products.

Figure 13.2: By industry shares of firms providing digitally-enhanced products or services, %



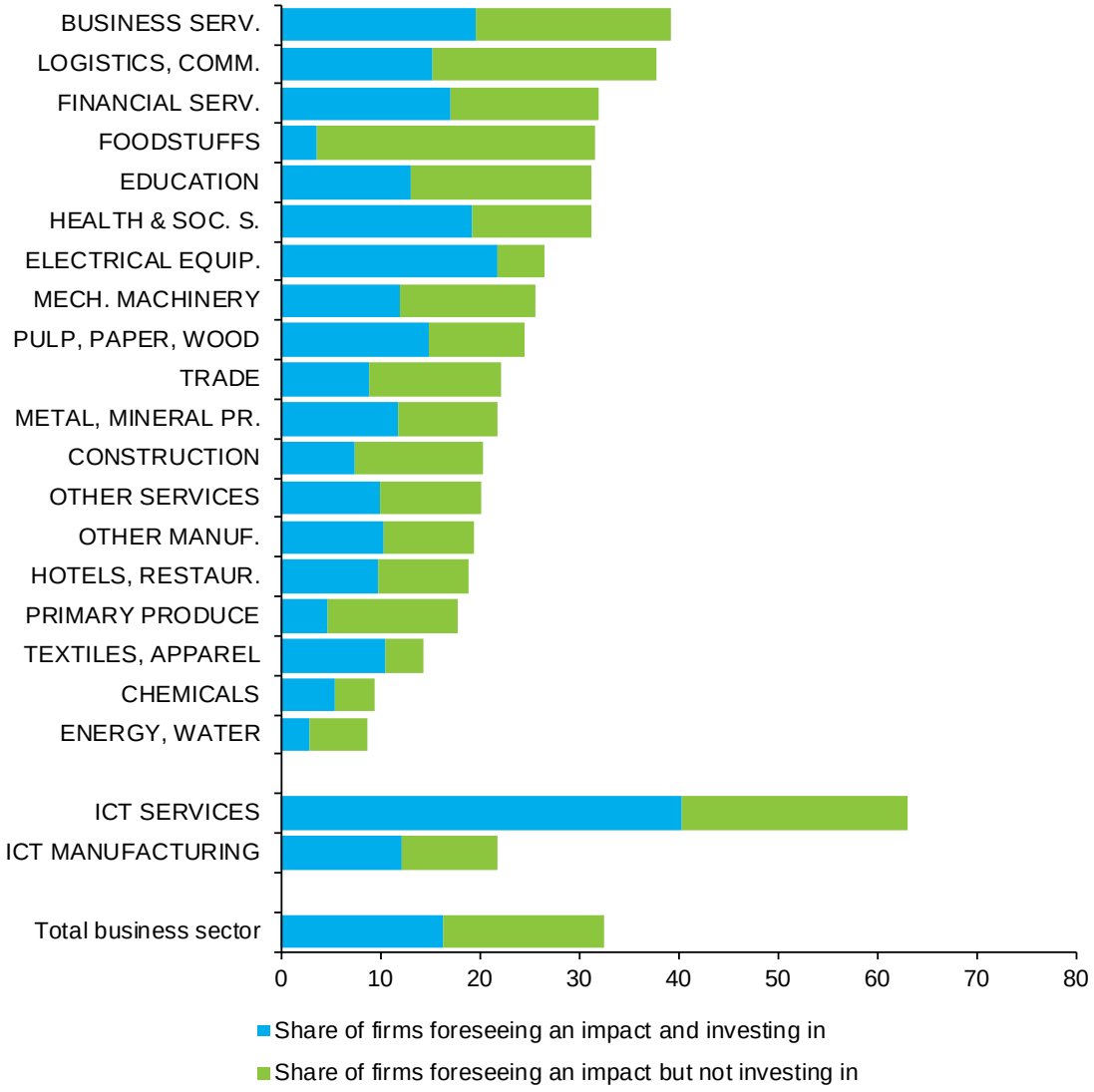
Source: Etla 2015 survey. Share of firms stating that their offerings are enhanced by digitalization to a quite or very considerable extent

Big data and related analytics

One third of the Finnish firms foresee that big data and related analytics have an impact on their industry during the next three years. This view is the strongest by industry among ICT services in which over 60 percent of the companies think that big data and related analytics are changing the industry. Also in business services (39%) and in logistics and communication (38%) companies foresee frequently that big data will have an impact to their industry in the next

years. On the other hand, in energy and water supply and in chemical industry less than 10 percent of the firms assume that big data will change their industry during the coming years.

Figure 13.3: The future impact of big data and related analytics by industry, %



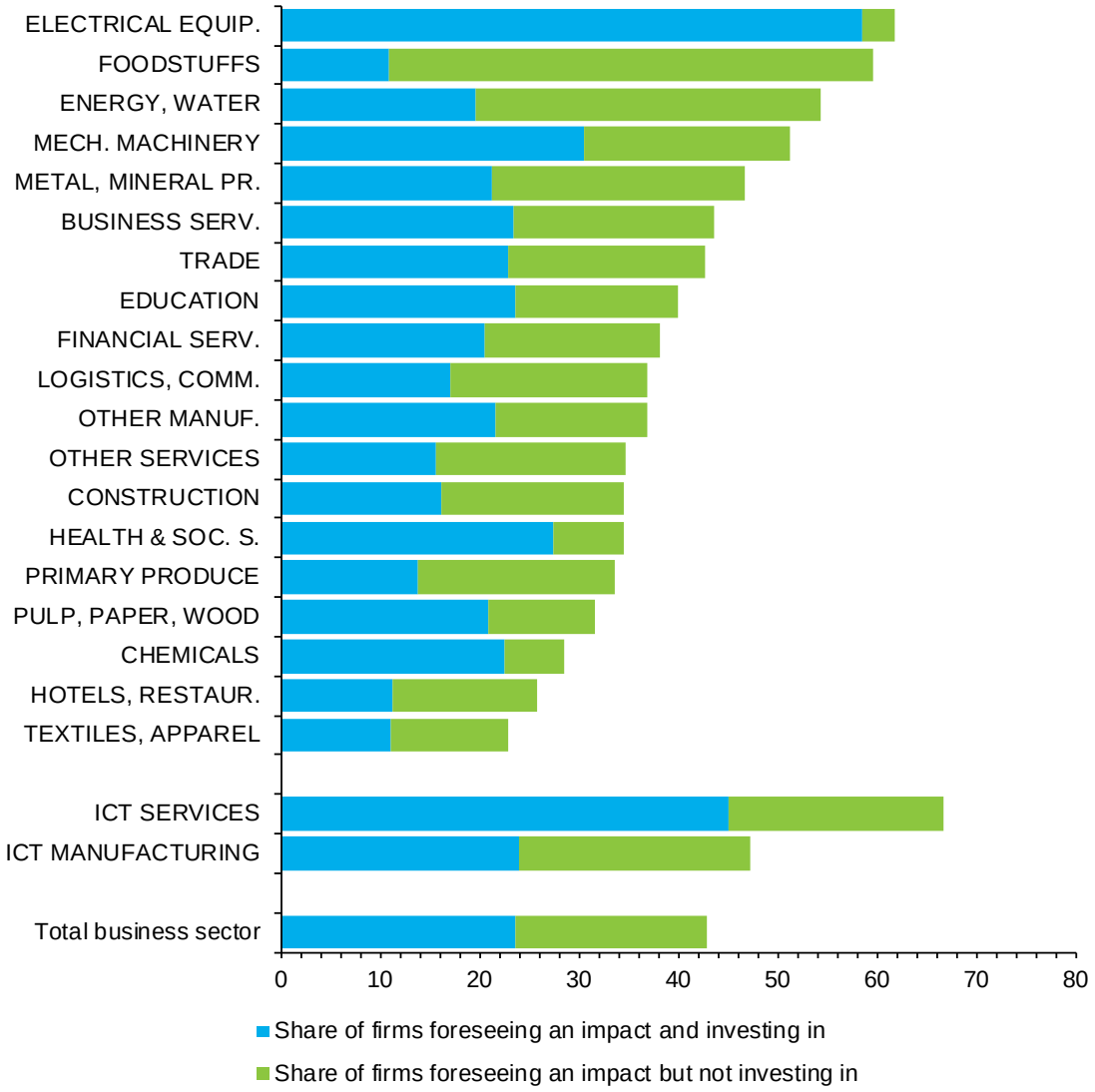
Source: Etla 2015 survey.

The share of firms who foresee that big data will have an impact on the industry and who are also themselves investing in it is the highest in ICT services in which 40% of the firms share this opinion. This is almost two times higher share than in electrical equipment industry in which the percentage is the next highest. Also in business services and in health and social services nearly 20 percent of the firms foresee the impact of big data on their business and are investing in it themselves.

Internet of things

Internet of Things is seen as more significant phenomenon in the Finnish business sector than big data during the next three years. 43% of the firms foresee that Internet of Things has an impact on their industry whereas the corresponding percentage regarding big data is ten percentage points lower.

Figure 13.4: The future impact of Internet of Things (IoT) by industry, %



Source: Etla 2015 survey.

By industry, ICT services firms believe strongest that Internet of Things is changing their business. This view is shared by two thirds of the companies in the industry. The shares are high also in electrical equipment (62%) and in food industry (59%). In contrast, in textiles and apparel, and in hotels and restaurants less than one fourth of the firms assume that Internet of Things is changing their industry.

The companies in electrical equipment industry are most commonly (58%) assuming that Internet of Things will change their business and at the same time are investing in it themselves. This is over ten percentage point higher than in ICT services in which this percentage is the next highest. The share is the lowest in food industry, textiles and apparel and in hotels and restaurants in which about 10% of the companies share this opinion. In contrast, almost half of the firms in food industry believe that Internet of Things will influence their business, but they are not investing in it themselves. The corresponding percentage is high also in energy and water supply (35%). In electrical equipment industry it is rare to think that Internet of Things will affect the industry but not to invest in it itself. Only 3% of the firms in this industry share this view.

14 ICT related technology shifts in the engineering sector

Magnus ***Gens,*** *Eric* ***Giertz*** *and Annika* ***Rickne***

Many Swedish engineering companies have successfully introduced embedded systems into their complex products and mastered a disruptive technology better than foreign competitors. This chapter is based on successful cases, which seem to have two things in common. The case companies have worked closely together with demanding customers and they have benefitted from previous experiences in telecom and defense industries.

14.1 Introduction

Sweden has often been recognized for its strength in engineering industries. Indeed, engineering companies were already identified by Erik Dahmén when he in 1950 described important development blocks in the Swedish industry.[179] Today Sweden hosts a blooming industry and with several examples of global leaders. There are, in relation to the size of the country, a high number of large Swedish engineering corporations in different subsectors.

We are in this chapter interested in how large and well established Swedish companies in the engineering sector have handled technological shifts involving the move to an increasingly ICT based competence platform, with embedded systems. New technology can be the basis for new products, new services and new companies, but it can also be a threat to existing companies. As a consequence great companies are challenged when new technology enters into their existing products. This was also true for large engineering corporations in Sweden when digital electronics made an entrance into traditional mechanical products some 50 years ago. We will in this chapter focus on understanding how Swedish firms have acted to incorporate ICT-based components and systems into their products.

As highlighted in a previous chapter (chapter12) there was, what we may call, a ‘first wave’ of engineering companies experiencing technological shifts in the telecom and defense industries (starting in the 1950s). These companies did not choose to rely entirely on in-house competence. They also hired very qualified R&D related ICT consultants. From this, a new ICT consultancy industry was born. In this chapter, we analyze the ‘second wave’ of engineering companies experiencing ICT related technological shifts in their products (starting in the 1970s).

