Fragmentation of GINs and capability building in the ICT industry: the case of a Telecom equipment company

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1. Introduction

The objective of this paper is to discuss the relationship between competences and the internationalization of R&D sites in a Swedish ICT company- ICT2[1]. It portrays the interplay between the availability of competences in the home country as well as in the host country, with the specific strategy of the firm and the changes in the environment.

The paper starts by providing an overview of the education system of Sweden as this may provide some explanations to why ICT2 has established some of their R&D labs abroad, particularly in China. Through in-depth interviews with ICT2 in different world locations (Sweden, South Africa and China), the paper explores the interplay between globalization of innovation and competence building, from two perspectives:

a) To what extent the access to qualified human resources may be the driver for the location of R&D labs abroad? – competences as a driver
b) Which competences globally dispersed companies need and how are they managed? – competences as an enabler

The paper is structured as follows. First, it provides an overview of the educational and research system of Sweden. It will focus particularly on the provision of qualified human capital. Section 3 is centred on the relationship between globalization of innovation and competences in ICT2 and it is organized around the two previous questions. Last section of the paper concludes with some reflections on the role of competences in GINs, based on the ICT2 experience.

2. Competence building in Sweden[i]

2.1 Universities and research centers

The university sector in Sweden is dominated by approximately 10 universities which are responsible for almost all R&D performance in the country: The Karolinska Institute, Chalmers University of Technology, Uppsala University, Lund University, Gothenborg University, the Royal Institute of Technology (KTH), Stockholm University, Linköping University and Luleå University being the most important ones. The size of the universities in terms of the number of students (FTE) in 2008 is plotted next:

[1] The real name of the company is not disclosed, due to confidentiality agreements.

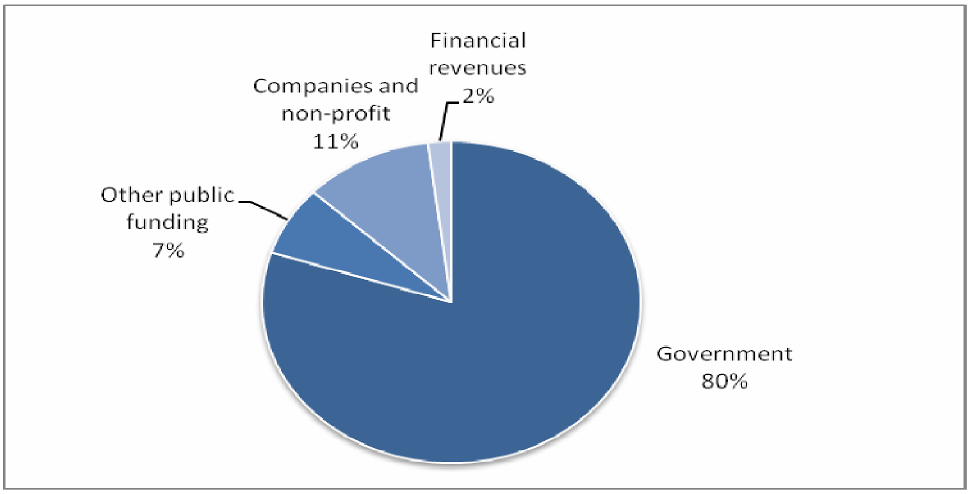
Table 1: Number of students enrolled in the 10 largest Swedish Universities (2008).

University	Number of Students FTE
Lund University	24600
Gothenburg University	24100
Stockholm University	22400
Uppsala University	19900
Linköping Univ.	16900
Umeå	15600
Linnaeus Univ.	15000
Royal Institute of Technology (KTH)	11700
Chalmers	8471

Source: Swedish Higher Education Authority (2009)

With few exceptions (Karolinska Institute and the Royal Institute of Technology), most of the funding of Swedish Universities comes from the public sources (regional and national government and EU) and only a small proportion (approximately 11%) is funded by private firms and foundations, as shown next:

Graph 1: Sources of funding of Swedish universities.



Source: Author own elaboration with data from SNAHE (2010).

Additionally, Sweden has a number of University Colleges (Swedish Högskola) that provide degrees at graduate (University diplomas and Bachelor degrees) and post-graduate level (Master and Doctorate). In comparison with Universities, University colleges are usually specialized in just one academic discipline. For example, Blekinge Institute of Technology and Mälardalen University are specialized in Engineering, while Stockholm School of Economics is in Business and

Economics and Malmö University (although is currently diversifying) has a strong focus on Medicine.

