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Nordic small countries in the global high-tech value chains: the case of telecommunications systems production in Estonia

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Contents

1. Introduction

The liberalisation of markets and the globalisation that the world has witnessed in the course of the recent decades, has made the movement of capital and goods on and between different continents easier than ever before. The greater size of the market allows in-depth specialisation which is the key enabler of productivity growth. Specialisation brings also about the increasing fragmentation and delocalisation of various economic activities that are part of a value chain of any specific product or service.

Indeed, the total world trade of merchandise and commercial services has increased from 4,230 billion USD in 1990 to 19,900 billion USD in 2008 (in current prices) (WTO 2009). Proportionally, the volume of trade of manufactured intermediate goods increased between 1988 and 2006 from 2,018 billion USD to 9,580 billion USD (in constant prices). Furthermore, it appears that the electronics industry has benefited remarkably from the ongoing trend of globalisation, as the share of electronics has increased from 8.1% to 17.4% of the total trade of manufactured intermediate goods (Cattaneo *et al* 2010: 248).

For a long time, globalisation was primarily about off-shoring the production or customer care activities to lower cost locations. However, it has become increasingly apparent since the turn of the century that it is not only the more cost-sensitive production tasks but also the R&D and design of the new products and services that get increasingly relocated from developed to developing countries (Cattaneo *et al* 2010). One can therefore argue that we are witnessing the transformation of the global production networks into the global innovation networks (GIN), where not only the production but also innovation takes place on the global scale (INGINEUS). As companies and regions specialise in different fragments of GINs, we expect them to require different competences and resources. Prior to assessing the impact of GINs in the EU, we need to understand the general industry dynamics, company strategies that determine their activities, and the competences involved.

In this paper we focus on the electronics industry, and more specifically on the production of telecommunications systems, which is characterised both by very rapid growth of the global trade and very high ratio of R&D investments in the sales revenues (Moncada-Paternò-Castello *et al* 2010). More specifically, we analyse the distinctly different development paths of the three major telecommunications systems producers in the Nordic countries: Ericsson, Elcoteq and Skype. Ericsson was established in 1876, and has been a well-known brand name for decades. By contrast, Elcoteq grew from a small company into a global multinational corporation in less than a decade only in the 1990s. As a global company, Skype is still less than ten years old, but it facilitates today more international calls than any other telecommunications operator on the planet.

The evolution of the technologies and the market demand, as well as the competition situation in the industry and the particular location based advantages, are all important factors that determine the behaviour of these specific companies. Therefore, we start the analysis by presenting a short overview of the general industry dynamics in the telecommunications equipment manufacturing. Subsequently, we briefly summarise the corporate history of the three case study firms – Ericsson, Elcoteq and Skype – in relation to Estonia as the host economy. The aim will be to establish the interplay between the broader industry dynamics, corporate strategy and location choice. In other words, we are interested in the different push and pull factors that have led to the relocation of specific activities to Estonia or away from Estonia.

This way, we set the stage for analysing the role of capability building as one of the crucial factors in determining the possibilities for moving from the relatively simpler manufacturing or service functions to the more knowledge intensive and value added R&D and product development activities. The subsequent chapters of this paper deal with capability building that has taken place on the level of the public education and R&D systems and on the company level in the case study firms. Finally, we discuss catching-up strategies for latecomers in a modern R&D intensive industry, such as ICTs and electronics.

2. Recent developments in the industry

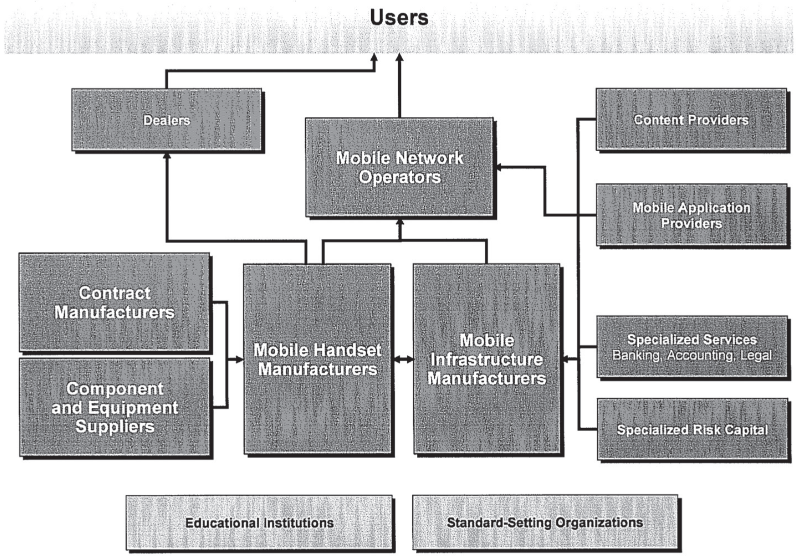
2.1. The global telecommunications equipment production

In the period of 1990-2000s, with the advent of the Global System for Mobile Communications (GSM) standard and the broad take-up of the mobile telephony services by consumers, the Nordic telecommunications equipment manufacturers became the global market leaders both in the manufacturing of the mobile telephones and the related network equipment. The United States and Japan were developing competing standards which had internationally less success than the European GSM standard.

Nokia had 31% and Ericsson 10% of the mobile phone handsets market in 2000. Motorola, as the closest competitor, had 15% of the market in the same year. When Nokia was the leader in the manufacturing of the handsets, then Ericsson had remarkable 30% and Nokia 10% of the mobile telecommunications infrastructure equipment market. Motorola had 13%, Lucent 11% and Nortel 9% of the infrastructure equipment market in 1999. (Rouvinen and Ylä-Anttila 2003, Porter & Sölvell 2006: 13).

In order to properly understand the sources of the Nordic competitive strengths in the mobile communications industry, one should consider the respective investments and the evolution of the mobile telecommunications in the Nordic countries at least since 1970-1980s. The various elements of the value chain of the mobile telephony industry (Figure 1) were fairly closely located in the Nordic countries even in the 1990s. In the following decade, however, both the competition situation and the geography changed notably in this industry.

Figure 1. Mobile telephony value chain



Source: Sölvell & Porter 2006.

The initial saturation of the market, Nasdaq crash and the emergence of the next generation (3G) mobile telephony standards[1] led to a significant restructuring of the industry in the early 2000s. For example, Ericsson who was the market leader in network infrastructures, but had in handsets a weaker market position merged its handsets business with Sony's. Siemens merged, for similar reasons, its network infrastructures business with Nokia, and sold its handsets business all together to the Taiwanese BenQ.

Although the market share of the Asian producers was negligible in the turn of the century, various emerging market actors, such as Samsung, LG (both Korea), Huawei (China), and others have been rapidly building up their product development and manufacturing capabilities. Furthermore, various integrated microchips and ready-made integrated platforms that are instrumental for developing mobile telephones, have became readily available from the various semiconductor manufacturers, such as Qualcomm, Infineon, ST-Ericsson, MediaTek. Thereby, from the technological point of view the mobile telephone market has become much easier

[1] At the time of the development of the original GSM standards, no one could properly estimate the future importance of the mobile data communications. Therefore, the original GSM standard foresaw only the possibilities for a very limited (9600 bps) speed of data communications. The shift from the GSM (2G) mobile telephony systems to the 2.5G (EDGE), 3G and the forthcoming 4G networks is, therefore, foremost about the increasing of the bandwidth that could be made available for the mobile data communications.

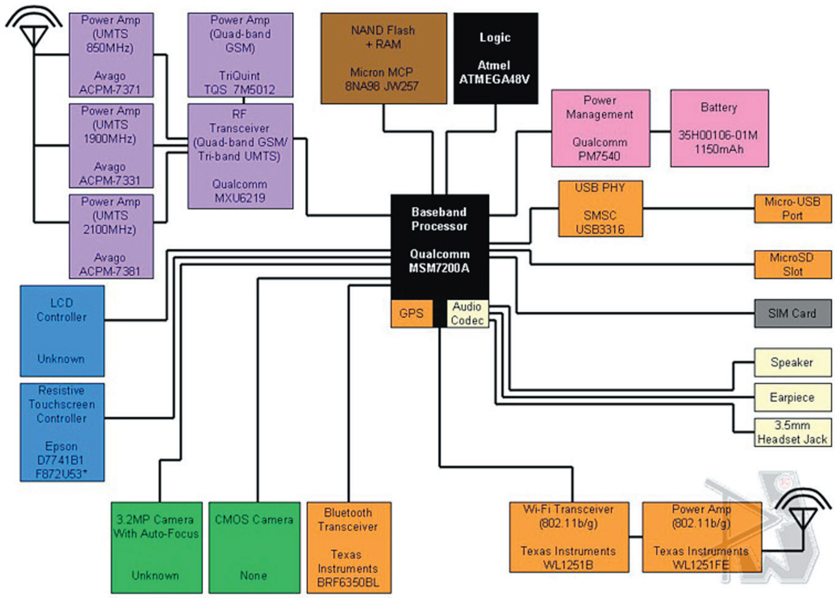
to enter for the new actors. What matters the most in the low end of this market, is the market power and access to the end customers at large emerging markets, such as South-East Asia and Africa.

In the 1990s, the product development and manufacturing were, although dependent on the independent suppliers of microelectronics components, fairly closely connected in Western Europe and in the United States. However, with the saturation of the European and other developed country markets, Asia became both the greatest growing market and the largest manufacturing base. The mobile telephony production value chain have become truly globalised in the course of the last decade.

For example, the Apple's iPhone, which is one of the today's most eye-catching electronics products, is actually manufactured by the Taiwanese *Hon Hai Precision Industry Co Ltd*, while the various microelectronics components are sourced from different companies and manufacturing plants across the globe. Thus, the various parts of the Apple iPhone related global innovation and production networks are indeed dispersed across the globe. The iPhone 4 display, application processor and memory come from LG and Samsung in Korea, radio chips come from Broadcom and Intel in the U.S., and Infeon in Germany, and the various smaller components come from elsewhere (iSuppli 2010).

Sony Ericsson's mobile telephones build similarly on the standard components that have been designed by the various major microelectronics firms, such as Qualcomm, Texas Instruments in the U.S., Avago in Singapore, etc. (Figure 2).