We base our analysis on, first, an overall description of the development of the Swedish engineering sector leaning on long-term engagement in the field operatively and through research. Second, the study rests on qualitative cases of seven well-established companies in

[179] Dahmén (1989)

the engineering sector. Our selection is focused only on successful companies, in order to address the issues of how technological disruptions were managed. The case companies represent several important subsectors in the Swedish economy: Atlas Copco Tools and Assembly Systems and Alfa Laval and DeLaval in machinery, Scania and Autoliv Electronics in automotive, Electrolux in small appliances, Nibe developing heating systems and Maquet Critical Care in medical critical care.[180] To learn more about how the engineering companies transformed their technology base and in essence partly became software development companies, we focused on their R&D operations and conducted interviews with key individuals with knowledge about the transition period.

14.2 The general development of the engineering sector

Software engineering – a radical shift in product development

The engineering firms we focus on are today well-established and often one of the global leaders in their industry. Most of them were founded in the late nineteenth or early twentieth century, and originally developed and manufactured purely mechanical products. Already some 50 years ago they could be considered fairly old companies in rather mature industries. According to Utterback they would be in the *specific phase* of an industrial life cycle.[181] Their industries had left the *fluid phase*, with a lot of new inventions and new ventures, and the *transitional phase*, with the emergence of a dominant design, and moved into the *specific phase*, which is characterized by low-unit-cost production of highly specified products. However, a major change started in the engineering industry some 50 years ago when digital electronics made an entrance into their typically complex and assembled products: Software engineering thus became an important ingredient in product development in the engineering industry.

In some industries, e.g. the telecommunication industry, digital electronics caused a major shift in almost all parts of the entire product. Until the 1950s all telephone exchanges were purely mechanical. In the 1960s so called electronic switching systems were introduced on a small scale and during the 1970s telephone exchanges (e.g. Ericsson´s AXE-system) completely controlled by computers were introduced at a large scale. In these systems a program was stored in the memory and the processor executed the instructions automatically one by one. An immediate consequence of program control was full-scale automation of exchange functions and introduction of new functions to users. Computer controlled exchangers grew rapidly and completely took over the industry in the 1980s. This introduction of a disruptive technology was initially rejected by mainstream customers and some then leading companies in the telecommunication industry did unwittingly bypass opportunities until it was too late (see chapter 2).

[180] Some other important companies in the engineering sector are Ericsson in telecommunications, Volvo in automotive, Saab in defense, Husqvarna in appliances, SKF in ball bearings and Sandvik in hard materials. In addition there is ABB, a Swiss-Swedish owned company in electrical equipment, and former Swedish owned companies now belonging to foreign corporations, like Bombardier in transport and ITT Flygt in submersible pumps, with important R&D and manufacturing still in Sweden.
[181] Utterback (1994)

This was a radical shift in technology and the need for mechanical engineering was - during a rather short period of time - replaced by a tremendous need for qualified software engineers. Introducing computers to carry out control functions of a telephone exchange was not as simple as using computers for commercial data processing, and hence the competence was rather scarce in Sweden as elsewhere. A machine, like a telephone exchange, must run automatically and without interruption around the clock. This called for special expertise that could develop compilers, data warehousing, billing systems and so on, for billions of automated transactions.

Within telecommunications, digital electronics initiated a major shift in almost the whole product system. In other industries - e.g. the defense and automotive industry - software engineering was already at an early stage essential for developing some vital parts of the complete products, e.g. control systems and injection systems. Other (mechanical) parts stayed more or less unchanged for a longer period of time. The same is true for engineering companies making different kinds of machinery or appliances. The dominant design of the complete product stayed unchanged and the industry as a whole more or less stayed in the specific phase of the industrial life cycle.

Being in the specific phase of the life cycle makes it important to focus on the efficiency in manufacturing and other processes. The companies that still manufactured assembled products with mechanical components were all major users of factory automation. Thus, the need for mechanical engineering almost stayed unchanged but it was complemented by a great need of software engineering for product as well as process innovation. Many of these companies also hired R&D related ICT consultancy firms when developing e.g. control systems and embedded systems as integrated parts in their complex product systems as well as their manufacturing systems.

For some engineering companies e.g. in the machinery industry, their own process development as well as their product development (of process equipment) was, closely linked to the development of automated manufacturing systems. Companies like Atlas Copco (making equipment for underground mining and industrial tools and assembly systems), DeLaval (milking systems), and Sandvik (tools and tooling systems for metal cutting) focused during the 1980s on the development of more integrated and automated production systems to help their *customers* improve productivity and lower labor cost in their various production systems.

The larger engineering corporations in Sweden generally coped very well with the transformation that took place when digital electronics became an essential part of their products. They often gained market shares on the global market when the transformation shook out smaller competitors. But other Swedish industries, with a mainly domestic customer base, did not survive the transformation. The Swedish machine tool industry is one example. Until the 1970s the machine tool industry was one of the key Swedish industries. It had achieved international recognition, and as an equipment supplier it had played an important part in the international success of Swedish engineering industry. It consisted of a large number of small companies, each manufacturing their own types of machine tools (turning, milling, grinding, punching, drilling, etc.), but the competitive conditions changed when computerization and more integrated and automated manufacturing systems were introduced during the 1960s and 1970s.

When computerized numerical control (CNC) was introduced the computers were built into the machine tool control systems in multi-operation machines and they were capable of controlling several machine functions simultaneously. The technology matured quickly and CNC-machines soon were the rule rather than the exception in engineering companies in Sweden. It was a radical shift and many small Swedish machine tool firms with long traditions went into bankruptcy. In the middle of the 1980s almost the entire machine tool industry in Sweden was completely wiped out. The small Swedish companies could not compete with larger competitors, e.g. Japanese machine tool firms, which produced standardized machines for a much larger market.[182]

Software engineering in process development

Swedish engineering industry was, even when the Swedish machine tool industry went into bankruptcy, one of the foremost in the world in terms of automation. During the 1980s it had a very high penetration of CNC machines, industrial robots and automated material handling systems.[183] Several of the large Swedish engineering companies also introduced automation products, originally developed for their own manufacturing systems, to the market. Examples of these were ABB´s and Electrolux´s industrial robots, Volvo´s Auto Carrier System and Sandvik´s Block Tool.

However, the most profound results of automation were not teased out when CNC machines, industrial robots or automatic material-handling systems were stand-alone units. It was only when these automation elements were linked together and combined with the feasibility of concentrating the remaining and essential manual labor contributions that the really significant economic gains were made. Production could then continue with a minimum of personnel for long uninterrupted periods. A new production engineering expertise was born, and integrated manufacturing systems with limited manning emerged. They developed flexible manufacturing systems (FMS) consisting of machine tools, tool changers, industrial robots, transport devices, automated stores, technical and administrative computer systems and other items and services.[184]

In the middle of the 1980s the need for expertise in process control systems, embedded systems and industrial communications programs formed the basis for a new R&D related ICT consultancy sector. The technical competence was very similar to the ICT consultancy sector related to product development, but the application focus was entirely on developing industrial manufacturing systems. Some of the customers were engineering companies developing automation products and product systems for their own end-customers. The ICT consultancy firms also worked for costumers in other industries, who ordered customized automation for their own production.

Ericsson, who successfully handled a radical shift in product technology, did not choose to rely entirely on in-house competence. Ericsson also gave birth to a lot of very qualified R&D related ICT consultants. A new ICT consultancy industry, which was very different from the ERP

[182] Ehrnberg and Jacobsson (1995)
[183] Carlsson and Jacobsson (1997)
[184] Giertz (1987)

consultancy business already in place, was born during the 1970s (see chapter 12). This newborn industry grew fast and played an important role in product development and helped other engineering corporations to master the dynamics of innovation, which occurred when digital electronics made an entrance into their products.

14.3 Cases of ICT driven technology shifts

The cases presented below all tell us stories about how well-established Swedish companies in the engineering sector have handled technological shift involving the move to an ICT based competence platform.

From pneumatic to electric powered tools

The story of Atlas Copco Tools and Assembly Systems (ACTA) reveals the critical role of early and demanding customers and how external consultants were combined with building own internal expertise. ACTA is a vital part of the Industrial Technique Business Area in the Atlas Copco Group. The business area has about 5,000 employees and annual sales are around 11 Bsek. ACTA develop, manufactures and markets handheld power tools and systems. Until the mid-1980s ACTA only offered pure mechanical and mostly pneumatically powered tools. Today, ACTA’s revenues are dominated by electrically powered tools with substantial embedded software and control electronics.

The activities to develop embedded software started in 1987 when ACTA began to evaluate new transistors for power electronics in nut-runners. At this point the company put together a small group of engineers to evaluate the possibilities of new power electronics. It had previously assessed transistors in grinding machines but dismissed them because they did not add enough value in that application. In assembly applications on the other hand, benefits were more obvious since customers required precision control and traceability. Thus, customer demand was the driving force that initiated the transition to electronic control and power in assembly tools.

In 1989 ACTA received an order from the new American car manufacturer Saturn. Saturn, established by GM in 1985, wanted to build modern factories and had decided to rely entirely on electric tools. Saturn soon found that the range of electric tools was rather limited and it proved somewhat difficult to find appropriate tools for all applications. This constituted a business opportunity for ACTA. A deep and long-term cooperation developed, which included ACTA’s extensive hands-on work in Saturn's factories in the United States. The collaboration resulted in a new product called Tensor. During a few critical and successful years ACTA delivered around 1,500 handheld tightening tools to Saturn. The Swedish engineers were looked upon as crucial resources by the plant management in Saturn. For ACTA's part, it was an efficient way to finalize a prototype like product. There was a definite deadline when the customer had to ‘go live’, which forced ACTA to solve initial problems in a very compressed time frame. Johan Wallgren was at the time an electronics engineer and is still with the company. Today he is a senior manager but still involved in the product development of low torque tools. According to Wallgren, ACTA could quickly increase the product quality thanks to

intense debugging activities in the factories. To have a demanding customer put positive pressure on the company.

> *"It was a highly efficient way to develop the product. Maybe not always cost effective, but definitely a time-efficient way to debug the product. We spent a lot of time at the customer's premises and were constantly replacing components, cables, etc. It was a challenging time but it helped us increase our level of quality rapidly. I think this was a success in itself."*

In 1994, ACTA launched a new generation of screw and nut runners called Focus 2000. The development team consisted of 5-10 engineers, and one engineer was now fully allocated to software development. The embedded computer was still programmed entirely without support of an operating system. Focus 2000 allowed integration with the factory networks, which established the foundation for an extreme sales success. During the late 1990s, customers asked for more functionality and network communication. During this era, the power electronics were developed by a specialized, external consultancy company (Mikrologik). Micrologik was acquired by Atlas Copco, and changed name to Atlas Copco Controls in 1991. The consultancy company thus formed the base for building ACTA's own expertise in embedded systems.

To manage the shift in technology and handle the massive software engineering expansion that followed, ACTA has built up its own competence and recruited intensively during the last 25 years, from a handful electronics and software engineers in 1990 to some 50 engineers today. During all this time ACTA has also interacted with several consulting companies with different specialized experience from software development work in other Swedish industries.

From milking machines to fully automated milking

Our next case above all illustrates how a company has handled the shift through a refined balanced of own competence development and recruitment, and engaging external consultants to open up for new solutions in a more systematic manner. DeLaval (former Separator) was established in 1883 and is today a leading producer of dairy and farming machinery. DeLaval offers automatic and conventional milking systems, cooling and feeding systems, effluent and housing systems and farm management support systems. The company has its head office in Tumba, Sweden, and is part of the Tetra Laval group. The company has about 20 factories worldwide; employs around 5,000 people and annual sales are around 10 Bsek.