With regards to Research Institutes, the Swedish R&D institute sector (for example technical centers or specialized research agencies) is one of the smallest in the OECD, mostly due to the fact that almost all public R&D investments go to the Universities in Sweden (Marklund et al, 2004). Despite their small size, they are active in a variety of industries. Some of the most important ones are the Swedish Defense Research Agency (FOI) (aprox. 1250 employees), the industrial research institutes (jointly owned by the government and industrial associations, employing aprox. 2100 employees) and other government research institutes and agencies like the Swedish Institute for Infectious Disease Control or the National Institute for Working Life, employing aprox. 430 researchers full time (VINNOVA, 2006).

2.2 Tertiary education in Sweden

Although the proportion of higher educated people in Sweden is high, Sweden is not at the top of the OECD rankings that measure the proportion of higher educated people to the total population. Table 2 summarizes the number of students participating in tertiary education in 2006 in total and as a proportion of the population between 20-26.

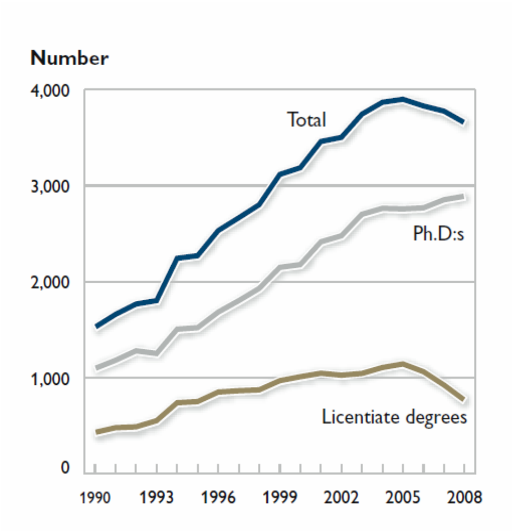
Table 2: Number of students enrolled in Tertiary education (all cycles) and number of Graduates (2006)

	Students enrolled in tertiary education		Graduates 2006	
	Total numbers	% population 20-29	Total numbers	% population 20-29
In any field	422614	39,1	60762	5,6
In Science, Maths and Computing	43910	3,8	--	--
In Engineering, Manufacturing and Construction	68846	6,4	--	--

Source: Eurostat (2009)

Since 2008, tertiary education in Sweden has been divided into three cycles: Bachelor, Master and PhD, which is showing different trends over time. While the number of degrees awarded to the first and second cycle has decreased over time, the number of doctorates awarded has slightly increased, particularly in the last year for which data is available (2008).

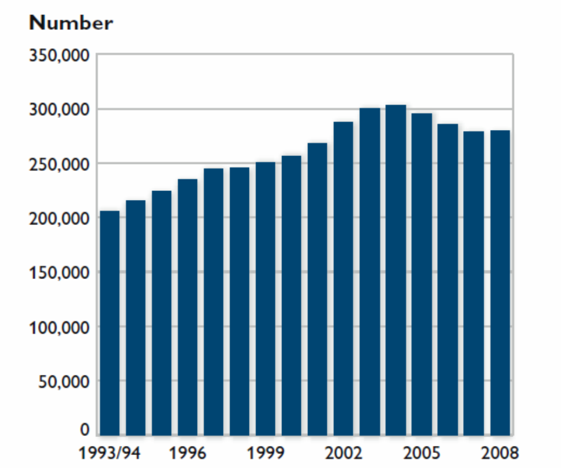
Graph 2: Number of degrees awarded in tertiary education (1990-2008).



Source: SNAHE (2010)

The declining trend observed in the first and second cycle is not a good indicator, particularly taking into account the role that competences play in the emergence and development of Global innovation networks: we may expect, that countries and regions with higher proportion of qualified human resources will be also the ones better positioned to attract GINs and to participate in GINs. However, one may expect this negative trend to reverse in the next future as 2008 showed, for the first time since 2003, an increase in the number of FTE in first and second cycles which may translate into an increase in the number of graduates in the coming years.

Graph 3: Number of FTE in first and second cycle of tertiary education (1993-2008).