Figure 2. Schematic Sony Ericsson Xperia X1

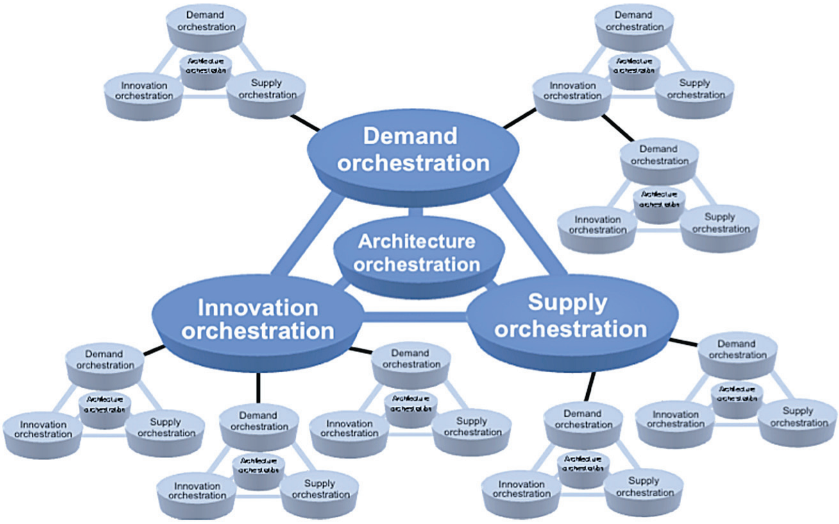


Source: iFixit 2010.

Both the major brand names in the telecommunications equipment manufacturing, but also their component providers operate on global basis. Their headquarters, marketing, R&D and product development, manufacturing, services and support activities, etc., are located in different parts of the world.

The fact that the various semiconductor components and ready-made modules of the mobile telephones are increasingly readily available to anyone and the whole production chain has become truly global has shifted the very nature of the market competition in this industry in recent decades. The market competition in the telecommunications equipment manufacturing is not about mastering the development and production of the individual products any more, but about development and commanding the whole ecosystems of different organisations who are involved in the whole product life cycle from R&D and product development to manufacturing, sales and customer care (Figure 3).

Figure 3. Innovation networks and ecosystems



Source: Ollila 2011.

Apple has recently managed to control its whole global innovation and production network in a way no other mobile phone manufacturer has been able to follow. This together with the superior product design and the specialisation in the upper end of the market allows Apple to reap unrivalled economic benefits.[2] Although Apple sells only 4% of all mobile telephones, it collects a remarkable 50% of the total profits of the mobile handset industry. By contrast, the former market leader Nokia has been recently underperforming. Nokia sells still 32% of all handsets, but it has been increasingly competing in the overcrowded lower end of the market, and this has allowed it to benefit from only 15% of the industry profits (Figure 4).

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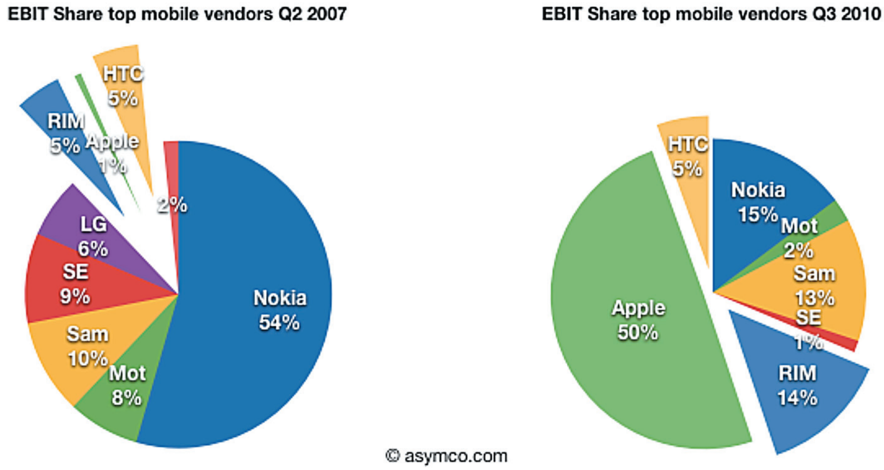
2 The various iPhone components cost only $187.5 and the assembly only $6.5 of the $600 iPhone 4 sales price (iSuppli 2010).

Figure 4. Earnings of the major mobile telephone producers.



Source: Asymco 2010.

The Nokia's and Sony Ericsson's recent failure to capitalise on the smart-phone market is largely due to the failure of the Symbian operating system that (OS) Nokia and Sony-Ericsson have been developing jointly with some other manufacturers. Unfortunately, the Symbian consortium has been never able to establish a consistent OS that would allow for the development of applications that run without modifications on a myriad of different hand-sets produced by Nokia, Sony Ericsson and others. The development and maintenance of applications that run on multiple similar but mutually incom-patible platforms is costly. It is also confusing for the end users to figure out what specific version of the software they should acquire. As a result, the Symbian mobile applications market never took off, and Apple has overtaken the market leadership with its innovative touch-screen user interfaces and iTunes App Store, which everyone else now attempts to copy.

The competition for the establishment of a *de facto* standard of the mobile operating system is, however, still ongoing. Google, another newcomer at the mobile telephony market, is currently Apple's fastest growing and strongest contender in the fierce competition for establishment of a dom-inant software platform. Sony Ericsson has started a partnership with Google and introduced its first Android powered smartphone in the spring of 2010. On 11 February 2011, Nokia announced a new software partner-ship with Microsoft, another ailing giant that has failed to establish its software stronghold in the mobile telephone industry (Bloomberg 2011)[3].

3 Both Apple and Google have also taken serious steps at extending their iOS and Android platforms beyond mobile telephones to other devices such as, e.g., the tablet computers and flat screen TVs, and have come up with the Apple TV and Google TV systems respectively.

The mobile telephone network equipment market is another completely different market segment for the telecommunications equipment manufacturing industry, which has a rather different competition and demand dynamics as compared to the market for handsets.

The infrastructure equipment market contracted in 2009-2010, as the operators cut spending during the recession and aggressive Chinese vendors drove down the prices. In this market segment, Ericsson continues to be the market leader with 33.6% of the market in Q3 2010, while the Chinese Huawei (20.6%) has performed recently slightly better than Nokia Siemens Networks (19.8%). The fourth largest player, the U.S. based Alcatel-Lucent had 16.2% of the market (Reuters 2010).

What makes this market different is that it is not the consumers but the network operators who are the equipment manufacturer's clients. The number of individual units sold to this market is much smaller than the number of mobile telephones sold, and the variety of consumer preferences and the different models of the products is also much more limited here. Nonetheless, the market for the mobile telecommunications network equipment continues to be anything but a fully harmonised global market that relies on universally adopted global standards.

The developed countries continue to be the main market both for the high-end smartphones and for the 4G (Long-Term Evolution, LTE) infrastructure equipment, while the continued rolling-out of the simpler telephones, and the 2G and 3G network infrastructure will drive the growth at the developing markets[4]. Some of the large developing nations, e.g. China, are also moving very fast to the 4G technologies. Furthermore, they continue to compete with the major developed nations for the standardisation of their particular specifications of the 4G networks and protocols.

The different market dynamics and smaller production volumes imply, in turn, different location choices for the development and manufacturing of the infrastructure equipment as compared to the handsets.

2.2. The importance of the telecommunications equipment industry for Estonia and the Nordic countries

ICT sector is one of the most knowledge and R&D intensive industries both globally and in the Baltic Sea Region. However, both the size and

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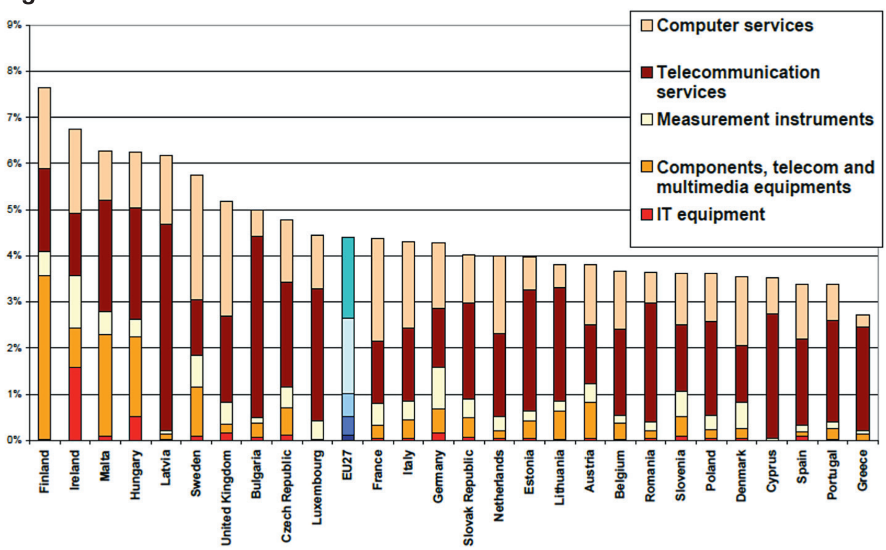
4 The transition from 2G to 3G to 4G networks is primarily about allowing for a major increase in the data communications bandwidths in the mobile telephone networks.

the knowledge intensity of the ICT sector vary substantially both across the different ICT sub-sectors in the different countries in the region. The share of the ICT sector in the GDP is in Finland and Sweden among the highest in Europe. This is largely due to the major contribution of the manufacturing industry, in particular the manufacturing of telecommunications equipment. The presence of a strong ICT manufacturing sector is indeed what distinguishes the Nordic countries from the majority of the other European economies, where the ICT sector accounts only for 3-4% of the GDP (Figure 5).

Figure 5. The ratio of the ICT sector value added to the GDP in 2005



Source: Turlea *et al* 2009: 46.