Initially DeLaval (through Separator and Alfa Laval) was based on patents around separation technique. One of the original applications of a separator was to separate cream from milk. Through its involvement in the dairy industry, DeLaval also developed a vacuum-based milking machine and has since the 1920s had a strong position on the global market. Milking machines were pure mechanical products until the end of the 1970s, but then a major shift of technology started. Today, DeLaval develop, markets, installs and maintains more or less automated systems for the milking of cattle.

The introduction of software began around 1978, when a specialized company in the Tetra Laval group - Alfa Laval Automation - developed a system (Alfa Recordings) that analyzed milk from specific individual cows in the yard crew and regulated the feeding based on

automated calculations. The innovation incorporated computers and network technologies to log data related to the individuals in the crew. The measured milk volume, and other parameters, then decided the amount of feed that was assigned to an individual animal. Alfa Laval's data bus had shortcomings, which meant that DeLaval spent a lot of time with trouble shooting on customer sites. In 1980, Uzi Birk decided that DeLaval should develop a proprietary data bus of their own. At the time, Birk was an electronics engineer at the development department. He stayed with the company until his recent retirement and was DeLaval's key strategist and head of development for over two decades.

> *"We were four engineers at this time; me, two engineers from Alfa Laval in Lund, and another engineer whom I hired, and who had a background in Ericsson. One of the engineers from Alfa Laval Automation had specific knowledge of both communication buses and our application."*

Up to that point DeLaval had chosen to ally with external suppliers of control systems, but now they shifted strategy to rely on proprietary electronics and software. During the coming period DeLaval expanded the electronics department with 35-40 multi-talented engineers, who were skilled in software as well as electrical engineering.

> *"I hired experienced engineers with backgrounds from Ericsson, with knowledge of both digital and analogue electronics. We hired both experienced and inexperienced engineers in electrical engineering, but mostly experienced individuals."*

In 1993 DeLaval acquired a UK based concept platform intended for fully automated milking of cows. The fundamental principle was that the cows would voluntarily seek out an automatic milking station when it was time to be milked.

> *"When we got to the launch of the robotic milking system, we called it the paradigm shift and I worked more and more internally just to enable and support. Automatic milking - we had now become a high-tech company."*

During a second decade (1995-2005) DeLaval expanded the team for electronics to about 60 people, where everyone in some way contributed to the development of the new digital systems. Only in 1997 they needed to recruit 25 new engineers in the areas of digital electronics and software. In addition, DeLaval used consultants with previous experiences from telecom and defense projects.

> *"I had learned from previous experiences that it was next to impossible to enforce changes in technology strictly with the existing staff, who was stuck in the existing solutions and technology."*

Over the years, DeLaval has gone from entrepreneurial activities in a fluid phase to more capital intense product and service delivery on a global market. Initially the company competed with a multitude of smaller companies on differentiated geographical markets. Some of these have disappeared, and some has been acquired by DeLaval or others. At present, DeLaval operates a large development unit in Sweden and a global marketing organization with involvement on all continents.

External expertise made Saab an early mover in car engines

The journey of how Scania developed the petrol engine used in cars with the Saab brand illustrates the crucial in timing of understanding the need for a paradigm shift, and also to identify where to source crucial knowledge. Scania was founded in 1891 and is a manufacturer of commercial vehicles like buses and trucks. Scania had a very long experience from development of combustion engines. When Scania merged with Saab in 1969 Scania got the assignment to develop and manufacture Saab engines to replace previously used Ford engines. In the late 1970s Scania developed a new turbo charged engine for the Saab 99 model. During roughly the same period Sweden's politicians began to set ambitious environmental targets. Sweden should become a leader in regulations on emission linked to automobile transports. The engines at the time were based on strictly mechanical and electromechanical components. Initially, engineers could deliver reduced emission through simple concepts like exhaust gas recirculation (EGR) and overdrive, but they were quickly limited in the analogue technology domain.

Hasse Johansson, an electrical engineer from Chalmers University in Gothenburg and founder of the company Mecel in Åmål, had developed a concept regarding the analysis and control of the combustion process in spark-ignition engines: more specifically of how to electronically analyze the ion concentration in the gap between the electrodes of the spark plug. Per Gillbrand, head of development at Scania, thought that a similar technology could be used for controlling engine fuel injection, ignition and turbo systems, and Mecel was hired to make this happen. By introducing an exhaust gas sensor the idea was that one would be able to measure the amount of hydrocarbons in the exhaust gas and then automatically control fuel injection and ignition position. Peter Gillbrand, the son of Per, who at the time worked as an engineer at Scania describes how the technology shift started.

> *"When a catalyst converter is introduced there will be a need to control the engine much more precisely. Even Scania extensively tried to combine catalysts with analog carburetors and ignition systems. The most advanced carburetors approached a nuclear power plant in complexity. There were extremely advanced and sophisticated solutions that demanded skilled artisans with resemblance of the masterpiece of Swiss watchmaking."*

Today Peter Gillbrand is the CEO of a specialized international automotive consultancy company. Catalyst converters were introduced to reduce emissions and they required very precise Lambda control. Lambda regulation is about precisely controlling the ratio between air and fuel in a combustion engine. It was possible to use the catalyst converter together with the most advanced carburetors, but it was very complicated without computerized control technology in the toolbox. During a few years in the 1980s lambda control was the main challenge for the engineers and PhDs in companies in the automotive industry.

> *"We got these incremental emission regulations in front of us, which basically meant that the accepted emission levels would dimidiate every two or three years. We always struggled with the level we were at the moment. We could possibly have vague ideas on how we could reach the next emission level, but we had absolutely no idea about what the technological design would look like. And today we are basically at a zero level regarding emissions*

compared to the regulatory demands of that time. But the funny thing is that in retrospect no one seems to think that the journey has been especially dramatic."

Aggressive regulatory requirements regarding emission levels generated the need for more complex and powerful control technology, which, in turn, spurred the introduction of digital electronics. At an initial stage, Scania procured a controller from Bosch but Mecel began to develop its own digital ignition system, APC. The proprietary system was integrated with the turbo control system, and in the next phase control of the fuel system was integrated. Saab-Scania's development department had come to the conclusion that if the new emission legislation would be met, and the engines would also have turbochargers, the technology solution was to be based on software running on microcontrollers.

"We began developing our proprietary APC system due to that Bosch could not deliver turbo control functionality, or they probably could, at PhD level, but the area was considered too small, too exotic and not worth engaging in. But they were badly mistaken, our technology belonged to the future, and today you find turbochargers in almost all cars."

At an initial stage a few skilled electrical engineers at Mecel and Scania could develop the new digital electronics and its software. In the second phase, just a few years later, Scania began using external expertise via specialized computer software engineers from consultancy companies. These consultancy firms had experiences from prior projects in the defense and telecom sectors. Today, merely a few global companies develop industrial combustion engines complying with modern legislation.

Having an open mind towards external expertise and ideas helped Saab to become an early mover. An extremely small car manufacturer in Sweden created a new standard for car engines and the expertise from Mecel was crucial both to initiate and diffuse the invention. Mecel was seen as very important to Scania. Saab Scania (through its subsidiary Combitech), also became part owner of Mecel along with the founder Hasse Johansson. When Saab Automobile at a later stage was separated from Saab Scania and sold to GM, Hasse Johansson was told to sell his shares in Mecel. He later moved to the US to become technical director in GM’s electronics division, and introduced the new technology throughout the GM organization before he returned to Sweden and Scania.

Development of ventilators for intensive care

The case of ventilators as developed by Maquet Critical Care has a long history, and the technological discontinuity, here under scrutiny, has been handled in a careful mainly internal development process. In 1950 the Swede Carl Gunnar Engström invented the concept of artificial respiration. The design and initial implementation of the Engström respirator was to help patients who had suffered from respiratory paralysis as a result of polio. Engström’s respirator consisted of a large piston driven by an electric motor that cycled air into the patient's lungs. Today, modern ventilators incorporate a variety of parameters and principles by which the ventilation of the lungs is conducted. They are complex machines that require extensive training of its operators.

Maquet Critical Care was founded in 1838 in Heidelberg, and has since 2000 been a part of the Getinge Group's business area medical systems. Maquet develops ventilators for critical care in Solna and has about 400 employees and annual sales of around 1.5 Bsek.

Maquet has a long tradition of manufacturing ventilators. During the 1980s and 1990s it was still difficult to solve the details of pressures and flows, and automatic control combined with electrical engineering were critical areas of expertise. During this era, the development department focused on doing the same thing as Engström's machine from the 1960s, only better, with the help of control technology and digital electronics. At this time some 5-10 engineers worked with control technology, sensors, measurement electronics and software. Maquet had no engineer who worked full-time strictly with software; instead electrical engineers carried out the programming. Around 2001 Maquet released a product called Power-I, which became a great sales success, and won various design awards. The product was considered revolutionary at the time and was centered around a simple interface, based on a touch screen. The product was a major leap forward regarding architecture, testing capabilities, debugging and design. Tomas Westerlund, an R&D manager and architect, describes the shift of technological competence:

> *"In this building we have a very extensive knowledge about the pressures and flows. That's what earns our living, you could say. It has been that way since around the 1970s. Nowadays, through the possibilities with software, we can make therapy more adapted to a specific patient."*

Maquet had transformed into a software developing company with a strong focus on testability, design, product mindset and maintainability. In the spring of 2015 the company develops products with around 120 engineers; of these 43 are software developers. Maquet also reinforces its software grouping with about 20 external consultants.

> *"We have tried to do what Apple did for mobile phones with their iPhone. We are pretty close to succeeding, actually. Normal introductory training for an operator of a specific ventilator, even if you have driven ventilators earlier, is two or three days, up to a week. We have tested and successfully accomplished to get experienced users to be up and running after 10 minutes. "*

The new ventilators Power-U and servo-N were launched in 2014 and are both sprung from a mutual system platform. Today Maquet sells its products on a highly competitive market and parameters like integration capabilities and how fast it is possible to introduce new users to the system are the crucial sales-success criteria. In the ventilators early year's greater performance linked to the basic application was the key to success. In the 1970s a handful engineers could develop a ventilator but today it's a matter of very capital intense operations. At the present date only a few global companies can develop and market ventilators for intensive care.

From seat belts to car safety

The exciting story of Autoliv and Autoliv Electronics, with headquarters in Linköping, deals with needs of ICT based technological competence for airbags and image processing and

camera solutions for safety. Autoliv (former Autoservice, and established in 1953) develops electronics for automotive purposes and has around 300 employees and annual sales around 2.2 Bsek. Autoliv started by producing seatbelts and grew its business through mergers and acquisitions. In the early 1990s, Autoliv began its digital journey by the introduction of micro-controllers to control airbags in cars. Autoliv found the expertise needed to enter into a completely new market in other existing companies. Autoliv had ideas of a number of innovative solutions and was an early player on the market. The company also developed a patented protective side curtain that became a standard solution throughout the world. Today, the firm is one of very few car safety companies on the global arena.

The software required to control the air bags quickly became relatively complex due to the high demands on system security. Former CEO of Autoliv Electronics, Bo Wass describes how the technological change started:

> *"The development of airbags was made in collaboration with customers. As a foundation there was a number of innovative principles for how to control the airbags (which was Swedish technology), which would prove to make global impact. Autoliv engaged in these product development activities by extensive use of both partners and subcontractors. At this specific time Autoliv placed the airbag development, and production, at Nokia in Motala."*

Nokia in Motala was sprung from Luxor, which at one time had been a manufacturer of home electronics and computers (see chapter 5.4). At this time there was a lot of electronics expertise in Motala. After an initial collaboration in 1995, Autoliv chose to buy 50% of Nokia's business in Motala and then in 1998 to buy the remaining shares and transform the Motala unit into a regular Autoliv site. Around year 2000, Autoliv, now located in Linköping, began experimenting with cameras to detect the risk of drivers falling asleep.