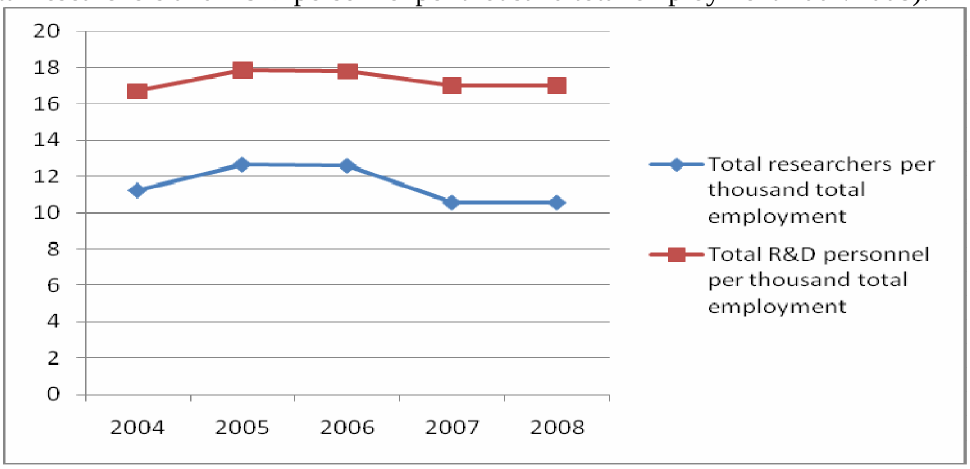


Source: SNAHE (2010)

2.3 Researchers and R&D personnel in the Swedish NIS

The proportion of researchers and R&D personal in the Swedish innovation system has decreased slightly since 2005 and, in 2008 the proportion was quite similar to that of 2004. This, again, is not a good sign if one takes into account that one of the most important determinants in the location of innovation activities in a certain country or region is the availability of competences (qualified human capital).

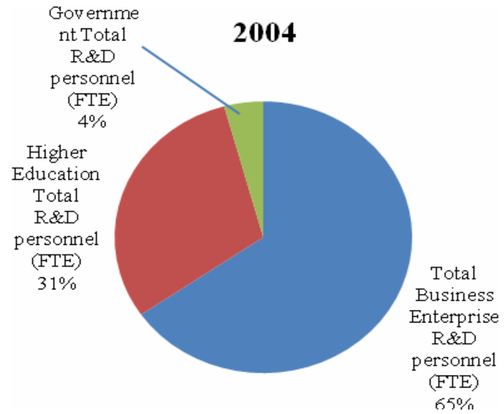
Graph 4: Total researchers and R&D personnel per thousand total employment 2004/2008).

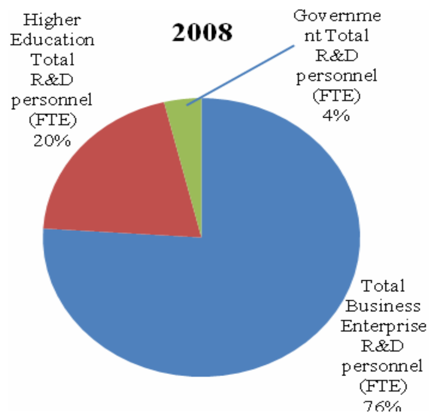


Source: Authors' own elaboration with data from OECD (2010)

The business sector has traditionally the most important employer of R&D personnel in general and of researchers in particular and its importance in relative terms has increased over time, as next graphs show:

Graphs 5: Percentage distribution of R&D personnel (FTE) between Business enterprises, Higher Education and Government in Sweden (2004 and 2008).





Source: Authors' own elaboration with data from OECD (2010)

The observed decreasing trends in the numbers of graduates in tertiary education as well as in the number of researchers available for the industry has important implications for large multinationals such as ICT2. This will be discussed in the next section.

3. Globalization of innovation at ICT2 and competence building

3.1 General overview of the firm

ICT2 is a world-leader provider of telecommunications equipment and services. ICT2's main business is the provision of network equipment and services for telecommunication. ICT2 is organized around 4 business units: multimedia, global services, mobile systems and networks.

The R&D sites (20-25) are in proximity with the main manufacturing units, which indicates a high degree of overlap between the global production network and the global innovation network of ICT2. In terms of locations, ICT2 has important R&D facilities in countries like Germany, Canada, USA (Silicon Valley), Ireland, Hungary and China. Currently the three largest ICT2's R&D facilities in the world for the radio division are the one in Sweden, the one in the Silicon Valley (USA) and the one in China.

In the past 10 years the number of European sites of ICT2 has declined to gain more efficiency. According to one of the interviewee: "small sites with 100-200 people are not attractive places for people as they do not grow". While the number of sites in Europe has decrease, presence in USA remains unchanged while new R&D sites within the emerging economies, like India and China have been opened.

In general, the R&D activities and the most specialized competences (in the internal network) remain concentrated in the sites located in Europe and USA but, according to the interviewee, China has upgraded rapidly as an important R&D site inside ICT2. The reason for this move towards large Asian economies is related to being in proximity to the local market and adaptation of the products to the local demands and standards.

3.2 Competences as a driver of globalization of innovation in ICT2

When enquired about the drivers for offshoring of production and innovation in Southern countries, the CEO of ICT2 indicated that the main reason for off-shoring innovation in Southern countries is to gain the proximity to the market and second to access specific competences.