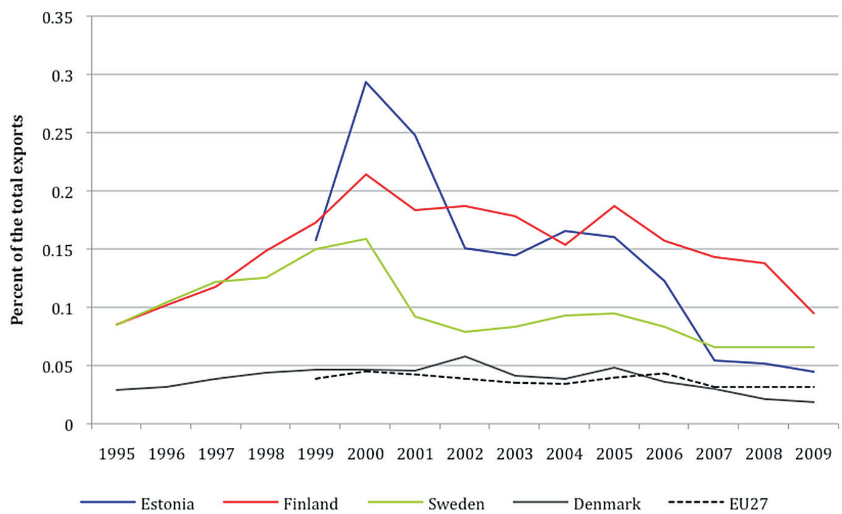
Finland has a particularly strong specialisation in the manufacturing of the telecommunications equipment. In fact, Nokia's remarkable success in the last decades has been clearly visible in the Finnish economy, especially when considering its small size. Nokia contributed more than 2% of the Finnish GDP growth in 2000. More recently, however, the consolidation of the industry and the rise of the U.S. and Asia based competitors has changed the situation substantially. Nokia's contribution to the economic growth in Finland was negative even during the global crisis in 2008-2009 (Ali-Yrkkö 2010: 12). In contrast, Sweden's industry is much more diversified which makes it much less dependent on particular large companies such as Ericsson, or other multinationals that are headquartered in Sweden.

The important role of the telecommunications equipment manufacturing in Finland and Sweden is even more visible in the export figures. Finland's and

Sweden's exports of goods doubled between the 1995 and 2009. Estonia's exports grew in this period even more rapidly. While this is the case, it can be observed that the export of telecommunications equipment in all three countries clearly hit the peak around the turn of the century (Figure 6).

This has, once again, to do with Nokia in case of Finland, and Ericsson in Sweden. Estonia's exports in the telecommunications equipment have also predominantly to do with the two above-mentioned companies. Their manufacturing service provider Elcoteq has been for more than a decade responsible for the vast majority of imports and exports of telecommunications equipment to and from Estonia (Tiits & Jüriado 2006).

Figure 6. The share of the telecommunications equipment in the total exports of goods



Source: Authors' calculations, ComExt 2011.

In order to shed some light on the location decisions both for the R&D and manufacturing activities of the major players in the telecommunications equipment manufacturing, we present first the cases of Ericsson and Elcoteq. Thereafter, we contrast these with Skype, a disruptive software firm that has become the largest provider of international calls in less than half a decade. In addition, it has challenged the whole business model of the established telecommunications industry. Ericsson and Elcoteq located primarily their manufacturing activities into Estonia, while Estonia has been since the very beginning the location of Skype's main engineering centre.

Both these firms' motivations for operating in Estonia and their intra-firm capability building activities are, as seen in the following chapters, also very different. The capability building that does or does not take place within the firms and their location choice depends, however, also strongly on the success of the public education and R&D systems in making the qualified workforce available to the firms. We review, therefore, prior to discussing the case study firms briefly the recent supply of the ICT workforce at the various qualification levels in Estonia.

3. Competence building on the national level in Estonia

3.1. The availability of R&D personnel

The number of researchers and engineers remains, both in absolute terms and as a ratio to the employment, lower than that of the Nordic countries. While Estonia's public sector R&D efforts remain, both in terms of personnel and investments, comparable to the European Union average, industrial R&D lags behind.

The Estonia's total R&D personnel count was close to 9900 persons (5500 in full-time equivalent) in 2009. This includes 7500 researchers and engineers (4300 researchers and engineers in full-time equivalent), while the rest are technicians and supporting staff (Statistics Estonia 2011). This is, in absolute terms, a relatively small number of researchers that is comparable to a single research lab of a major multinational corporation.

The fact that the full-time equivalent of the R&D personnel varies in Estonia significantly from the total number of R&D personnel is explained by two reasons. About one half of the R&D personnel in Estonia is employed in the higher education sector, whereas the majority of the R&D personnel acts there half of the time as researcher and half of the time as teaching staff. Similarly, in the enterprise sector, most of the R&D staff undertakes various other tasks besides R&D activities (e.g. product development, market research) rather than being involved in pure R&D.

Statistics Estonia provides us with no estimation of the number of ICT researchers in the public sector, but the Estonian Research Portal which is the official interface for national R&D funding applications, lists altogether 410 persons who are active in the field of computer science as their field of research. However, only 162 of them have at least one publication referred in ISI Web of Science, and only 127 of them have a PhD degree.[5]

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[5] Estonian Research Portal that is for public sector institutions the interface to national R&D funding. See: http://www.etis.ee.

By the same token, Lipmaa has identified 131 Estonian computer scientists that have at least one citation of their research paper.[6] Based on this, we estimate that in Estonian public sector there are no more than 150 reasonably active and productive computer scientists.

The Estonian business enterprise sector had about 3100 R&D personnel (2900 in full-time equivalent) in 2009. The above included 189 persons (118 in FTE) of R&D staff who were in the manufacturing of electric and optical equipment and 712 (572 in FTE) R&D staff who were involved in computer related activities. Thus, Estonian ICT enterprises had a R&D staff of no more than 1,000 (700 in FTE) in 2009 (Statistics Estonia 2011). Furthermore, the industrial ICT R&D personnel is also very concentrated in terms of the number of the enterprises. A tiny number of relatively larger R&D and product development intensive ICT firms such as Skype, Playtech and Cybernetica are most likely to employ vast majority of the above-mentioned R&D staff.

Given the above, Estonia's R&D investments remain also significantly lower than those of Finland or Sweden, for example. Estonia's gross R&D expenditure (GERD) was 1.4% of GDP in 2009 (1.3% of GDP in 2008), while Sweden's and Finland's GERD continues to be more than 3% of GDP. Comparatively speaking, Estonia is lagging behind primarily due to the smaller number of R&D personnel in the industrial sector, which has in turn to do with the structure of the industry itself.

Estonia does not possess, similarly to most of the newer EU member states, a highly R&D intensive ICT and electronics industry. Foreign investment enterprises, which are responsible for the vast majority of electronics exports, have located only relatively less demanding production functions here. Furthermore, Estonia does not have a strong biotechnology, pharmaceutical or automotive industry. Yet, the above-mentioned industries are responsible for the vast majority of the global industrial R&D investments (Moncada-釘ernò-Castello *et al* 2010).

3.2. The supply of the ICT sector labour force

There are about 20 different vocational schools in Estonia that offer education in the fields of computer sciences and/or in the electronics and automation. In some schools a modest number of students (15-20 people) is admitted in the above-mentioned ICT programmes, while the larger schools admit to the ICT studies up to 300-500 new students annually.

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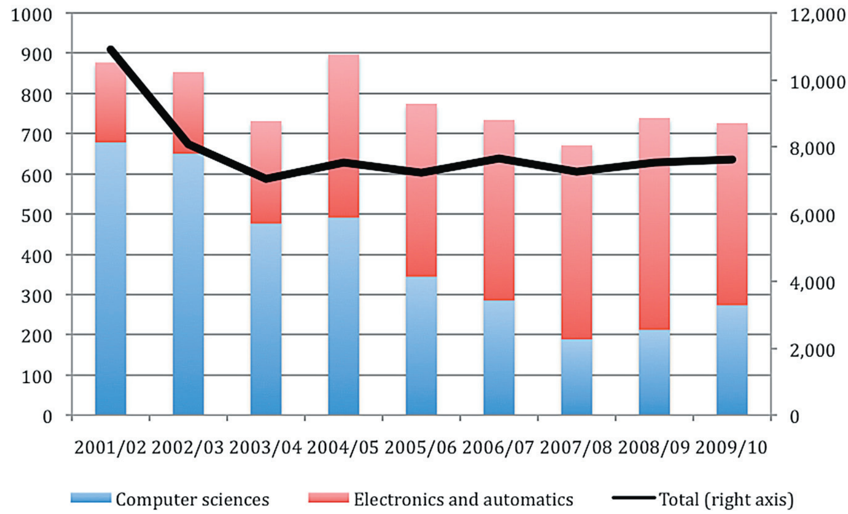
6 Helger Lipmaa, data last modified 1 July 2009, http://research.cyber.ee/~lipmaa/cites/php/estcit.php.

This raises some questions about the effectiveness and efficiency of the organisation of the vocational education system, especially when one compares the admittance numbers with the number of people graduating.

The number of people graduating from vocational education has decreased in Estonia by approximately 20% in the last decade. The decrease in the number of graduates has been even faster in the computer sciences, while there has been at least twofold increase in the graduation rate in the field of electronics and automatics (Figure 7).

Figure 7. Graduation from the ICT vocational education in Estonia

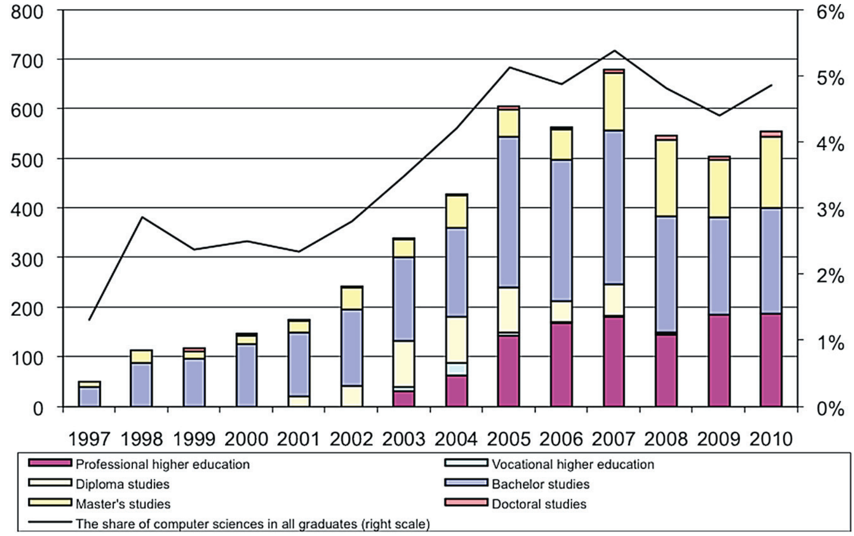


Note: On the both scales the number of graduated students is indicated.
Source: Estonian Ministry of Education and Research 2011.

Unfortunately, the ICT related vocational education system is not very efficiently organized in Estonia. Each year an average of 392 computer sciences and 362 electronics and automatics students discontinue their studies (based on the statistics from the years 2005-2010). In other words, in the ICT fields roughly every second student stopped with their studies.