Around 2001, 30-40 engineers were engaged in the development of Autoliv’s digital electronics. The Motala unit had recently developed a telematics solution designed for automated assistance in cars in the case of accidents. In 2004, Autoliv reorganized and the main task for a new unit was to develop a night vision system, which initially was only a situation awareness system for cars. A situation awareness system is intended to give the driver of a car better ability to analyze the surroundings of the vehicle. The same year they also began the development of a new night vision system with new features such as pedestrian detection.

Therefore, Autoliv Electronics - a subsidiary of Autoliv - began to strategically build up expertise in image processing. One method for this was to cooperate with the Swedish research institute FOI, which happened to be across the street in Linköping. The Linköping company developed its first commercial night vision system (Autoliv's Night Vision 2), which came into production in 2008, first in BMW and later in Audi. Night Vision 2 was Autoliv Electronics’s first real product with digital imaging features. Since 2011 the area of active safety has expanded extensively. With Night Vision 3 they also introduced features concerning animal warning and this system went into production in 2013.

Autoliv Electronics has used external competences extensively to manage the technological disruptions. Autoliv’s Linköping unit is located closely linked to the university, the defense

company Saab and a substantial Ericsson development site. External software developing consultants are continuously reinforcing the development work at Autoliv in Linköping. Today only a few companies in the world can compete with Autoliv when it comes to digital vision systems for automotive use.

The introduction of software into vacuum cleaners

Electrolux - established in 1919 by the merge between the companies Elektromekaniska and Lux - has a history of developing vacuum cleaners and coffee machines and our focus here is on the former product group. It is developed within Electrolux Small Appliances – a business unit in Electrolux with roughly 2,600 employees and sales of around 8 Bsek. Until recently a vacuum cleaner consisted strictly of mechanical components. The first digitalization dealt with controlling the electric fan motor with more accuracy and to a lower cost. At this time the main task for the development team was to design engine control units, destined to regulate speed of the motors. By designing an integrated digital system based on a PIC processor, Electrolux got an inexpensive solution that was far superior to the prior analog design. Furthermore, the module also enabled new functionality for accessories, and could, for example, realize remote control functionality so that the vacuum cleaner could be controlled from the nozzle via an IR transmitter.

In 2007 Electrolux increased its focus on battery-powered vacuum cleaners that would build on lithium batteries. Earlier, the batteries had been too bad to allow a vacuum cleaner that was worthy of the name. With the new lithium technology, however, came a need for a microcontroller based battery management systems to maintain and charge the vacuum cleaners new power source. The first project that was delivered relied on a lithium battery and battery management solution from a sub-contractor.

> *"Around 2010 we began to sketch on a modular system for battery products too. Basically, one could choose which battery to insert and the system would automatically adapt its battery supervision and battery management. So we began creating a module for this too. It's in production today. Now we had two large module areas: one for ordinary vacuum cleaners and one for battery machines. At the same time we started to create modules for coffee machines, so now we have three different module areas to maintain."*

Around 2010, about five engineers worked with the development of electronics and software, and the company had recently moved its R&D department to Stockholm from Västervik. After the move Michael Persson, a development engineer, and another electrical engineer received the task to design the foundations of Electrolux's future electronics development capabilities. Persson is today the development manager at the small appliances department.

> *"It made us think more and more about how we could modularize systems. Although there are different models they are all the same product type; a vacuum cleaner is a vacuum cleaner. We created one module in 2007, which today is used in all premium and middle-range vacuum cleaners. We have a modularized system now for both hardware and software."*

In February 2015, 57 engineers work with electronics and software systems at Electroux in Stockholm. At the electronics department both employees and consultants are working in the development projects. According to Michael Persson, the shift of technology and the following expansion has gone very quickly.

> *“By this time we saw something like an explosion; really, you could say that in 2009-2010 the need for embedded software engineers increased dramatically. In 2011 we initiated the robot project, the development of a new robot vacuum cleaner, and it speaks for itself that the demand for both hardware and software competence increased a lot. "*

Regarding the conventional vacuum cleaners and coffee machines it is still about lighting some indicating diodes, speed control of motors and facilitate limited remote control. In terms of battery-powered vacuum cleaners, with lithium power sources, the software is an essential part of the design due to their mandatory microcontroller-based battery monitoring systems. One could say that software development is a necessity if one is to develop products that have embedded lithium batteries.

Development of heat pumps

Nibe Industrier is a Swedish company developing and manufacturing heating systems: liquid-based heat pumps for buildings. The company was founded in 1949 in southern Sweden. From the beginning Nibe manufactured and marketed heating systems for buildings, and has grown organically and by numerous acquisitions of competing businesses over the years. Today, Nibe has around 10,000 employees and sales of about 11 Bsek, sells its products on five continents and is still growing rapidly. The industry in which Nibe Industrier is active has undergone heavy consolidation over the years. Nibe and its current competitors have acquired many smaller companies, while other firms have gone out of business.

The initial heat pump technology sprung from essentially the same principles as for a refrigerator or a freezer. In 1998, merely two employees were working with engineering activities in the field of electronics and software at Nibe in Markaryd. One engineer focused on the hardware development and the other on software development. Already at this time, digital electronics had made its entrance in the company's products.

> *"It’s all about controlling temperature. You have a lot of temperature sensors and then you do the calculations, then you regulate. You control both a compressor and an immersion heater. You control based on the heat demands, so to speak, not just based on the temperature for the moment. You try to predict what future heating needs a client will have. In order to keep down the compressor’s number of starts and stops we try to predict the coming heat demand, and thus possibly buffer heat."*

Around 2000 the Nibe management decided to modernize their product line and the company initiated, with the help of Michael Persson and another electrical engineer, a development project to produce a new platform for control of heat pumps. The platform was based on a modular concept and featured a proprietary data bus that could connect all the company's modules. The new platform was a success and was to form the functional foundation for their

products over many years. Nibe chose early on to make use of external expertise through consultants who had suitable previous experience, for instance from the automotive industry.

> *"Around the turn of the century ideas started to emerge regarding the intelligent home and management wanted to be able to control the heat pump via a mobile phone. So we developed our own proprietary bus system, we even created a proprietary protocol too."*

14.4 Explaining the success in handling the technological shifts

We were in this chapter interested in how large and well-established Swedish companies in the engineering sector have handled technological shift involving the move to an ICT based competence platform. How can we explain the success of Swedish engineering companies? Our discussion below relates to recognizing the characteristics of the technological shifts, competence sharing through ICT consultants, and extensive fieldwork with early, dominant customers. It seems as insightful decision makers in Swedish industry have foreseen the advantage that the new microcontrollers could give them. By staying patient and persistent various Swedish industry companies managed to become early adopters of technology that would give them an advantage in their specific industrial areas. Was the fact that various management teams in Sweden had the courage to invest heavily in introducing ICT technology in their products, based on experiences from industries like defense and telecom, before the need from the market was obvious, in retrospect a key to success?

Recognizing the characteristics of the technological shifts

The manufacturing of mechanical parts in the companies' core products is a well-established process. In this way, the sector can be said to be in a specific and mature phase. In one way it's a very capital intense production system that manufactures assembled products in high volumes with very specific methods and tools. On the other hand, ICT components add things like traceability, increased accuracy, higher rates, yield improvement and configurability. ACTA's product line of industrial nut runners is such an example of an innovative ICT based product that helps customers like Scania to increase its effectiveness a notch. Also, DeLaval adds value and increased productivity as well as quality to dairy farms. The dairy farms production system is an old and mature model but it can be optimized by innovative equipment like DeLaval's automated milking machines.

At the same time, to improve functionality in their products or increase the degree of automation on their costumers premises, the companies developed embedded systems with a new, ICT related competence base. Maquet in intensive care could be regarded as such a company that helps its client to fine-tune its processes by innovative ICT based products from the company's development department. Also Electrolux Small Appliances provides such an example with its launch of an autonomous vacuum cleaner, an actual cleaning robot for ordinary people's homes.

An important explanatory factor is the companies' ability to recognize the characteristics of the technological shifts, embracing a move into an enlarged software base. There are today a

number of Swedish industrial companies that have gone from being manufacturers of strictly mechanical products to now being software-developing companies.

All of the studied companies have gone from conducting their development projects with multi-talented engineers, to now having multiple highly specialized computer software engineers. Software was at the time typically developed for one set of hardware, by one engineer, for a specific product release. Today, the code base contains much IPR, system behavior parameters and possible variants of the system. On the other hand, in most modern operations, the software developing engineers need to know relatively little about the hardware in the products. The embedded systems software has gone from being a necessity only, to now providing the key features and unique selling points for many products.

Thus, this type of software development has become an increasingly larger and more important element of the progress, and this shift in core competences needed for competing successfully have lead the companies into a new, fluid phase of the industry lifecycle. This phase has been characterized both by some firm's failing to adapt to the technological shift, and to others proving successful. It has also been a time of consolidation. These specific early movers of the new technology rather quickly gained success. This in turn gave them the opportunity both to obtain business from the competition, and to acquire smaller companies with interesting business segments. The companies that could create momentum and thereby the gravity needed to attract employees with the new essential competence seem to have outperformed its competition. Eventually, these software development operations would become so capital intensive that the dominant companies could be said to be active on an oligopoly market. By the time of the introduction of the microcontrollers there were many smaller manufacturers acting on more local markets. Many firms went out of business or were acquired as a consequence of the technological disruption.

Swedish engineering companies have to a large extent come out as winners in this transformation. Indeed, the studied firms have not only endured, but also exploited the technology disruptions very well and gained an even stronger position on the global market afterwards. They have handled the technological shift well, partly due to leaning on a solid access to well-educated employees, and a profound competence base and experience regarding production engineering, control systems and embedded systems technology. This has lead to a now strong global position in development and manufacturing of production machinery and process equipment. Today, many Swedish engineering companies are conducting global operations on a highly competitive market, with relatively few but large competitors. Many of these companies seem to be operating in an extremely capital intense environment with an extensive aftermarket business.

Competence sharing through IT consultants

As a consequence of the first wave of engineering companies – outlined in the beginning of this chapter - a new ICT consultancy pool was created. This led to that R&D related ICT consultancy firms, born from the late 1960s and on, would play an important role in research and product development also for the second wave of engineering firms. The decline of Ericsson in 2000 also created a pool of available consultants looking for new customers. Based

on their long-term competence and skills they could help engineering corporations, as well as companies in other industries, to master the dynamics of innovation.

Indeed, all the studied companies that began its software developing eras in the 20th century have either 1) recruited employees with previous experiences from the defense and telecom sectors or from ICT consulting, or 2) used ICT consultants. In our cases the development of the new digital electronics started with few employed engineers in an experimental and often successful phase. In the following expansion phase the interviewed companies used consultants with telecom or defense backgrounds to improve things like requirement management, testing strategy, version management, release management and development of tool environments. Most of the studied organizations started to develop software in the 1990s, and it seems rather clear that they have reused experiences from the Swedish defense and telecom industries. In one case – Nibe - automotive experiences was the foundation.

These ICT consultants have not been tied to one specific engineering subsector. Instead they have moved between customers in various subsectors, bringing with them their new and accumulated experiences. This means that engineering companies in one industry have been able to benefit from competence and experience developed in other firms in different industries, through the mobility and competence diffusion of ICT consultants. A conclusion is, thus, that thanks to the externalization of R&D in the first wave, the competence did not get locked in.