The research conducted in R&D centers worldwide can be both for the development of a completely new product or service for the whole corporation as well as for the adaptation of an existing product to a local market.

An example of the development of a local solution for local needs could be the development of radio equipment in rural areas in India that would be conducted completely by ICT2 India. Another example of a development in which the subsidiaries will be involved could be a technology developed in US that needs to be adapted to the standards and requirement of the market in which ICT2 is commercializing that technology.

Access to competences and more explicitly, access to "domain competences" is regarded as the second main driver for the location of R&D activities abroad. In the last decade or so, ICT2 has followed a clear strategy of reducing the number of R&D sites worldwide while increasing the size of the remaining sites (so, less sites bur larger ones). This has occurred in parallel with the increasing technological complexity of ICT products and services, which demands a larger variety of skills (from software developers, to radio experts, computer engineers, etc). Accessing domain competences is on of reasons for ICT2 to locate one of the largest corporate R&D sites in China, but is not the only one. When asked if they would change their strategy if they could find the required number of skilled people with the desired qualifications in Sweden, our interviewee responded that they would not change their strategy, as the main driver for locating the R&D lab in China continues to be the access to one of their largest markets and the development of products and services for that market. So, while competence scarcity in the home country (Sweden) plays a role, it is a combination of large market opportunities together with the availability of highly qualified personnel at a lower cost, what makes China (and more precisely Beijing) one of the most important locations of R&D sites in ICT2.

In the case of China since 1995, different R&D sites has been established all of the country with a focus on different fields. The centre in Chengdu is regarded as a response to the "China's western development strategy,", although the interviewee states that the result has not met their expectations. Whereas the Nanjing centre has been started due to presentence of regional actors, being universities and colleges, as well as ICT2's biggest manufacturing unit. According to the interviewee in China

"the advantages of establishing research and development centers in different areas: Attract high-end talents in different regions; make the cooperation of different regions come true."

The interviewee with the Operation Development Director of ICT2 in China also regards the large pool of skilled people coming from various Chinese universities as a main reason for locating the R&D sites in this country. However, in his view there are not many differences between the Chinese market and markets in rest of the world. In his words: "Our market strategy is to provide global solutions, and solve problems in terms of network smooth and call quality, whether what we face is high-end markets or low-end markets".

The division of labor in terms of innovation between the HQ and the subsidiary is better explained by the CEO of Ericsson in Sweden. He indicates that "For the activities related to Radio based station important are the innovations that are sustained in Sweden, Canada and China but Sweden does mainly core innovation while in China the activities are mainly related to the implementation of idea. The Chinese subsidiary can be relevant, for example, for incremental innovation (e.g. reducing cost and adapting the product to the specific profile of Chinese operators). But some of those innovations also have a global effect. An example of incremental innovation with a 'global' effect is the production of a play station adapted to the local context; this idea is starting now to be spread worldwide".

This possibility of the subsidiaries to develop solutions potentially useful for the entire corporation puts an additional emphasis on the competences in the subsidiaries. There are not merely adapting the products to the local market, but developing products or services (sometimes brand new) that are potentially useful for the entire corporation.

In this respect, each of the largest R&D sites of ICT2 sites has specialized in a particular knowledge domain. For example, the site in the Silicon Valley (USA) has the R&D site for radio products, India is strong in IT which is related to ICT2 Internet Protocol (IP) business. With respect to the differences between the Indian and Chinese R&D sites, our interviewee indicated that although Indian can be regarded as strong within the IT area the Chinese have a broader range of domain competences in many different areas and thus conduct research for different business in ICT2. So R&D in India is not narrower than in China because the Indian market demands fewer or less sophisticated products, but because they don't have all the requisite competences. Especially since ICT2 as a group benefits from what goes on in its Chinese operation in that it generates knowledge and equipment for global markets, competences rather than market proximity seem to matter more. So, it is the breadth and depth of skills available in China what makes the Chinese site a more interesting location for R&D for ICT2 than India.

Although the person interviewed in the HQ in ICT2 does not refer explicitly to the activities of ICT2 in South Africa, the interviews done by GIBS may provide some insights. A CEO of ICT2 in Sub-Saharan Africa, refers to their continuous travels to the HQ in Europe and rest of Africa. He considers that the broader pool of skilled people in SA as well as the presence of the HQ of multinational companies in Johanesbourg are a main reason ICT2 to locate in SA in comparison to other African countries. The presence of other MNCs would attract more multinationals which results in reduction of costs although it raises the competition for attracting highly skilled workers.