The prospective new students have given higher education very strong preference over vocational education. This is clearly visible in the increase of the admittance to the higher education in general, as well as to the ICT related higher education in particular. The share of the computer sciences increased from 3% to 7% among the newly admitted students in the higher education in the years 1997-2002, and has remained stable since then (Statistics Estonia 2011). A similar increase in the importance of the computer science is also visible in the number of people graduating from higher education (Figure 8).

Figure 8. Graduation from the ICT higher education in Estonia

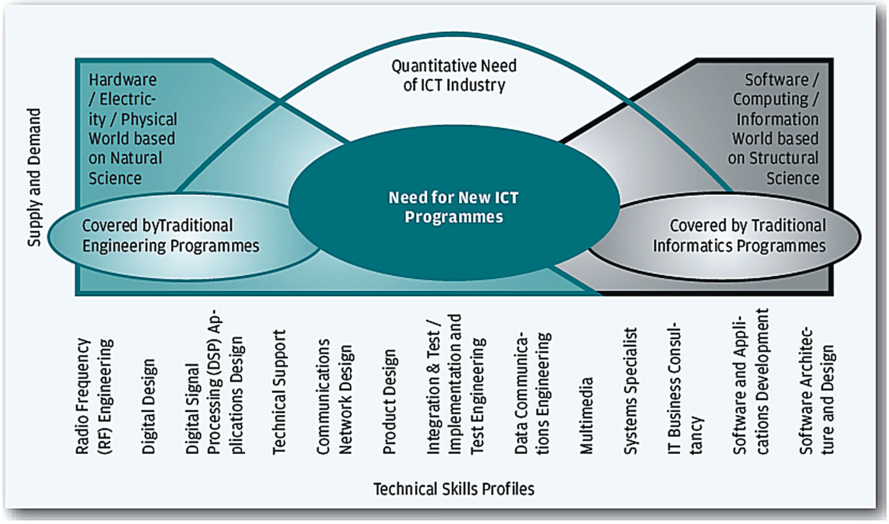


Note: The above data refers to the graduation in the computer sciences.
Source: Statistics Estonia, 2011.

The higher education system suffers, however, similarly to the vocational education, from the delays in studies and a very high student dropout rate. About half of the students did not complete their studies in computer sciences in a timely manner in Estonia in the recent years. The high demand for work force, the need to work in order to fund the studies, and the modest quality of some of the study programmes are all likely to contribute to the high discontinuation frequency of the studies.

Another issue is that ICT curricula stem from traditional branches of study and science – on one hand from physics and engineering and on the other hand from mathematics and informatics – even though the needs of the present-day industry presume a synthesis of both areas and more. Modern ICT companies do not just produce, install and maintain ICT tools and systems. They have to be in touch with business systems in a particular application area and to able to see ICT tools in this context. Therefore, in addition to the engineering and informatics background they also need to be ready for an interdisciplinary approach, where the emphasis is on the applications solving rather than the ICTs *per se*. Even though traditional curricula that focus on engineering and informatics are necessary, there is also a need for curricula that integrate both areas and are interdisciplinary (Figure 9).

Figure 9. The profile of ICT industry's needs for Degree Qualifications

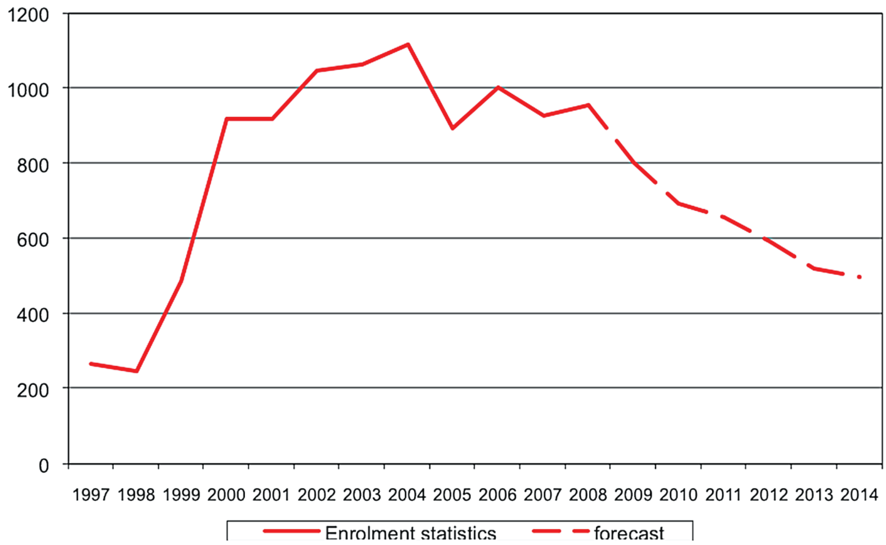


Source: Career Space and International Co-operation Europe Ltd 2001

The various studies on Estonian ICT education conclude that a lack of skilled labour is the main factor that hinders the development of local companies, whereas skilled labour would allow them to rapidly move ahead in areas where they already have a certain competence for development activities. Important shortcomings that were brought out are insufficient specialisation and in certain areas also weak basic education (e.g. system analysis). The problem can be summarised as follows: people who have acquired higher education need a couple of months or even up to a year before they meet the requirements and interests of the companies. At the same time, the knowledge and skill base of experienced people is relatively low, making it a starting point from which it is hard to strongly and rapidly move towards R&D activities (Kattel and Kalvet 2006).

The Estonian ICT sector, which employed all together 15565 persons in 2010, has according to a recent study currently about 1700 vacancies, and there is a need for about 4200 additional bachelor's or master's level employees within the next three years (ITL 2011). The current supply of the highly qualified labour is not, unfortunately, able to meet such a demand. The demographic trends in Estonia contribute to the challenges in the supply of qualified labour even further. The new students to be admitted to the ICT higher education will decline in Estonia twofold between the years 2008-2015 (Figure 10).

Figure 10. Number of first year IT students admitted



Source: Praxis, authors' calculations.

Overall, as long as the supply of the research and engineering personnel for the ICTs and the other science intensive industries remains insufficient, upgrading to the more R&D intensive activities remains constrained at the enterprise level and Estonia's total business R&D investment is also bound to remain significantly lower than that of Finland or Sweden.

4. Firms' motivation for operating in and from Estonia

4.1. Established major brand name: the case of Ericsson

Ericsson was founded in 1876 as a telegraph repair shop. In the early 20th century, Ericsson was a rapidly growing international company that was very interested in the rapidly growing markets of the eastern shores of the Baltic Sea. The Swedish company even considered moving its headquarters to St. Petersburg, Russia. The Bolshevik Revolution put an end to this plan in 1917. Some of Ericsson's leading engineers moved from the St. Petersburg factory to Tartu, Estonia and contributed to the development of the local telephone factory (Tartu Telefonivabrik). Eventually, this Estonian company became Ericsson's most important partner in Eastern Europe, as it started to produce telephones under a licence from Ericsson and under the Ericsson brand name (Högselius 2005:56). World War II and the resulting occupation of Estonia by the Soviet Union brought an end to this business relationship.

Ericsson was one of the pioneers of the Nordic Mobile Telephone (NMT) and GSM telephone systems in the 1980–1990s, when the two Nordic firms Nokia and Ericsson were the global market leaders in manufacturing mobile telecommunications equipment. Ericsson continued to offer exchanges and other infrastructure equipment for fixed telecommunications and special radio communications networks.

These were the main products Ericsson was interested in finding new markets for, when Estonia had restored its independence in the early 1990s. Shortly after independence Swedish Telia and Finnish Sonera became shareholders of the dominant fixed telephony company Estonian Telecom, along with the government of Estonia. Soon very rapid development of the new digital communications networks started, and Ericsson became an important vendor of new technologies in the first major deals, including digital telephone exchanges for the fixed telephony network and slightly later also the NMT mobile telephony network.

As discussed above, Ericsson handed the manufacturing of mobile telephones over to Sony Ericsson – the joint venture of Sony and Ericsson – when the consolidation of the industry started in the 2000s. Furthermore, Ericsson's subsidiary ST Ericsson also started to sell mobile telephone components and kits to third parties. Ericsson itself continues, however, to be the market leader for the manufacture of mobile telephone network equipment. This is also visible in the specialisation of its Estonian subsidiary.

Ericsson Estonia started as a local representative and a wholesale organisation that caters for the needs of local clients in Estonia in the early 1990s. In time, in addition to the wholesale of Ericsson equipment, the share of the various value added services such as network planning and systems integration started to increase in sales. For example, Ericsson Estonia started to serve network operators in Denmark, Sweden and Japan in the early 2000s.

Today, Ericsson Estonia provides telephony and data communications systems planning, integration and maintenance services to various clients. In recent years, the network maintenance services provided to the various network operators in the Baltic States have also gained in importance. The logistics unit of Ericsson Estonia serves the other Baltic and Nordic firms within the Ericsson group. For 2008–2009, about half of the sales revenues were earned from the sales of telecom equipment and the other half from the sales of various services.

In summary, Ericsson Estonia predominantly sales and service functions in Estonia for two decades. Ericsson's R&D and product development activities continue to take place in its major corporate development centres outside Estonia. Ericsson Estonia's activities were primarily upgraded in the 1990s and 2000s due to the gradual extension of the services portfolio from basic sales and support activities to more knowledge-intensive network infrastructure planning and maintenance services as well as support for the development of various value added telephony and Internet services.

Occasionally, some middleware solutions have also been developed for Ericsson mobile telephone networks in Estonia. For example, a mobile positioning system was developed for the 112 emergency services in cooperation with the Estonian GIS firm Regio in the early 2000s. This system allows the geographic location of a mobile telephone that has placed an incoming phone call to be automatically detected based on the mobile telephone network. Later, Regio started to offer an advanced version of this mobile positioning system internationally under the Ericsson brand name. Such cooperation with Regio as a local partner has, however, been mostly handled directly from Sweden.

However, the profile of the Ericsson organisation in Estonia changed significantly when Ericsson acquired a major share of the Elcoteq facility in Tallinn in 2010. Ericsson has had Elcoteq as a global manufacturing partner for two decades. Even though Elcoteq manufactured for Ericsson in Estonia, there was no direct business between the subsidiaries of these two firms in Estonia. With this recent deal, Ericsson took over the facilities and personnel that Elcoteq used for offering Ericsson electronics manufacturing services. For Ericsson's part, this acquisition of the manufacturing operations in Estonia does not seem to have been part of a longer-term corporate plan for the expansion of the facilities in Estonia. It was rather a chance event that was connected to the restructuring of Elcoteq's global network that the global economic crisis brought about in 2008–2009.