It seems that the Swedish system developing companies have been – perhaps unexpectedly or unusually - indifferent to the fact that the newly acquired competence of a specific consultant or consultancy firm may be used for the benefit of another engineering company. In the study we have found that competence in the field of lithium batteries is shared between Electroulx and ACTA. Also, Maquet have used competence acquired from both the defense industry and ACTA. One explanation is that the engineering firms are not direct competitors: In fact, there is often only one firm in each sub-segment in this small country. Another important factor is that the R&D related ICT consultants in Sweden often have been – and to a large extent still are – Swedish owned and focused on a domestic customer base. They have thus not turned to foreign customers that directly compete with their Swedish ones. The de facto openness – on the side of the engineering firms as well as from the R&D related ICT consultancies - could possibly be contributing to the individual success of the many branches of Swedish engineering companies. Such a flexible ecosystem would be an advantage for the Swedish export industry.

Early, demanding customers

All of the studied companies started out in a playful experimental phase where engineers simply evaluated new digital electronics in their own specific applications. In some cases the end-customers were subjects for new regulations that created a demand for new technology. This was true for ACTA whose customers started to demand proof-of-quality information linked to each of the systems operations, and for Scania that was forced to meet new regulatory demands in terms of reduced emissions of hydrocarbons.

The benefit of challenging and early customers is made clear from the cases. Several of the studied companies with business-to-business operations started their microcontroller based

product development together with some important initial customers. These customers have been demanding but also keen on getting a system delivery with the benefits of the new technology. This was exemplified in the cases of ACTA's Tensor system as well as the Scania's APC system for Saab Automobile. These early customer helped the companies to finalize prototype like products by fine-tuning them in factories and assembled systems.

The engineers at the product development companies had the benefit of outfitting their products in the actual environments where they would eventually operate at an early stage.

15 Emergence of an ICT-based disruptive mobile payment service

*Niklas **Arvidsson***

The chapter scrutinizes the emergence of mobile payment services in Sweden. The case illustrates how the Swedish model of corporatist society development has formed retail banking and enabled Swedish banks to become proficient and early adopters of advanced ICT-systems, leading to internationally competitive financial services.

15.1 Introduction

Cash-based payment services are in 2015 still important in many markets in the world, but Sweden is a different story where the use of cash is low and also reducing rapidly[185]. There are many reasons behind this such as a tradition of electronic payment services, efforts by unions in Sweden to reduce the risk of work related robberies in cash-intensive industries, the interest among banks to supply new services as well as the willingness of consumers to adopt new payment services[186]. If cash were to be replaced by electronic services, one may argue that banking has become 100 percent digitalized.

The introduction of the mobile payment service *Swish* in Sweden is a case where an ICT-based payment service substitutes a paper-based payment service – cash – and thus speeds the process potentially making Sweden one of the first more or less cashless societies in the world. The case illustrates how the Swedish model of corporatist society development, e.g. in the form of development via mutually beneficial cooperation between governmental and commercial actors[187], has formed retail banking. Due to the nature of banking, however, development builds in a network of actors rather than via developing couples as has been the case in other industries. The corporatist society model has allowed and enabled Swedish banks to become proficient and early adopters of advanced ICT-systems, leading to internationally competitive financial services. And, this transition of banking would not have been possible without highly skilled ICT-companies.

Digitalization of banking implies that the essence of banking becomes (if it not already is) a matter of combining banking expertise, an ability to meet regulatory demands, and ICT-skills. In addition, digitalization creates a need to handle new competition from actors in sectors as social media or telecom as well as from new ventures supplying banking and finance services.

The chapter first discusses the history of cooperation between banks, governmental actors, and how this has enabled retail banks to be in the forefront of automation for more than 50 years.

[185] Sveriges Riksbank, 2014
[186] Arvidsson, 2013
[187] As discussed in chapter 1 in this report.

We then turn to Swish, which is a globally unique payment service developed through cooperation between retail banks and the central bank. We conclude by outlining how banks simultaneously cooperate and compete in relation to Swish. Last, the chapter pin-points the most critical factors of success behind the development of Swish.

15.2 ICT in retail banking in Sweden – The historic development

Development in Sweden

There is a long tradition of cooperation between banks in Sweden with the ambition to create banking infrastructure and services that can be shared by several banks even if the banks in the end compete in their ambitions to sell financial services. This cooperation has also involved regulatory actors such as the central bank[188] and the financial supervisory authority,[189] and thereby making it extend beyond business-oriented companies to also involve representatives of the state in the form of financial market authorities. Cooperation has therefore not only enabled infrastructures realizing network externalities between businesses but also leading to a fit and harmony between regulatory frameworks and business operations.

This tradition of cooperation led Swedish banks to be early adopters of computer technologies or ICT-solutions with the savings bank in Sweden as one particular example.[190] There are also other examples such as commercial banks' development of ICT-systems in collaboration with primarily companies from the manufacturing industry with examples such as videotext systems for transfer of information on financial markets, and cooperation between banks to develop automated banking services via the telephone system or Internet banking services These efforts illustrates how the financial industry in general and retail banking in particular builds on developing infra-structure that can be shared by many banks in order to not only share investment costs but also – and more importantly – to realize network externalities[191] based on high inter-operability[192]. Other historic examples include the creation of data processing facilities operated by a shared corporation called Spadab[193] built by Swedish savings banks in the mid-1900s[194] and in the creation of the giro system in 1959 – Bankgirot – for inter-bank transactions and processing via an open and shared system and thereby sharing development costs, realizing economies of scale in use and securing a high level of security[195].

[188] Sveriges Riksbank (www.riksbank.se)
[189] Finansinspektionen (www.fi.se)
[190] Maix´-Altés, 2014
[191] One key feature of retail payment services that become successful is that they are characterized positive externalities. A positive consumption externality (or network externality) signifies the fact that the value of a unit of the good increases with the number of units sold. The key reason for the appearance of network externalities is the complementarity between the components of a network. See Economides (1996).
[192] By inter-operability we mean an infrastructure where many actors on both sides of a transaction, for instance both many payers as well as many payees, can and are willing to connect to and use the system. The term is often used for payment services and is another term for stating that there are strong network externalities in the system.
[193] Sparbankernas Datacentral AB - SPADAB
[194] Maix´-Altés, 2014
[195] From Bankgirot's web site: https://www.bankgirot.se/om-bankgirot/press-och-aktuellt/bankgirots-historia/

A similar story explains the creation of the Swedish ATM-system. The cooperation between savings banks in Sweden started in the formation of the savings banks association[196] in 1900[197]. This collaboration was intensified in the 1920s in terms of, for instance, coordinating purchases of material for retail banks. In the 1960s the savings banks met new competition and faced growing administration costs but as technologies for automated service had been developed, they decided to join forces to develop and launch automated teller machines services in Sweden. This cooperation was manifested in Spadab and led to development of punched card readers and computerization of book-keeping which initiated the use of computers in these banks. The banks' interest in automated teller machines led them to contact Metior – a company in the Tetra Pak Group – that had developed automated petrol pumps and coin sorting machines. All in all, collaboration between savings banks made them able to launch the first automated teller machine in Uppsala, Sweden, on July 6, 1967. After some initial problems, the use of ATMs grew during the 1970s in Sweden and in other parts of the world, where Metior became an important exporter of such machines from Sweden. The savings banks continued to be in the fore-front of developing ATMs to curb fraud and increase efficiency in their branded machines called Minuten.

The corporatist society process is further illustrated by how systems for payments of wages and salaries in Sweden were developed. In the 1960s a radical change of payments of salaries and wages to workers and staff was implemented which became an important part of the digitalization of the retail banking sector. Banks were automating their services and building their IT-systems which significantly increased their capacity of handling transactions. This, on the other hand, meant that retail banks could receive and also were in need of new customers. Companies, on the other hand, were offered a new and more efficient way of handling payment to employees. The initial reactions from unions and employees were mixed and in the end the unions were afraid that wages and salaries would be hurt by service fees from the banks. They were therefore able to realize their demand that banks should not put service fees to workers that want to access their wage or salary via their bank account. This is still today a dominating feature of the Swedish cash-handling system – consumers generally do not pay banks fees for using cash or ATMs[198]. All in all, the digitalization of wage and salary payments, which laid the foundation for the high number of personal bank accounts in Sweden, was realized through collaboration between companies, unions and banks. This digitalization, in turn, was essential for the launch of card payment services in the 1990s[199] and mobile payment services today.

The corporatist society features in relation to the development of Swish are seen in how actions to reduce cash in the Swedish society have been formed. The unions became an important force in the ban of cash in public transportation in the end of the first decade of the 21st century. As the number of robberies of bus drivers in public transportation increased, the unions started to push the question of no longer allowing cash as a form of payment on buses from a work

[196] Svenska Sparbanksföreninngen
[197] This section draws heavily on Batiz-Lazo et al, 2009.
[198] During the last decade there are many examples of how banks and other actors put fees on cash-handling such as fees for ATM-withdrawals or administrative fees for cash-handling services.
[199] Arvidsson, 2013

environment perspective[200]. They simply wanted to reduce – or ideally eliminate – the risk of this form of crimes and violence towards their employees. And they succeeded. Unions in banking worked in the same direction as the number of bank robberies increased in the latter part of the 2000s. In addition, banks did not have direct revenues connected to cash which meant that their business interest was well aligned with the unions' interests. All in all, there was cooperation between unions and banks to reduce cash in Sweden. And mobile payment services became an important tool for achieving this.

Our main focus in this chapter – the development of Swish – is the most recent example of bank cooperation leading to a shared infrastructure and thereby realizing network externalities and inter-operability in the form of a globally unique and disruptive innovation called Swish.

15.3 Swish – The emergence of a disruptive mobile payment service in Sweden

Retail payment services

The central role of retail payments is the task to create secure and cost-efficient payments[201] or financial transactions[202], i.e. "to guarantee the settlement of a claimed balance between the buyer and the seller with a minimal use of financial resources and minimal risk exposure necessary to process the transaction"[203]. In this text we focus on banks and their supply of one particular mobile payment service - Swish. Cash has been the dominating payment service in Sweden – and the world – during the last millennium but electronic payment services – electronic transfers, card-based payments and giro transaction – has risen in importance during the last 50 years and we have seen – at least in Sweden – a decline of cash payments especially the last 5 years[204]. In 2015 we see a rapid decline in the use of cash as innovative payment services – such as Swish – has become a direct substitute to cash payments in situations where cash historically used to be the only alternative, e.g. payments between friends or in situations where electronic payment services did not function.

The story of Swish starts in the first decade of the 21st century in the form of intensified efforts by banks, telecom operators and other providers of IT-based financial services to create mobile payment services. Factors as problems with cash-handling[205], technological development both in processing as well as consumer products, and competition between banks and telecom operators as well as consumers' increased interest led to efforts to launch mobile payment services in the first decade of the 21st century[206].

[200] Arvidsson, 2013
[201] Retail payments play the role of transferring a certain amount of money from the payer to the payee. The payment system primarily includes actors as banks, payment service providers (e.g. related to cash, cards, and electronic payments) and telecom operators. Then there are other actors such as those receiving and making payments as well as suppliers of hardware and software. In addition, the central bank – Sveriges Riksbank - and the regulatory agency – Finansinspektionen – play critical roles in thus system.
[202] Sveriges Riksbank, 2014
[203] Willesson, 2007:12
[204] Arvidsson, 2013
[205] Svensk kontanthantering, 2014
[206] See e.g. Sveriges Riksbank, 2015; Sveriges Riksbank, 2013; Arvidsson, 2013; Arvidsson, 2014

The developers of payment services for retail payments in Sweden in 2010 were debating which kind of technological infrastructures it would use. Should mobile payment be based on the card infrastructure where a mobile app replaced the traditional credit or debit card but where the processing, clearing and settlement was done in the same way as for a traditional card payment? Would the mobility aspect be realized via NFC, QR codes or Bluetooth? Would the identification and security features be based on the SIM-card or could the cloud be used? Was the underlying account storing money to be a traditional bank account, a card or a new form of account in a mobile wallet? The questions were many and the implications for each actor were of course different depending on which answers that were given.

There were also new strategic choices that had to be made. The tradition in the payment industry was that the use of cash was not charged directly to the consumer[207]. Cash services were basically just costs for the banks. Card payments, on the other hand, were charged via annual fees and perhaps other charges such as interest and credit fees to consumers as well as via contractual fees and transaction fees to payment receivers such as merchants[208]. This meant that banks could see a potential in just replacing cash services with some sort of electronic service that could lead to a situation where they could reduce costs and perhaps also increase revenues at the same time. Telecom operators, on the other hand, needed to realize new revenues from mobile payment services if they were to benefit from these initiatives. There were also several entrepreneurial firms such as Seamless, Izettle, Payair, Payer, Klarna, PaybyBill, Payson, Collector and Payex[209] that put pressure on banks to renew their services in order to maintain a strong position in the area of payments. One question that got the bankers' interest was if payment services could be priced through a transaction fee to consumers – a set-up that would be truly innovative.

The history seemed to have made the banks convinced that they must create a solution were the telecom operators do not have a strong position and influence. And, the banks must do this jointly with all the other, major banks. In addition, if the banks have a potential of saving costs by replacing cash payments with mobile payments, the solution must have features that are similar to those of cash, i.e. the transfer of value should be immediate. The features of such a service will demand innovation of disruptive kind, i.e. that innovation "create potential for new value proposition i.e. different dimensions of performance"[210]. The essence of disruptive innovation is consequently that they fundamentally change the market in terms of creating new dimensions of performance and competition.

15.4 Launching Swish

In early 2012 the banks – via their jointly owned clearing and settlement processor called Bankgirot – start to communicate that they are developing a new mobile payment service that will be very innovative. One of the main innovative features will be speed with which money is

[207] Arvidsson, 2013
[208] Arvidsson, 2013
[209] There has of course also entered new actors since 2013 while some at the same time have disappeared. This list is based on Sveriges Riksbank, 2013: 53.
[210] Christensen, 1977; see also Christensen & Raynor, 2003

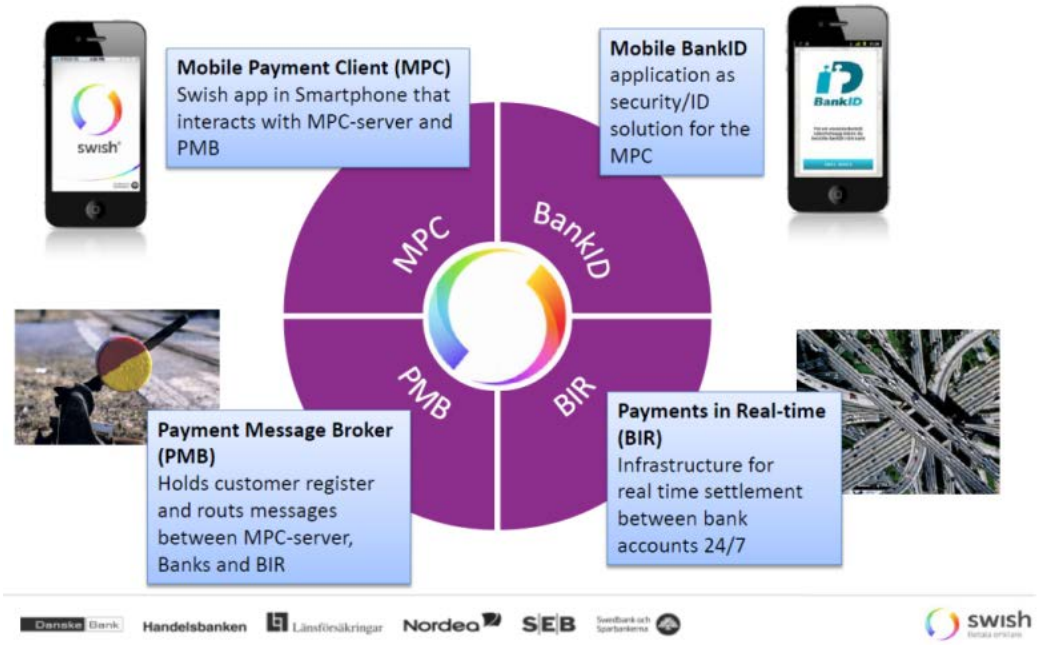
transferred from the payers' account to the payee's account. This is in fact a critical feature if the service is to replace cash where the value is transferred the moment a bill or coin leaves the payers' hand and reaches the payee's hand. The new service must have a similar feature and the idea of real-time settlement – which was not new as such – became a key feature of the efforts to launch a new service. The CEO of Bankgirot Birgitta Simonsson writes in the annual report for 2011 that they will launch real-time settlement in their new mobile payment services that is to be launched in 2012. The reasons behind this initiative are the strong use of mobile handsets, a great number of mobile apps, generally good access to Internet services, an increased demand for rapid payments, a societal desire to reduce the amount of cash in the society, and the new type of competition from new actors in the mobile payment service industry. It was evident that the move by the telecom operators to launch WyWallet[211] put pressure on the banks to launch their service. Interestingly, the ambition to realize rapid payments led to a new challenge: the banks were forced to develop the service through cooperating with Sveriges Riksbank – the Swedish Central bank. The reason being that the Swedish central system for processing, clearing and settlement of payments – the RIX system - simply did not allow real-time settlement at this time. If real-time settlement of transfers between different banks were to be made in real-time, the infrastructure for clearing and settlement provided by Sveriges Riksbank had to be changed. The development of Swish was therefore dependent on collaboration between Bankgirot and Sveriges Riksbank to develop a new – and highly innovative – infrastructure for handling a mobile payment service with real-time settlement[212]. And this meant that the collaboration had to extend beyond the commercial actors in the form of banks to also include the central bank. To solve this challenge, Sveriges Riksbank granted Bankgirot the task and responsibility to handle real-time settlement for Swish payments in the RIX-system.

On December 12, 2012, at 00:12, the new mobile payment Swish is launched in the Swedish market by the six banks Swedbank and the savings banks, Danske Bank, Handelsbanken, Länsförsäkringar Bank, Nordea and SEB.

[211] WyWallet is the shared platform for wallets that were developed jointly by four Swedish telecom operators – Telia, Tre, Telenor and Tele2.

[212] Bankgirot has developed Payments in Real-time (Betalningar i realtid - BiR) which is a payment system that enables clearing and settlement 24 hours per day, all around the year between the participators in the system. The clearing and settlement is done via accounts that are administrated by Bankgirot and where the balances are guaranteed by a corresponding balance in the RIX system. Processing, clearing and settlement are done in real-time even when the payers and payees have different banks. The system is open 24 hours per day on 365 days per year which enables payment handling even when RIX is closed. Similar systems are developed in other countries but the uniqueness with BIR is the clearing and settlement in real-time which means that the risk that the payer will not pay does not exist anymore. Swish was the first payment service that was based on BIR, where one of the possible results could be that cash payments are replaced by Swish payments.

Figure 15.1: The basic components of Swish



Source: Bankgirot

One of the ambitions behind Swish was to disrupt the payment service industry in Sweden by introducing transaction fees directly charged to consumers when they made a payment. This was truly disruptive as consumers previously had not paid direct transaction fees for payments. It seemed like the banks wanted to try a totally different approach to fees and thereby monetizing payment transactions that historically had been paid via indirect annual fees or even cross-subsidized via fees from other payment services such as card payment services. Now the banks wanted to change this and each bank introduced their own ambitions for how to realize a new business model. When Swish was launched several of the participating banks announced that the first six months would be free but that transaction fees of around 1 – 1.5 SEK were to be introduced by July 1, 2013. One bank also announced they would have a monthly fee of 5 SEK for the customers using the service. However, when June 2013 came, the banks stepped down from this ambition. The introduction of transaction fees were moved to January 1, 2014, for some banks while other banks just said they would introduce transaction fees in the future – without specifying when. In the fall of 2015, none of the banks have introduced transaction fees for consumers when they use Swish. The users are deemed to still not be ready for such a disruptive feature.

In late 2014 and first part of 2015 Swish has proved itself in many respects. The number of registered users as well as the volume and value of transaction have increased significantly. In December 2013, there were 700 000 registered users of Swish and payments with a value of over 1.5 billion SEK was made during the first year of the service[213]. In December 2013, clearing and settlement handling in real-time showed strong results with an accessibility of

[213] GetSwish AB, 2014

99.95 percent[214]. According to the same source, Swish broke a new record on December 23, 2013, with 29 658 payments in one day. More than three million Swish transactions with a value of more than 2 billion SEK were done in 2013, and more than 700 000 new users were registered. In August 2015, Swish transactions with a value of 4 061 290 650 SEK was done; there was an inflow of registered users of 198 510 making the total number of registered users in August, 2015, to be 3 305 336[215].

15.5 Swish – a platform based on collaboration and competition

The way banks simultaneously collaborated and competed in order to develop Swish is a modern example of corporatist society cooperation. Swish was realized due to an intricate collaboration between Bankgirot – a representative of banks – and Sveriges Riksbank. This collaboration illustrates how the tradition of a corporatist society[216] was used to develop a truly disruptive and successful innovation in the markets for mobile payment services. Swish is at the same time an illustration of how co-opetition[217], i.e. simultaneous cooperation and competition, is a critical factors in industries characterized by strong network externalities. As seen in another study[218], there are several areas where the banks collaborated but some in which they set up a framework for competition (table 15.1).

Table 15.1: Areas of collaboration and competition in relation to Swish

CO-OPETITION IN THE CASE OF SWISH	
AREAS OF COLLABORATION	AREAS OF COMPETITION
TECHNOLOGY DEVELOPMENT[219] (BIR, MOBILE BANKID, MPC, PMB)	Basic conditions and fees for consumers using Swish are set by each bank
HANDLING OF REAL-TIME PAYMENTS IN THE RIX-SYSTEM TOGETHER WITH SVERIGES RIKSBANK	Marketing and sales campaigns launched by each individual bank
CREATING THE BRAND NAME SWISH	Special offers
CREATION OF A JOINTLY OWNED COMPANY – GETSWISH AB – THAT ORGANIZES THE COOPERATION AND OWNS THE BRAND NAME	Each bank's communication of the service on their web sites or other forms of communication
SHARED COMMUNICATION ABOUT THE SERVICE VIA THE JOINTLY OWNED COMPANY GETSWISH AB	
A BUSINESS MODEL WHERE CONSUMERS ARE TO PAY A TRANSACTION FEE (NOT YET REALIZED)	

Source: Maghoub & Arvidsson (2014)

15.6 Summary and conclusions

There is a long tradition of cooperation between banks in Sweden with the ambition to create infrastructure and services that can be shared by several banks even if the banks in the end compete in their ambitions to sell financial services. Examples include the development of, for instance, a giro-system for payment handling and ATM services for cash withdrawals. This

[214] Bankgirot, 2014
[215] www.getswish.se
[216] Giertz, 2015
[217] Bengtsson & Kock, 2000; Brandenburger & Nalebuff, 1996; Gnyawali & Park, 2011
[218] Mahgoub & Arvidsson, work in progress
[219] See figure 1 above.

cooperation has also involved regulatory actors such as the central bank and the financial supervisory authority, and thereby making it extend beyond business-oriented companies to also involve representatives of the state in the form of financial market authorities.