The number of Ericsson employees grew considerably with the acquisition and expansion of manufacturing activities in Estonia. Ericsson Estonia had about 100 employees in 2007–2008. The number of Ericsson Estonia employees increased, however, with the acquisition of the Elcoteq plant and the transfer of the more than 1200 related personnel to Ericsson at the beginning of 2010.

Earlier, Elcoteq manufactured equipment for the 2G and 3G mobile communications networks as well as for the fixed broadband networks in Tallinn for Ericsson. After the change of ownership, the production of 4G data communications network equipment was launched in Estonia in May

2010. This production line achieved full capacity by August 2010. Ericsson exports most of the equipment produced in Estonia to various network operators in Europe, North America and Africa, but some of it also remains on the local market where TeliaSonera's local subsidiary EMT continues to be Ericsson's local key customer.

More broadly speaking, the specialisation of the Tallinn plant in Ericsson's global production network did not change after the change of ownership. The Tallinn plant continues to provide electronics manufacturing services for Ericsson, just as it did under Elcoteq's ownership. As previously, Ericsson's research and product development continues to take place outside Estonia, while the subsidiary in Estonia focuses primarily on the organisation of manufacturing, etc. Accordingly, learning by doing and manufacturing-related organisational innovation remain the main forms of development.

Ericsson does not disclose the exact production figures for the Estonian plant, but it is still obvious that Ericsson's contribution to Estonia's foreign trade is massive. According to Veiko Sepp, CEO of Ericsson Estonia at the time of the interview, Ericsson was responsible for about 10% of Estonia's exports and about 50% of Estonia's exports to Sweden in Q4 2010.

4.2. Integrated manufacturing service provider: the case of Elcoteq

Elcoteq[7] was founded as Lohja Microelectronics in 1984 to support the Lohja Corporation's (Finland) development and production of electroluminescent displays. However, this business did not develop as initially hoped, and some free capacity became available in Lohja Microelectronics. Meanwhile, Nokia Mobira in Finland and Ericsson in Sweden had both developed their first Nordic Mobile Telephony (NMT) telephones, the full-scale production of which was held back by their small components assembly capacity, and they were looking for additional manufacturing expertise. This is how Lohja Microelectronics became an electronics manufacturing service (EMS) provider, with Nokia and Ericsson as its largest customers in the early 1990s (Elcoteq 2010a).

In 1990, in preparation for a merger with another Finnish industrial conglomerate, Wärtsilä, Lohja Corporation restructured itself and registered its different business operations as separate companies. Lohja Microelectronics was renamed Elcoteq. Metra corporation, which emerged as the result of the merger, did not however consider microelectronics to be its

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7 Hereinafter 'Elcoteq' refers to the Elcoteq corporation globally, and 'Elcoteq Tallinn' refers to the particular subsidiary established in Estonia.

core business, and Elcoteq went through a management buy-out in 1991. This was the beginning of Elcoteq as an independent enterprise with both Nokia and Ericsson as its key customers.

In the early 1990s, when Swedish and Finnish entrepreneurs were the first to invest in Estonia, Elcoteq started pilot production in Estonia already in 1992, and formally established a subsidiary in Estonia in 1993. This was Elcoteq's very first subsidiary abroad. Although initially various Asian countries had been considered as a potential location, a better alternative was eventually found closer to home in Tallinn.

One of the Elcoteq Tallinn's veterans has described the creative destruction that took place in the early 1990s with the following words: "*It was a productive time, the industry had collapsed and the town was full of unemployed engineers.*" The newly employed engineers were initially sent for training to Finland or Sweden. Later on, training was increasingly organised locally in Estonia.[8] While the existing engineering in Estonia was trained on the latest technologies and production methods, but they were no more in charge of the actual product development, where Elcoteq itself had no say either.

In 1996, Elcoteq Tallinn started to operate as the repair centre for GSM mobile telephones[9]. Already in the following year, volume production of GSM mobile telephones was initiated, and Elcoteq became the very first EMS business that started to 'box build' mobile phones for a major brand name from start to finish. The fact that Ericsson had subcontracted the whole production of its Ericsson 628 mobile telephones brought Elcoteq to a completely new level of collaboration with its clients. Most notably, Nokia soon also followed suit. What followed can be characterised as a true co-evolution of the major brand names and Elcoteq as an EMS that was an integral part of their value chain. By the late 1990s, Elcoteq was producing mobile handsets in Estonia for two market leaders of the time.[10]

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8 When Estonian independence was restored in 1991, its economy was in a poor state. So was the economy of the whole former USSR. Therefore, both for political and economic reasons, Estonia began immediately to reorient its economy to western markets, which had both greater purchasing power and growth prospects. However, as became evident very soon, the majority of the electronics industry that Estonia had inherited was not competitive on western markets, and was therefore forced to close down (Tiits 2006). As a result of this, experienced workforce for the electronics industry was readily available in Estonia in the early 1990s.

9 GSM is widely a used acronym for the Global System for Mobile Communications, originally Groupe Spécial Mobile, standard, which is used in digital cellular networks.

10 Both Nokia and Ericsson were clients of the Finnish EMS firm Elcoteq already since the mid-1980s; and Elcoteq had manufactured mobile telephone circuit boards for Ericsson already for a number of years.

This was a prosperous time both for the Nordic mobile telephone producers and the EMS businesses that were working with them. The European mobile telephony market was booming and production and sales volumes went up very rapidly. This is also very vividly reflected in both the Nordic and Estonian foreign trade statistics. In Estonia, telecommunication equipment had reached up to 20% of the manufactured exports by the turn of the century. In this period, most of the production technologies and components were imported and virtually all of the produced goods were exported. The share of local content other than labour remained virtually nonexistent. Thence, not surprisingly, the value added generated in the Estonian electronics industry also remained significantly lower than that in traditional industries, e.g., wood processing, etc. (Tiits *et al* 2006).

In the late 1990s, Elcoteq also started to expand internationally, as increasingly it made sense to locate manufacturing activities close to the rapidly growing consumer markets. The need to serve the key customers – Nokia and Ericsson – at their new markets was the main driver of Elcoteq's very rapid globalisation. To finance the expansion, Elcoteq's shares were floated on the Helsinki Stock Exchange in 1997.

First, a new manufacturing site was established in Hungary, and an office was established in the United States. An office was also established in Hong Kong for managing the manufacturing activities that were located in southern China, etc. In effect, within two short years Elcoteq became a truly global corporation. By the end of 1999, Elcoteq's network of plants covered already more than ten countries in the three fastest growing regions of the world: Europe, America and Asia.

The business model and the *modus operandi* that were originally adopted in Finland and Estonia provided a good starting point, but needed adapting for Hungary, Russia, Germany, Mexico and China. Elcoteq's Finnish and Estonian business development and engineering staff were therefore actively involved in the establishment of the new sites elsewhere in the world, and in training the local staff. Also, through these experiences, a well-documented system was established in Elcoteq for transferring any specific production line from one site to another. As opposed to some other multinational corporations, the individual units within Elcoteq continue to rely on uniform standardised technologies and processes also today.

The NASDAQ crisis brought about consolidation and global restructuring in the whole ICT and electronics industry from 2001 onwards. The large-scale manufacturing of consumer electronics, incl. mobile telephones and similar, has shifted increasingly to the low-cost locations close to the final markets. For example, Ericsson, as the part of streamlining its value chains, moved the manufacturing of its mobile telephones from Elcoteq Tallinn to St. Petersburg (Russia).

Also, a number of mergers and acquisitions took place between ICT enterprises. The establishment of Sony Ericsson Mobile Communications company and the subsequent sale of Ericsson's own mobile telephone manufacturing plants to a competitor was, further to the general market downturn, another major blow for Elcoteq (Elcoteq 2010a). Despite the above, in Tallinn (and in other sites) the manufacturing of Ericsson mobile network equipment and Nokia telephones continues for the time being.

Initially, Elcoteq engineering centre, which is in charge of prototype testing and new product introduction, was located in Finland. In 2000, a new engineering centre was established in Tallinn, Estonia. In 2002 one more engineering centre was established in Beijing, China. To strengthen its engineering capabilities even further, Elcoteq bought the R&D unit of the Finnish mobile telephone and telematics company Benefon in 2002 (Elcoteq 2010a).

In the 2000s, Elcoteq had to adjust to a weaker demand and a general slowdown in the ICT industry. It was acknowledged that manufacturing activities alone would not be sufficient for sustaining profit margins in the changed market environment. Consequently, Elcoteq started to further its own design, R&D, engineering and after-sales services. Special New Product Introduction (NPI) centres were established within Elcoteq to strengthen the co-operation with clients and their design houses in testing prototypes and making preparations for actual production.

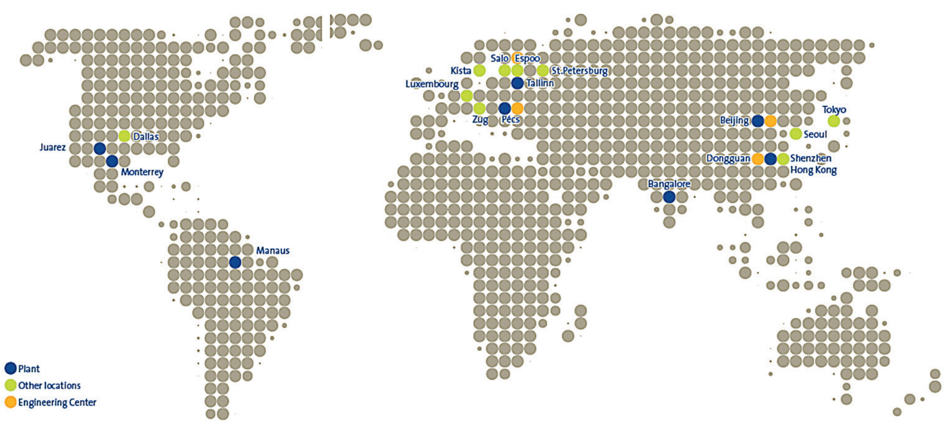
Although Elcoteq had all the capabilities for designing mobile telephones, and even developed at one point in time one handset for Ericsson, it did not challenge its main customers in R&D and product development, but remained a contract manufacturer. The competition continued to intensify in the EMS business on all fronts in the 2000s. For example, Nokia started to source some of its printed circuit boards from Foxconn (Hon Hai) and GKI in Asia, and handled the manufacturing all together in-house in Brazil. In the mid-2000s, Nokia continued to streamline its supplier network, and gave a preference to larger vertically integrated suppliers such as the Foxconn and BYD. As a result Elcoteq was eventually forced to downsize significantly its Nokia handset business (Seppälä 2010).