These efforts have not only enabled infrastructures realizing network externalities between businesses but also leading to a fit and harmony between regulatory frameworks and business operations. The history of banking is a case of how a corporatist society has allowed and enabled Swedish banks to become proficient and early adopters of advanced ICT-systems leading to internationally competitive financial services. This is seen in the development of ATMs, wages and salaries being paid directly to electronic bank accounts instead of in cash, the giro system, telephone banking and Internet banking. Swish is an example of how a globally unique innovation was created in the tradition of a corporatist society in banking.

It can be concluded that even if there often are complaints on the lack of competition in the Swedish banking sector, collaboration between banks is a pre-requisite for developing innovative services in an ICT-dominated industry. The collaboration with governmental agencies was another critical success factor in the development of Swish.

So, driven by factors as: an increased societal interest in reducing cash payments in Sweden; pressures from ICT-skilled competitors primarily from the telecom sector, social media but also from potential new entrants in the payment service industry; technological advances both related to processing of transactions in large ICT-systems and to how consumers access Internet via smart phones; ambitions to reduce the use of cash in Sweden; and ambitions to take banking into the 21st on-line society; banks decided to develop an innovative and disruptive mobile payment service called Swish. On December 12, 2012, at 00:12, the new mobile payment Swish was launched in the Swedish market by the six banks. Swish is a disruptive innovation in the mobile payment service industry that has succeeded in creating an interoperable service for the Swedish market, and this chapter has told the story of how this service was developed.

16 Conclusions & implications

Annika ***Rickne,*** *Eric* ***Giertz*** *and Petri* ***Rouvinen***

The aim of this report is to understand the historic development of the ICT sectors in Finland and Sweden, and to scrutinize the mechanisms behind the major success stories. We have been interested in understanding not only the history but also the current position for the ICT sectors for these small but leading economies. In this final chapter we first summarize the previous chapters and then provide some points for further discussion.

16.1 Summarizing our findings

The first chapter – '*Finland and Sweden – Small, knowledge intensive nations'* – sets the scene for comparing ICT provision and use in Finland and in Sweden. We observe many similarities but also considerable, and somewhat surprising, differences between the two countries. The Nordic countries have a great legacy both as leading ICT providers and as the world's foremost knowledge economies. While Finland and Sweden has been changed on both fronts, there are good reasons to believe that the Nordic success in ICT will continue in the future.

The chapter *'Dynamics of the global telecom sector – the telecom equipment supplier industry'* analyzes the transformation of the global telecom equipment supplier industry; from the nationally oriented "PTT regime" (dominated by national telephone monopolies supplemented by primarily domestic suppliers) of the 1980s to the globally competitive industry of today (2015). A number of pervasive trends and major events have affected the sector: service expansion and growth in particular mobile and datacoms (Internet); rapid technological progress, in particular; digitalization, and the resulting convergence (of telecom, IT, software, media, etc.); the changing role of standardization and R&D regimes, liberalization, and the resulting changing industrial structure. In this process of turbulent change, almost none the leading players in the 1980s remain as independent entities – Ericsson being one prime exception, with former competitors having been acquired, merged, or gone bankrupt. Many companies have disappeared (e.g. ITT and Nortel). The rise of mobile allowed some companies to enter and establish leading positions (Nokia, Motorola), but did not manage to survive as major players (e.g. Motorola), while others merged or were acquired (Alcatel-Lucent, Siemens). Following from the widespread diffusion of the Internet and globalization, some new entrants have risen to global leadership (e.g. Huawei from China and Cisco from the US).

Chapter 3 compares the *Finnish and the Swedish ICT sectors*. In both Finland and Sweden, the ICT sector's accounts for 5–6% of GDP and 3–4% of total working hours. Since Sweden is a larger economy than Finland, its ICT sector has about twice as many workers. Software and services is the biggest ICT sub-sector in both countries. The most apparent structural difference relates to ICT consulting, which in Sweden is over one-fourth and in Finland under one-tenth of

ICT employment. The Swedish ICT sector appears more diverse and more dynamic than its Finnish counterpart.

Chapter 4 considers the *historical evolution of the Finnish ICT sector*. National regulation, policies, and even politics, played a crucial role in the early history of the Finnish ICT sector. Subsequently Nordic, European, and ultimately global developments grew more important. The move from analog to digital technology in mobile telecommunications – that coincided with worldwide de-regulation and liberalization of telecom operation – was Finland's big break into the global ICT markets, which was capitalized handsomely. Following this, chapter 6 reviews *the current Finnish ICT sector*, which has experienced exceptional turmoil since the 2008 financial crisis. *Nokia*'s downsizing is what first meets the eye and without *Nokia* the sectors employment in Finland would have remained about the same. There has been a wave of mergers and acquisitions – in particularly *Tieto Group* has been heavily molded. ICT in Finland has grown more international and has become more consolidated.

Chapters 5 and 7 outline the historic development of Sweden and its current position, which helps us understand where Sweden comes from, where it is today, and perhaps where it is heading. The chapter *'Understanding the Swedish saga through an historical exposé'* illustrated how liberal reforms in the mid-1800s initiated a belated but rapid industrialization in Sweden. Sweden also took the lead in telecommunication through the establishment of hundreds of private telephone networks, who bought products from the new venture Ericsson. After World War I many companies went into liquidation or bankruptcy and the ownership of Swedish industry was transferred to less than a dozen financial spheres. In parallel government strengthened its grip over the infrastructure and the governmental agency Televerket acquired all private telephone networks. The consolidation laid the foundation to a corporatist society, with a very close cooperation between government, incumbents and trade unions. There also was an extremely close cooperation between governmental agencies like Televerket and private corporations like Ericsson in what was named developing couples. Incumbents also set the agenda for higher education in engineering sciences and applied research. Incumbents in general and Ericsson in particular were very successful on the export markets thanks to early adoption on the domestic market. But in the late 1900s large corporations went into trouble and could no longer fully support the welfare society that had been shaped. In parallel infra services were deregulated and borders between countries were tore down. Sweden also became a member in the European Union and had to adapt to new rules and regulations. This called for new ventures and entrepreneurship. Sweden has been extremely successful in forming an expanding ICT sector characterized by structural changes, sectorial shifts and great dynamics.

'The Swedish ICT sector today' is a study of the of the ICT sector in Sweden. It divides the ICT sector into business logic sectors that are not present in traditional statistics. The resulting picture provides a significantly better position to understand the composition and development of the ICT sector in Sweden. The ICT sector in Sweden is in itself a rapidly growing sector of the Swedish economy. The study involves a total number of 2,729 companies with 132,142 employees distributed over 4,233 different locations around Sweden. They are spread all over the country but the concentration to the Stockholm area is remarkably high. Software and service companies dominate. Less than one quarter of the employees is employed in a hardware

company among which Ericsson still occupies a very dominant position. The number of employees working in companies delivering different kinds of software and services are divided almost equally on three different segments; Software & Net Services, IT operations & Maintenance respectively ICT Consultants. The ICT sector is characterized by great dynamics, and many companies have been acquired by domestic or foreign corporations. Indeed, during the period 2007-2011, the number of employees belonging to foreign-owned companies increased from some 40,000 employees to reach almost 50,000.

Given the good performance of the subsector of gaming in both countries we scrutinized this industry in two chapters. The chapter on the *Nordic gaming* (chapter 8), includes brief accounts of the origins and history of the industry in the different countries. It also mentions the key companies and their role in shaping the industry we see today. Sweden and Finland are the main video game exporters in Scandinavia. The balance was originally that the Swedish industry was about twice the size of the Finish in terms of aggregated revenues. However, recently tremendous growth in Finland has led to a shift in leadership, where Finland is now the bigger player. The Finnish industry's revenue is extremely dominated by Supercell with mobile game hit titles like "Clash of Clans" and "Hay Day". The Swedish industry is also quite concentrated, but there are more large firms and a much greater share of revenues coming from console and PC games.

The following chapter explains the Scandinavian success in video game development that have been observed and acknowledged in international media. It focuses on *'The Swedish game development sector*' and the link between domestic circumstances contributing to a strong innovation system that supports achievement within industry key success factors. While the data and analysis specifically concerns Sweden, many of the circumstances and industry formation process are similar to the other Scandinavian countries. A major source of competitive advantage appears to be the competence and networks in the industry, resulting from previous success. These become a general asset, especially for start-ups, because of the pronounced tradition of sharing and helping that characterize the industry culture. On the negative side, hampering the establishment and growth in the industry, are bureaucracy, taxes, and lack of government support, especially compared to competing nations like Finland and Canada. It is also difficult for game developers to attract significant capital from other sources than the publishers.

In order to understand the changing industry structures and the role of various types of firms, chapter 10 discusses *mergers and acquisitions in the Swedish software and services industry*. During the first decade of the 21st century, the Swedish ICT software and services sector developed from a pioneering state of wide-eyed enthusiasm via abrupt adjustments of expectations into a major business sector and an important part of the Swedish economy. Industrial consolidation through mergers and acquisitions played several important roles in this process. As a means of expansion, M&As allowed for greater scale economies. As a channel for less effective firms to be absorbed by more efficient competitors without total loss of operational assets, M&As constituted a force of creative destruction parallel to the mechanism of exit through bankruptcy. Drawing on new empirical evidence, we argue that M&As also provided new impulses and opportunities for entrepreneurship and stimulated between-firm job

mobility of key persons in the sector. We conclude that the intensive M&A activity of the period contributed to renewal and growth of the ICT software and services industry at large, but did not lead to the creation of new Swedish-based multinationals in the sector.

In a discussion on the '*Swedish entrepreneurial firms and ICT hotspots*' we take the perspective of startup companies in the Swedish ICT sector and looks at what positive sides or drawbacks there are being located in Sweden as compared to one of the major ICT hubs in the world: California (chapter 11). Sweden has an international reputation as a highly ICT productive environment, and especially, Stockholm is seen as a major hotspot for ICT. The interviewed firms are all in agreement that for software and hardware development, Sweden and Stockholm is one of the most favorable locations to be situated at globally. The labor force of engineers is highly educated and experienced, work efficiently and performs at high standards. As the ICT sector and ICT development in general is flourishing in Sweden, there is however a shortage of programmers, system developers, etc. What Silicon Valley can offer in terms of competence is highly experienced top managers, growth experts and financial officers, and competent capital. Likewise, there is a plenitude of role models to lean on: companies who have already been down the same roads and can give guidance. Most importantly, this is where there is a large market, in terms of end users as well as businesses.

In chapter 12 we focus on a specific segment within the ICT sector, namely *ICT consultancy companies* in Sweden focused on developing embedded systems and other ICT solutions intended for their customers´ products or manufacturing systems. These firms in essence function as external research and development department for their clients, and are a vehicle through which other sectors in the Swedish economy have been able to adopt ICT related changes and develop own innovations. Indeed, Sweden has a very large ICT consultancy segment. There are in total more than 80,000 employees working with ICT development in Swedish consultancy companies. The lion share of both the companies and the employees primarily offer services related to commercial and management software solutions. This chapter however focuses on a sub-segment, namely ICT consultancy companies focused on developing embedded systems in their customers´ products or production systems. In total there are more than 16, 000 employees working with R&D related ICT development of this kind. The R&D related consultancy segment bear some similarities to its more generic sibling but it is of a more strategic interest to their customers. It was born when the telecom and defense industries were introducing a disruptive technology into their products. The consultants then worked at the very frontier of knowledge. Through the externalization of product development this experience and competence also became available for other companies, for example large engineering incumbents and banking industry, when they introduced embedded systems into their products and ICT into their production systems.

While the ICT sector in and of itself is large and vibrant, ICT as a pervasive technology sifts into and influences or even revolutionizes most sectors of the economy. Chapter 13 gives an overview of *how ICT permeates a number of industries*, and especially discusses the important current trends of big data, Internet of things and cloud computing. A survey to Finnish firms in a variety of subsectors illustrates how managers perceive and plans the importance of these tendencies on their own business. While the ICT sector in and of itself is large and vibrant, ICT

as a pervasive technology sifts into and influences or even revolutionizes most sectors of the economy.