Elcoteq started therefore to capitalise increasingly on its telecommunications equipment manufacturing competences by manufacturing, later in the 2000s, to an even broader set of clients. Along with this, new plants were also inaugurated in Bangalore (India) and St. Petersburg (Russia) in 2005. In the same year Elcoteq was reincorporated as a European Company (SE) and the regional headquarters was established in Budapest (Hungary) for managing European operations. Furthermore, the domicile of the company was transferred from Lohja to Luxembourg in 2008.

The recent global financial and economic crisis brought about another restructuring of the Elcoteq global network. During 2009 the factories in Arad (Romania), Richardson (US) and St. Petersburg (Russia) were closed down. The factory in Shenzhen was consolidated into the factory in Beijing in China. Part of the Elcoteq Tallinn plant, which earlier served Ericsson, was sold to Ericsson. With this transaction, some 1200 employees of Elcoteq Tallinn moved also to Ericsson (Elcoteq Annual Report 2009). After this transaction, Ericsson continues to produce 4G (LTE) mobile network equipment in Tallinn, for which TeliaSonera in Sweden is one of Ericsson's most important customers.

In response to the above, Elcoteq has extended its client portfolio and continues to operate its EMS business on a global scale (Figure 11). It continues to produce both mobile handsets and infrastructure systems. On a global scale,, almost all major telecommunications equipment producers, incl. Nokia, Samsung, LG, Motorola, Sony Ericsson, Huawei, etc., continue to be Elcoteq's clients. Further to this, Elcoteq has established itself also in the production of flat screen TVs. (Elcoteq 2010b) In Europe, the plant located in Hungary is Elcoteq's main mass production plant, while Elcoteq Tallinn with its approximately 300 staff continues to cater for smaller niche markets.

Figure 11. The location of Elcoteq sites



Source: Elcoteq Annual Report 2009.

Overall, in a global comparison, Elcoteq still continues to be a fairly small electronics manufacturing service provider. Elcoteq revenues were 1500 million euros in 2009 (Elcoteq 2010b). The revenues of Foxconn and Flextronix – the largest contract manufacturing companies in the world – were, however, 21 and 15 times larger in the same year. This is why Elcoteq continues to focus on the technologically and organisationally more demanding small and medium scale manufacturing rather than large scale mass production, where the big competitors have an advantage.

4.3. Disruptive telecommunications service: the case of Skype

Internet was in the 1970-1980s, when the development of the modern digital telephone systems standards began, anything but widespread. At that time, voice communications were the primary means of communication, and most data communications ran on *dial-up* lines at what is by today's standards a very low speed. In a word, the architecture and business models of modern digital telecommunications systems were originally built for voice communication that gets billed per minute of use.

The very rapid spread of the Internet and the development of the underlying communications technologies has brought about major technological disruptions in the telecommunications industry since the 1990s. With broadband Internet access, there is no billing per minute, and international communications are virtually free of charge. The above technological change prepared, thereby, the ground for a major disruption in the whole telecommunications industry, since it became feasible to route otherwise costly telephone calls over the Internet, where international communications are virtually free of charge and no traditional billing per minute of use applies.

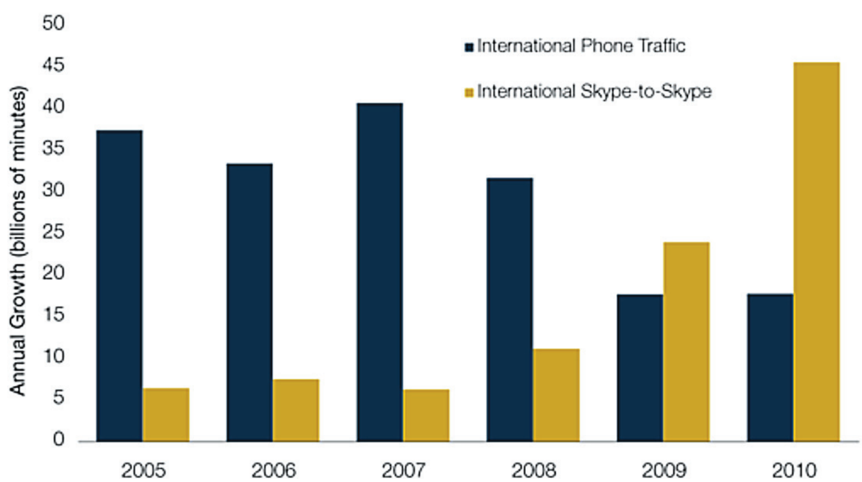
This is exactly where the Voice over Internet Protocol (VoIP) entered the scene from the mid-1990s. Skype is a VoIP software application that allows anyone to talk to anyone else on the Internet free of charge. It allows the calls, for a modest fee, also to be routed to the 'old school' telephone network. Skype was founded in 2003 by the Swedish and Danish entrepreneurs Niklas Zennström and Janus Friis. Skype's software development team was from the very beginning located in Tallinn, Estonia, which became immediately its largest office in terms of the number of staff.

The first beta version of Skype, which was released in August 2003, allowed for computer-to-computer voice calls. No other services were available. This very first software attracted the first 1 million registered users in only a matter of months. Subsequently, additional services (text chat, *SkypeOut* and *SkypeIn* calls to and from regular telephones, video calls, etc.) and support for additional devices (Apple Mac, Linux, special Skype Phones and Skype application for various smartphones) appeared.

Skype was not the first service to enter the VoIP market, but its ease of use, and the possibility of (multiparty) video calls, along with the free service, differentiate Skype very strongly from both other traditional and VoIP telephone services. The above, in combination with a hugely scalable peer-to-peer architecture and clever marketing made it an instant success. Skype, which offered initially only voice calls, has also differentiated itself increasingly from the competition by offering video and multiparty conference calls. Video capable software appeared first for Microsoft Windows in 2008. The Android and iPhone software that was introduced in 2009 included also video functionality. Skype was also the first to utilise networked flat screen TV-s, which have started to include built-in Skype software since 2010.

Skype had already 75 million registered users by 2005. As of 2011, Skype has more than 560 million registered users. The "cross-border traffic routed by Skype, by far the largest provider of Internet-based voice communications, is projected to grow by an astonishing 45 billion minutes in 2010—more than twice the volume added by all of the world's phone companies, combined." (Figure 12). Furthermore, 40 percent of Skype calls are actually video calls today (Skype 2010, Tuaw 2011).

Figure 12. International long-distance calls and Skype traffic 2005-2010.



Source: Telegeography 2011.

Skype has gone truly global not only in terms of its customer base, but also in terms of the location of its business functions during the last five years. As noted above, it was the combination of the experienced Scandinavian start-up managers and Estonian engineering talent that were at the core of Skype's immediate success. Soon, as Skype was seeking to attract international venture capital and to get closer to major marketing channels, the corporate headquarters were established in Luxembourg and an office was also set up in London. Although the headquarters were in Luxembourg, Tallinn and London remained the largest offices, and most of the decision-making continued to take place between these two offices.

In Q4 2005, eBay purchased Skype for approximately 2.5 billion U.S. dollars of upfront payment (eBay 2005). In connection with this deal, a Skype office was also set up in the United States, close to eBay's headquarters. The Skype office in the United States continued to operate as a marketing, sales and support office servicing the Americas. More recently, general management of the *Skype4Business* business line was also moved to the U.S., as the Americas are globally the largest market for enterprise communications, and some of the Skype's strategic partners for this business line, e.g., Avaya, are also located there.

Smaller Skype offices emerged also in Singapore and Hong Kong. These offices are in charge of the marketing, sales and support in Asia. Their perhaps even more important function is to maintain close contacts with the manufacturers of the increasing variety of different Skype enabled devices, including flat screen TVs, in Asia (Figure 13).

Figure 13. The location of Skype sites

Source: Skype, October 2010.

Even though PayPal, another eBay firm, proved a good payment partner for Skype, eBay itself was not able to build major synergies between its main business line and Skype. Furthermore in 2008, a legal dispute emerged between Skype and its original founders over the rights to Skype's underlying peer-to-peer communications technology. This contributed to the lessening of eBay's interest in Skype even further. Eventually, in November 2009, eBay sold 70% of Skype to a consortium comprising Silver Lake Partners, CPPIB, Andreessen Horowitz, and the original Scandinavian founders, valuing the business at 2.75 billion dollars.

Less than a year later, in August 2010, Skype filed with the SEC for listing on the NASDAQ stock exchange, where it sought to raise up to 100 million dollars in an initial public offering (Skype 2010). These plans were, however, cancelled, as Skype and Microsoft entered into a definitive agreement in spring 2011,whereby Microsoft will acquire Skype for 8.5 billion dollars. Once approval is received from the regulators, Skype will become a new business division of Microsoft. It is quite obvious, even though no public information exists in this relation, that Microsoft was willing to pay a very high price for Skype both in order to secure its late entry into the very rapidly growing VoIP market as well as to avoid the further strengthening of the other dominant firms in this market, such as, e.g., Google and Facebook.

Skype has been, typically for a venture capital backed start-up, essentially from its birth in an aggressive growth phase, and the availability of suitably qualified labour has been one of its important concerns. Initially Skype hired engineers and other personnel, e.g. for localisation and support functions, etc., rather aggressively in Estonia. However, as it emerged that no more suitably qualified labour was available in Estonia, a second engineering centre was established in Prague in 2007.

Overall, Skype continued to recruit its personnel internationally, indicating quite often for an open position two or three key locations where the newly enrolled person could start working. This has led to Skype's rather unique management model, where the various multidisciplinary teams operate indeed in most cases within Skype but on a trans-country basis. For example, the Prague engineering centre operates today largely as a satellite of the primary engineering centre in Tallinn. The Prague-based developers report to the team leaders who typically are located in Estonia. It is also quite common for the product managers and other mid-level managers who are in charge of development to be located part- or even full-time outside Estonia, for example in London or elsewhere.