Observing the change process from the point of view of the *engineering industry*, the next chapter illustrated how large, well-established firms have handled technological shifts. Large Swedish incumbents in the engineering industry have successfully introduced embedded systems into their complex products. They often seem to have mastered the introduction of a new and disruptive technology better than their foreign competitors. They have survived and gained market shares when their industry has been challenged and consolidated. Corporations who have coped with the transformation seem to have two things in common. They have worked closely together with demanding customers on very tough time schedules and they have been benefitting from the available expertise on the Swedish domestic market. They have employed people and/or hired consultants with previous experience from telecom, defense or automotive industry in Sweden. The authors argue that the externalization of R&D related competence concerning embedded systems and Internet of things has been a competitive advantage for Swedish engineering industry.

A final look on how ICT may influence our society is presented in chapter 15. The study of *'Emergence of an ICT based disruptive mobile payment service'* discusses how ICT has transformed the banking sector. There is a long tradition of cooperation between banks and governmental agencies in Sweden with the ambition to create infrastructure and services that can be shared by several banks even if the banks in the end compete in their ambitions to sell services related to savings, lending and payments. This cooperation has not only enabled infrastructures realizing network externalities between businesses but also a fit between regulatory frameworks and business operations. Driven by factors as: an interest in reducing cash payments in Sweden; pressures from ICT-skilled competitors from the telecom sector, social media and from new entrants; technological advances in processing and consumer products; ambitions to reduce the use of cash in Sweden; and ambitions to take banking into the 21st on-line society; banks decided to develop a disruptive mobile payment service called Swish. Swish has succeeded in creating an interoperable service for the Swedish market, and this chapter tells the story of how this service was developed.

16.2 Discussion

In this concluding section we will highlight a set of issues that we perceive deserves further attention. Indeed, our extensive scrutiny onto the history, current position and underlying driving forces of the ICT sectors in Finland and Sweden has teased out some essential lessons.

What we carry with us: Path dependency

By early 1990s, the two national champion companies – *Nokia* and *Ericsson* – had soaked up much of the nationally accumulated expertise in ICT and, with their expansion in the course of the 1990s; they became dominant forces in their respective home economies by year 2000.[220] If

[220] The Nordic ICT scene was vitalized with the development of the Nordic NMT mobile telephony standard since the late 1970s. Besides *Nokia* and *Ericsson*, the NMT players of the mid-1980s included *Dancall* and *Storno* in

one takes in to account both the direct impact (the value added share) and the indirect impact – including sub-contracting and partnering –, *Nokia* constituted well over half of the Finnish ICT sector and *Ericsson* was almost as dominant in Sweden. In the 2000s, first *Ericsson* in Sweden and then *Nokia* in Finland became subsequently less important, but the ICT sectors at large remained vibrant and also the integration of ICT-based solutions into the market offerings in other sectors evolved. Arguably ICT remains the single most important economic driver of future growth in the two economies.

Universities, research institutes and firms in both countries were highly competent – and also early – in understanding, adapting to and developing various technological solutions for the telecom sector. Moreover, they managed to set practices and standards for the global actors. While Ericson and Nokia naturally take on leading roles in the economies, the ICT sector and technological and market shifts go well beyond these sectors.

With the specific industrial structures of Sweden and Finland, this has also meant that various sectors that have functioned as motors in the countries' economies in general. ICT developments in Sweden relate to the automotive and armaments sectors; in Finland, banking and forestry were important early breeding grounds; in both countries, industrial equipment and machinery were important. These historical links do not determine future outcomes, but they nevertheless influence national positions in new domains. This is also true when it comes to IT adoption, development and diffusion. Thus, the traditional sectors are historically important, but also highly relevant today. With the emerging *internet of things*, the interplay of path dependences and re-deployments of expertise will again influence commercial outcomes.

This is also apparent for understanding the embeddedness of ICT in other sectors. For example, Sweden's engineering sector was highly able to incorporate ICT and become global leaders. The analysis highlights the importance of early on recognizing the characteristics of the technological shifts, to use competence development and sharing through ICT consultants, and to set in motion extensive fieldwork with early, dominant customers.

Another aspect of path dependency, what we bring with us into the future, relates to organizational aspects. Sweden's traditional corporatist society where policy and large corporations engaged in joint visions and operational actions, the policy clearly favoured the accumulation of capital within established companies, and included a governmental interest in research and higher education. Also, incumbents initiated applied research programs, often co-funded by government, in sectorial research institutes. In essence, there were strong links between basic research, education, applied research and industry needs. This was combined with a close cooperation between public customers and individual private corporations. In those so-called developing couples, engineers and technicians from both companies worked side by side with research, product development and implementation of new products and systems. Perhaps the most pronounced development couple was in telecom, involving the cooperation

Denmark and Simonsen in *Norway*. NMT was a forebear for Finland's and Sweden's big break in global provision of ICT, the ultimately global GSM standard.

between the Swedish PTT Televerket and LM Ericsson. Even today, we can see traces of such organizational solutions as revealed in case of banking in this report.

Dynamics and resilience

Around the year 2000, major global changes came into play with the advanced of, e.g., cloud computing and mobile internet. What is particularly interesting to us is how, since year 2000, Finland and Sweden followed rather different trajectories.

From 2000 to 2004, *Ericsson* reduced its Swedish employment by over 20,000 persons. Via its external networking and partnering, the company had employed tens of thousands workers in ICT related development, consulting, maintenance, and research; this segment felt *Ericsson*'s misfortunes even more forcefully than its own employment. In early 2000s, a huge volume of ICT expertise was re-deployed in Sweden. In hindsight it can be said the actors within the sector re-positioned themselves quite successfully thanks to accumulated expertise, advanced demand, and – despite the burst of the new economy bubble – still vibrant global market. New venture activity was particularly intense in internet services and software. Also, ICT consultancies seek engineering and other ICT using companies as their new customers in developing embedded ICT systems and deploying ICT services.

Nokia ran into serious difficulties in 2008. Within a few years, *Nokia*'s troubles lead into a re-deployment of ICT expertise in Finland, which in relative terms was quite comparable to the Swedish turmoil a decade earlier. For Finland, however, three things were different: the second disruption was now in full bloom, global demand was less vibrant and competition was more intense, and the bulk of potential domestic customers were not investing into avant-garde ICT services and solutions.

After being on rather different trajectories in the course of the 2000s, the Finnish and Swedish ICT sectors are quite similar in relative terms. Currently, *Nokia* and *Ericsson* remain nationally important companies, but not overwhelmingly so.

Sweden has had a form of dynamics and resilience to the necessary change process that Finland has not had to the same extent. Now in this disruptive phase this proves crucial.

A cluster: an environment conducive for innovation

We know from the literature and from numerous examples of vibrant regions and IT hotspots where Silicon Valley is the prime example, that agglomeration of actors and resources to what one may call a critical mass, as well as cluster formation, are crucial. It is also important to have a diversity of different types of actors along the value chain, as well as in various subsectors. Moreover, small and large firms interact and reinforce one another, and sometimes take on different roles in development process or in specific maturity phase of an industry segment. Furthermore, the business sector interacts with university groups and institutes and other types of actors in their innovation processes.

Both countries are ranked high among the global leaders and seen as good innovation milieus. The question here is how to further develop the countries – and the city hotspots within them – to not only retain but to strengthen their global competitiveness. In this vein, we note that

Sweden is indeed the larger country and also more diverse. This had ramification when it comes to how the economy in large handled the shift. Nowadays software is the largest ICT sub-sector in both countries in terms of employment. Even so, since Sweden is a bigger economy than Finland, its ICT sector is also larger: The sector in Sweden has about twice as workers as in Finland and nearly six times as many companies. The most apparent difference between the two countries relates to ICT consulting, which in Sweden accounts for over one-fourth and in Finland under one-tenth of overall ICT employment.

Our comparison of the Finnish and Swedish ICT sub-sectors by firm age and size as well as our analysis of the sector's "creative destruction" – in terms of entries, exits, and differences in growth rates among continuing businesses – suggests that the Swedish ICT sector is more diverse and more dynamic than its Finnish counterpart. In both countries we see a history where incumbents functioned as motors for the ICT economy. But today, when these firms have taken on a different global position and role, the industrial landscapes have – and still are – changing. It is important for both countries to find a way to deal with this.

One way to think about the altering knowledge bases and industrial landscapes is to discuss the actors, their connectiveness and formation of competence and actors clusters. So a multitude and variety of actors need to be present, and competence in specialized and general areas.

As regards research institutes and technical universities both countries are well endowed. Private companies have all along collected fruits of publicly funded research in university and research institutes; at the least they have depended on a steady flow of graduates with deep expertise in relevant technical domains.

Clearly, governmental units can be instrumental: The ICT sector has all along depended on intense *private-public cooperation* in various forms. Many of the key innovations in the sector can be traced back to public procurement. In virtually all countries, the sector has featured at least some public monopolies in operation of ICT services and also in providing necessary equipment by private or public national champion companies. Unlike in Finland and in Sweden, in most countries all this public affection has ultimately *not* led to global commercial success in ICT. In the past, the Nordics have obviously gotten something right in public-private cooperation and while policy (and politics) has played second fiddle in recent ICT developments, public action continues to the be central for the ICT sector's future. Also in the context of ICT, the longer-term Nordic strength has been sustained emphasis on supporting education and investments in basic research and applied R&D. While neither is in vogue at the moment, the have to be part of the Nordic success formula of the future.

It is quite clear that Nordic cooperation in various forms and at various levels has contributed to the Finnish and Swedish success in ICT. Also outside joint efforts such as the afore-mentioned NMT standard, there has been active Nordic cooperation with technical assistance and technology transfers going back and forth across national borders via, e.g., organizations such as *NordForsk* and *Nordisk industrifond* as well as engineering societies and personal connections. Leading corporations, e.g., *Ericsson*, *Facit*, IBM, *Nokia*, and *Norsk Data*, spread their R&D activities across the Nordic countries. Since the early 2000s, the Nordic connection was

somehow lost, perhaps in part because Finland and Sweden were on somewhat different trajectories in their national developments. But now that both national policy and corporate interests seem quite aligned, hopefully the spirit of Nordic cooperation can be re-discovered.

The entrepreneurial environment is of great importance. We have especially focused on the gaming sector. Even though its economic importance is still limited, one of the ICT sub-sectors we look at is electronic gaming – a globally booming industry, in which both Finland and Sweden has a good foothold. In per capita terms, Finland and Sweden have some of the largest gaming industries worldwide, although South Korea is the leading national economy in this respect. South Korea is, however, quite orientated towards its domestic market. According to the metric we employ, Finland and Sweden have the two most export-oriented gaming industries in the world. If we concentrate on successful mobile gaming apps, we observe that Finland has somewhat larger but less diverse footprint than Sweden; the surrounding ecosystem is more vibrant in Sweden and it is more resilient to any one company's success or failure.

The business sector has been dwelt on in other parts of this chapter, and we here suffice in summarizing that there are globally successful companies in software, hardware and services. Some firms have grown mid-sized and there is much experimenting in smaller, startup firms.

Until the early 2000s, the ICT sectors in Finland and in Sweden were strongly inter-linked and geographically clusters around a few centers of expertise. Since then, many time-honored links were broken and reliance on domestic clusters seemed to have weakened due to both commercial reasons and the second disruption. Obviously, collaborative networks had grown more global. But a closer look reveals that emerging new ICT sub-sectors, such as electronic gaming, *do* feature quite strong inter-organizational linkages and geographical clustering. National and even city-level conditions and local networks continue to be important.

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