Skype has acquired the required talents rather aggressively by acquiring other smaller firms that have the personnel with the required capabilities, relocating, if necessary, also the persons concerned to one of its offices. The purchase of the Norwegian start-up Sonorit Holding AS, a provider of voice technology for the Internet, in April 2006 is an example of the flexibility companies like Skype exhibit in attracting the very top talents[11]. The main motivation behind this acquisition was really the knowledge and talent this Norwegian company had regarding audio-video *codecs*[12] and regarding VoIP systems more broadly. As the acquired company itself did not yet even have an office in Norway, an office was set up for them in Stockholm, the closest possible location to the engineering centre in Tallinn. Nowadays, in this Skype Stockholm office some of the most advanced audio-video R&D in Europe takes place. Given the deep specialisation and the knowledge pool that is available in this Skype unit, a close exchange of information also takes place there with different research institutes and universities across the globe.

"Skype currently employs 850 staff, with most of its engineers in Estonia, though its disparate operations include a Luxembourg headquarters, marketing operations in London and audio-visual engineering in Stockholm. [The Skype CEO] Mr Bates said he plans to hire up to 400 new staff this year, with 80 per cent of these in Silicon Valley" (FT 2011). The newly established engineering facility in Palo Alto, California, will specialise primarily on development for the Apple IOS and Google Android mobile computing platforms, for which engineering personnel is more easily available on the western coast of the United States as compared to Europe.

5. Competence-building on the enterprise level in Estonia

5.1. Worker level

Ericsson, Elcoteq and Skype as global firms operate in very different market segments in the production of telecommunications systems. The specialisation and, thus, also the labour requirements of the Estonian subsidiaries of these firms are also very different. Both Ericsson and Elcoteq primarily manufacturing and various support activities in Estonia, while Skype has its main software development centre located in Estonia.

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11 In early 2011, Skype acquired another well-known Internet video communications firm Qik, in order to reinforce Skype's video functionality even further.

12 A codec is a specialised software (or device), which is capable of encoding and/or decoding a signal or a digital data stream. Audio and video codecs that are discussed here are responsible for encoding the analog audio and video signals into a digital data stream and decoding these in the receiving end pack into a voice and video that a human being can understand.

The structure of the labour force of these firms is, accordingly, also very different in Estonia. Manufacturing floor workers constitute a significant share of Ericsson's and Elcoteq's employees in Estonia. Contrastingly, Skype chiefly employs engineering personnel in Estonia, and the lower qualification levels are of limited importance for this firm. This is obviously also reflected in the capability building of these firms.

Furthermore, it is largely the former Elcoteq personnel that operate today's Ericsson plant in Tallinn. Therefore, most Elcoteq-related observations simultaneously also reflect human resource development that has taken place in relation to the plant in Tallinn now owned by Ericsson.

In the early 1990s, when Elcoteq started its manufacturing operations in Estonia, it built largely on the personnel that had become available from the former Soviet electronics industry. At this period in time, low (labour) costs and the geographical and cultural proximity to Finland made Estonia an attractive location for the expansion of production. Today, most of the enrolled workers are expected, preferably, to have previous work experience in the electronics industry. The textile and clothing industry, where employment was decreasing in the 2000s, has also however been an important source of experienced manufacturing workers for electronics manufacturing in Estonia.

Previous work experience is also important, as advanced electronics manufacturing involves some tasks, e.g. tuning radio communications equipment or diagnostics of manufactured products, where the necessary skills and productivity levels can only be achieved in practice. Today, an average Elcoteq manufacturing flow worker has 5-6 years of work experience in the firm. With the cyclical downturn in the industry, Elcoteq had some redundancies in the workforce the first half of 2009. More recently, however, a number of previous workers have been attracted back to their old jobs.

Elcoteq Tallinn considers the flexibility of its work organisation one of its main competitive advantages. The workers need to be able to switch rapidly from the needs of one client and the related manufacturing setup to another. Continuous on-the-job (client-specific) training to familiarise the workers with the specific production line and their specific tasks during the manufacturing process is the main training activity that takes place in Elcoteq and Ericsson at this qualification level. It is not uncommon for such training that one of the more knowledgeable operators of the surface mounting equipment (SMA operators, for short) instructs the other assemblers and operators, while the Quality Control Department oversees and supports such an internal training process when necessary.

Contrastingly, the limited number of basic worker level staff members only plays a minor support role in Skype, where most of the staff are involved in advanced engineering tasks in Estonia. Accordingly, this is not the key qualification level for capability building within Skype.

5.2. Technical and supervisory level

In Elcoteq, worker training is also connected with career opportunities, as more knowledgeable and experienced workers have the possibility to acquire qualifications that allow them to become foremen, who are in charge of groups of workers. Typically, such senior workers are also themselves familiar with the basics of business management and quality control techniques like Six Sigma or similar. In other words, there is a clearly established and well-communicated career path in Elcoteq. This is also the preferred way the supervisory level staff grow within the company.

In addition to client and product-specific training, management training is offered to supervisory-level workers, such as for example foremen. The management training offered to them includes skills for motivating team members, enhancement of skills for cooperation with engineers from other teams, quality control, etc. All foremen have a basic, i.e. yellow belt level knowledge of Six Sigma. Importantly, foremen and senior workers are also in charge of acquiring workers' proposals for improvement (innovation!). Such a continuous improvement system is also supported through the bonus system.

The company is building linkages with the Estonian education system. The main strategic partner is the University of Applied Sciences (Tallinna Tehnikakõrgkool), which is a professional higher educational institution, with the aim of providing professional higher educational studies (engineering diploma education, with 4 years of study) in the field of engineering.

For Skype, the technical level is really the lowest qualification level that is relevant to its core activities. The technical jobs in this firm still related to basic web development, language translation, etc., as well as various maintenance and support activities. The difference between the technical and engineering levels is essentially that of the creativity, technology and management knowledge, and of the experience of the respective persons. There is, therefore, similarly to Elcoteq, a possibility for technical workers to become engineers, in case they acquire more knowledge and experience.

This is why Skype has an on-line Global Learning Zone (GLZ) that contains specific learning materials accessible to everyone in the firm. There is also a specialised on-line reference library of technical literature that everyone can access. The objective of the GLZ is to lead all staff members to the relevant reading materials and/or training courses they consider necessary for themselves. Another related objective is to keep everyone in the firm up to date on the *modus operandi* of the firm and to communicate forthcoming changes in the organisation.

Technical jobs are ones for which, universally for all case study firms, internship opportunities are most frequently offered. Intern recruitment is handled through the regular recruitment channels. Higher qualification levels are, as it is easy to understand, normally not open to interns due to the greater importance of the previous training and work experience, as well as sensitivity of materials used.

5.3. Engineering levels

Workers and foremen do not have direct communications with clients for whom Elcoteq and Ericsson manufacture their products. In Elcoteq, such communication is limited to the management and engineers who are in charge of setting up production lines, including systems for testing product quality. The division of tasks is basically the same in Ericsson between the R&D and product development that takes place outside Estonia, and the manufacturing that takes place in Estonia.

From the mid-2000s Elcoteq built up a New Product Introduction (NPI) unit in Estonia, which was to assist clients in the final design and testing of their electronics products and in the preparation of production. This unit disappeared in Elcoteq with the transition of most of Elcoteq's previous activities and staff members to Ericsson in 2010. Currently, Elcoteq's engineering facilities are very tiny in Estonia. Elcoteq currently has four product engineers, two process engineers and one test engineer currently in Estonia. Additionally, there are 7 quality control engineers, and 7 engineers who are in charge of after-market (repair) services. In other words, the engineering workforce is clearly a minor share of Elcoteq's 300-person workforce in Estonia.

Elcoteq has recently recruited a new product engineer and a new quality control engineer simultaneously with the introduction of a new client. For the introduction of the new engineers (as well as other supervisory level workers) to the firm, a 6-month in-house training programme is provided. After that, typically, the client trains the Elcoteq engineers in the course of the introduction of the new products on the related requirements. No other broader intra-firm training system exists for engineers.

There is, however, strong competition for the best workforce between the different (mostly foreign-owned) electronics manufacturers in Estonia, which on occasion leads to intense headhunting. For example, it has been very difficult for Elcoteq to recruit a new lead engineer in Estonia recently in spite of active headhunting.

In summary, it still cannot be said that the lack of strong engineers with industrial experience has been the most important impediment to Elcoteq's activities being upgraded from electronics manufacturing service provision to the more R&D and knowledge-intensive design of its products. It has rather been the deliberate decision of the whole of Elcoteq as a global EMS service provider to not compete with its customers in R&D and product development.

Computer scientists and software engineers have generally been easier to find and recruit than microelectronics and industrial engineers in Estonia. Skype's main engineering facilities are, as discussed above, largely located in Estonia for historic reasons. This is where software development in Skype was initially established and additional engineering workforce was recruited as necessary.

The Global Learning Zone is, as discussed above, the key learning resource within Skype. All the various training possibilities are communicated across all Skype offices through this tool. In staff training the 70-20-10 principle applies: 70% of learning occurs on the job, 20% in the form of intra-firm coaching/mentorship, and no more than 10% of the working time is dedicated to classroom training or similar. For the latter, trainers come mainly from other EU member states (mostly the UK) as well as the United States.

5.4. Management and marketing levels

None of the three case study firms have their top management located in Estonia, i.e. their overall strategic planning and management take place elsewhere. Their marketing and sales activities are also, typically of any multinational corporation, globally dispersed and located close to (potential) key customers. Normally, the personnel of Estonian subsidiaries do not have a direct role in marketing and sales, except for Ericsson's marketing and sales on the Estonian market.

It is the business development managers at the corporate level who are in charge of client interaction, and hand over the planning of the specific production lines over to the engineers in Elcoteq. In this, the choice of the specific manufacturing plant depends largely on the general industry dynamics, the location and the needs of the client rather than anything else. In Ericsson, largely the same model applies, although the 'client' is either the headquarters or another subsidiary in the same firm. The subsidiary in Estonia is, in both cases, effectively locked in manufacturing and support functions that the overall corporate strategy and the allocation of roles between the different subsidiaries foresee.

Capability building at the management level is in any international firm ultimately about the recruitment of the right persons, and offering them stimuli for personal development and achievement of corporate business objectives.

Elcoteq has a global HR organisation, which has strengthened in the last few years. They offer a global personal development plan and bonus system, which seeks to translate the management targets set for a specific manufacturing site into the objectives and stimuli offered to the individual staff members. Also, the standardisation of the work places has started recently across the different subsidiaries in Elcoteq. Currently, there is an on-going, bottom-up mapping process whose aim is to document existing work places. Thereafter, the global HR organisation will be advising, top-down, the individual subsidiaries on possible revisions to their existing HR management and organisation of work.

What makes the internal management structure of Skype different is that it grew very rapidly from a small start-up firm to a major global actor. Initially, in Skype, personnel were largely recruited in different geographic locations where it was available at a particular point in time. The cost of explosive growth, which a successful VC-backed start-up must achieve, is, however, the extremely rapid growing complexity of its corporate management. As a result, there are today virtually no functional teams within Skype, where the team itself, the head of the team, and the boss of the head of the team would be located in the same country.

This is why Skype has now started to streamline its HR strategy, and is increasingly applying a competence-centre model. The aim is to concentrate the specific competences typically into no more than two offices. This is, obviously, to allow for greater synergy between the staff members, and to simplify the management. While the very top R&D talents may possibly remain an exception, where there is a lot of flexibility and interest for cooperation across the globe, the majority of the personnel are now increasingly employed in the existing locations of the specific teams within Skype that require additional workforce.

Centralised HR management, including personal development and training activities, has also been instituted in Skype. The internal organisation of

Skype's HR Department largely the above general competence-centre model. Each of the competence areas, e.g. engineering, etc., has its own global head of HR. The HR Department in Estonia deals primarily with the recruitment of the engineering work force. In human resources management, the development of the personal development plans of employees plays an important role in Skype, as personal development is very important in keeping the creative class motivated in their work.

The SCRUM management technique is applied in the software development process in Skype. It is an iterative process, where interdisciplinary teams select from the backlog a set of more important requests for improvement and implement these within a limited timeframe (typically a two to four-week period). For the improvement of the use of the SCRUM technique within Skype, mostly United States-based external experts have been used.

Skype offers separate training resources and programmes for the management staff. There is, for example, a 3-day joint management training programme with Harvard Business School on "managing the Skype way", which discusses a broad set of themes that are topical for a multicultural global firm (active listening, international communications, tough conversations, etc.).

The recruitment of competent leaders for groups of 100-150 people remains problematic both in Estonia and Europe in general. The most often suitably qualified (and experienced) managers are found in the United States. Such managers are, therefore, often recruited in the US and seconded for 2-3 years in Estonia or another European office, as needed. Mobility is also very active between the different Skype offices in the opposite direction. Estonian staff members have been, for example, active in building up various other offices and are currently also active in building up Skype's new development centre in the United States.

5.5. Innovation levels

The above case studies very clearly that both the importance of the staff on the different qualification levels as well as the capability building that occurs at the corporate level are very strongly dependent on the strategy of a particular firm and its role in global production and innovation networks.

Electronics manufacturing service providers, such as Elcoteq, manufacture various products that are developed by major industry leaders, such as Nokia or Ericsson, and its own R&D activities remain very modest. The innovation and the related capability building that take place in electronics manufacturing still primarily have to do with process and organisational innovation (Figure 14). Elcoteq's service line for New Product Introduction is perhaps the closest to what could be considered to be joint R&D activities with clients.

The same largely applies for manufacturing plants that major brand names like Ericsson own themselves. It is perhaps just that the latter manufacturing facilities tend to be used more often for the introduction of completely new products than ones owned by independent service providers.

Microelectronics design-related activities are, however, currently very strongly constrained by the lack of suitable engineering and R&D workforce in Estonia. Furthermore, the high and increasing capital intensity of the modern microelectronics industry seems to be one of the main reasons the various indigenous ICT firms focus on software rather than microelectronics.

Figure 14. Technological upgrading within Elcoteq in Estonia

Source: authors.

Skype has its main R&D and engineering centre, where most of the development and testing of new products and services takes place, located in Estonia. This does not mean, however, that the basic research or in-house R&D would be the predominant source of learning and capability-building in Skype. Much less formalised forms of learning by doing, interaction within the different Skype offices and Skype's outside partners, as well as corporate education and training resources, continue as much more important sources of inspiration for Skype's software developers (Figure 15).

Furthermore, it is perhaps the key lesson from the case of Skype (from the above cases) that building a highly innovative and successful business does not always necessitate major basic R&D efforts. The overall competitive situation in the industry, the major technological breakthroughs that occur independently of any specific firm, and many other factors can prove much more important than the R&D efforts of a particular firm.

Figure 15. Technological upgrading within Skype in Estonia

Source: authors.

The cooperation between Skype and the public education and R&D systems of different countries has also thus far remained fairly limited, as public education systems are always slow to respond and the company in an early expansion phase could not wait for too long to actually see the results[13]. Instead, Skype has, as discussed above, acquired the required talents rather aggressively, where they could be found more easily and quickly, relocating, if necessary, the persons concerned to one of its offices.

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13 However, Skype continues to make attempts to initiate cooperation with higher education institutions in order to strengthen the future supply of qualified labour in Estonia. So far, this cooperation has mostly taken the form of Skype engineers lecturing at specific courses in Estonia. As part of such interaction with universities, research topics are also proposed for master's and doctoral theses, etc.

Overall, all of the three cases exemplify that the innovation takes place in industry is often much more multifaceted than is often assumed in innovation studies. It is not enough to focus on R&D, when in analysing the evolution of the GINs and the related capability building. The different sources and forms of innovation, including learning by doing, adoption of technologies developed elsewhere, organisational and business model innovations, all need to be taken into consideration.

6. Discussion and conclusions

6.1. Industry life cycles and relocation of production and innovation

The industry life cycles and techno-economic paradigms literature (Vernon 1966, Perez 2002), which unfortunately does not get too often referred to in innovation studies, seems to explain the observed industry development pattern very nicely. According to this literature, the various economic activities get gradually relocated from developed to the developing economies, as the technologies disseminate, initial knowledge advantages vanish and, thereby, the importance of the economies of scale increases in time[14 15].

The Nordic mobile telephony industry pioneers, Ericsson and Nokia, originally designed and manufactured most of the critical components of mobile telephone systems in-house. Soon, as production volumes increased, they started contracting certain manufacturing functions out to electronics manufacturing service providers like Elcoteq while keeping critical technological know-how, product design and marketing functions in-house. When demand on more distant markets followed the lead of the Nordic countries, both Ericsson and Nokia as major producers globalised very rapidly, also thereby bringing about the globalisation of their manufacturing service providers and service centres like Elcoteq. It was the very closely-knit business relationship between Elcoteq and its key customers that did not allow Elcoteq to compete with its clients in R&D and product development.

However, nothing denied competitors from developing similar technologies and products. Therefore, after some time, the focal point in the industry started to shift from developed countries to developing countries,

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14 Traditionally, the off-shoring primarily entailed for the relocation of production, after-sales support and customer care, etc.

15 In this context, usually, the natural resource-seeking, market-seeking, and efficiency-seeking have been the main motivation for investment in developing countries. R&D is not, however, as important a type of input in traditional industries as it is in ICTs today (Moncada-Paternò-Castello *et al* 2010). This also perhaps explains why the strategic technological assets or capabilities-seeking behaviour has also recently become more important, especially in the context of the relocation of science-based industries (Dunning & Lundan 2008:67).

as developed markets became saturated and local producers, like Samsung, Huawei, HTC or LG, strengthened on the emerging markets. As a result, the Nordic manufacturers find themselves today squeezed between Apple as a new entrant to the high end of the market, and the various Asian manufacturers who also keep increasing their market share.

Along with the above, consolidation continues to take place in the industry, and earning power keeps shifting to firms that are able to establish and control dominant technology platforms from R&D and product development to production and all sorts of value added services, including the various applications that run on modern smartphones.

In fact consolidation continues to take place not only on the supply side, but also on the demand side of the industry, as large telecommunications service providers, e.g., Vodafone, France Telecom, and Telefonica, have acquired shares of various smaller operators across the globe. As a result, both clients' and suppliers' market power has increased remarkably, and the barriers to entry have been heightened for latecomers to the industry.

6.2. Capability building and the catching-up strategies for the latecomers

The established platform leaders in the production of telecommunications systems continue to enjoy vast economies of scale across their whole value chain from R&D and production to marketing and sales. For these reasons, independent market entry has become increasingly difficult for latecomers to the established industry, unless they are able to challenge the established technological standards or business models, thereby altering the established rules of the game.

The above three cases are in this context very interesting, as Ericsson, Elcoteq and Skype have all specialised in very different parts of the mobile telephony value chain. Both the time of their market entry as well as the rationale of their global location choice, including the requirements for the workforce, have also varied substantially. Ericsson has specialised in the design and production of its own telecommunications equipment for a long time, and has a long tradition of related in-house R&D activities. Ericsson and Nokia defined a whole new industry in the 1980-1990s with their R&D efforts and entry to the mobile telephony industry. This allowed them to reap the benefits of early growth in this industry.

Later on, the partnerships with or acquisitions of the relevant units of the competing firms have been some of the strongest shapers of Ericsson's global innovation and production networks. Different technical standards have also played a very important role in influencing the location choice for R&D and innovation. For example, China has been successful in utilising the vast market size of its domestic market in reinforcing its own technological standards. This has forced major equipment manufacturers to customise their already existing products or to develop new ones. This has also allowed for domestic latecomer firms, such as Huawei, more time for product development. China has also been successful in using its administrative power for increasing the importance of local input in foreign investment enterprises' production activities, thereby gradually upgrading the capabilities of local suppliers. This is for example how Elcoteq's local supplier network was gradually upgraded from basic metals and plastics to various electronics parts in China.

The above is obviously not so easy to follow in smaller firms and economies that do not have a large pool of R&D workforce or significant market power. The case of Skype illustrates, nonetheless, that even tiny newcomer actors can actually outcompete established, major multinational firms, if they are able to adopt new disruptive technologies and business models that allow for transforming the rules of the game in the whole industry.

Even though Skype's success is very strongly a result of Estonia's engineering talent, this success story would have never happened without access to international top-class venture capital and experienced senior management. It is, therefore, perhaps the most important lesson of all of the above case studies that capability building in terms of technological capabilities is extremely necessary. It is, however, not sufficient for participation in global production and innovation networks, and successfully catching up. This success still ultimately depends on the right time for market entry, superior product(s), a winning business strategy and world-class execution.

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