He emphasises the importance of finding locally speaking skilled people that also have the ability of speaking the local languages he states that "as more and more people get into the mobile arena with handsets and so on, the local languages become more important". Therefore in order to penetrate the whole Africa it is a necessity to have skilled people from African regions. He indicates that even though the HQ have the knowledge on networks they need to have a better understanding of the local consumers.

The Commercial Management of ICT2 in Subsaharan Africa also talks about reasons for choosing India and China as the R&D sites and he mainly refers to the issue of a large pool of skilled labour at a reasonable price. In his words:

"R&D price is still quite high and to do it we have to look at the centre that provides engineering expertise and efficiency. And also at a very low cost. And India and China provides those fundamentals".

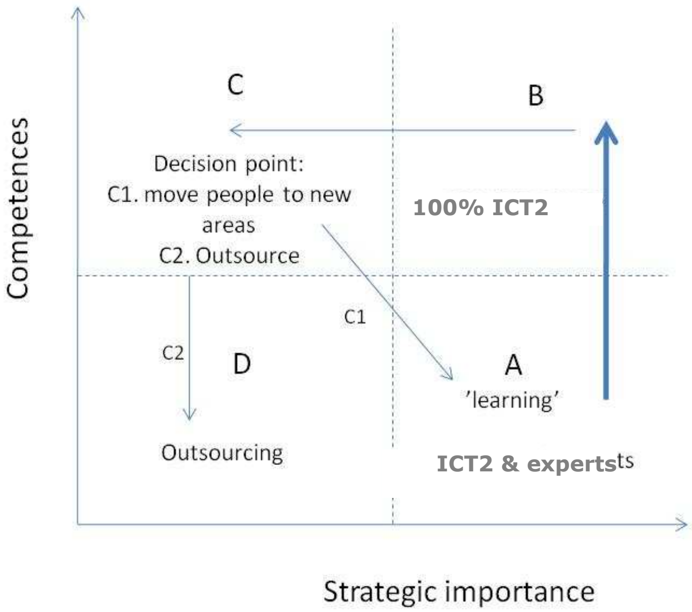
Further on he refers to the fact that access to Indian or Chinese market is also another incentive for starting and R&D site in those locations, that in case of China the products can also be supplied at a global level, thus confirming what the interviewee in the HQ said. He also explains the reasons behind a lack of R&D site in SA which is related to size of market (smaller than that of China and India for example) and the lack of skilled labor or specific expertise in certain competences (like the sites in Ireland or Hungary which are justified not because of the size of their markets but because their competences). He emphasizes the lack of engineers as a main hindrance for ICT2 in SA. The laws in SA are also regarded as another barrier for recruiting experts. He also refers to the Nigerian office and the fact that the lack of local experts makes it inevitable to bring expertise from outside or have training for the local skilled people.

The interviews held in Sweden (HQ of ICT2), China and South Africa point out to a kind of ranking of offshoring sites in ICT2. Core R&D seems to be conducted barely in three sites worldwide in Sweden, USA and China. These centers provide complex R&D solutions for the different business and for the entire corporation which require a combination of a wide arrange of skills. A second tier of centers are those that provide very specific competences in certain domain, like for example the R&D center in Bangalore which provides very deep expertise in software. They are also global, in the sense that they provide solutions also to the entire company, but only on specific domains. A final tier of centers are those that conduct mainly development for the local markets. Finally, there are locations in which there are not yet any R&D center, but only production and sales, with small adaptations to local markets. The site in South Africa falls into this last category.

3.3 Competence management in the global corporation

Our interviewee indicates that each of the subsidiaries have different challenges in terms of HR Management: a country like India has problems with retaining the employees whereas China has the opposite problem as only 3% of the local labor tend to move to other companies.

In ICT2 decisions for tackling new technological ideas are based on two dimensions which are the competences at ICT2 (how good they are) and strategic importance. The interviewee describes the process using a graphic that plots the strategic importance of the product to be developed and the internal competences.



When dealing with a new technology (A)**, ICT2 employees** and **external experts** are used for learning how to develop the core technology, but it will be the **ICT2 staff** (which could be from any site in developed or developing countries) that will reach the high level of competences (B). However as the competences are built within the company others [competitors] would also be on the way to acquiring the specific competences. Therefore time plays the key role on staying or leaving an area. The ideal situation is to have built the competences sufficiently fast to be able to stay in the strategically high zone for a while. Once the strategic importance becomes low (C) the technology will be outsourced to third firms in, for example, emerging economies that have gained a high level of competences while the ICT2 experts will be moved to a new area (a prevention for firing the experts, although some would prefer to stay and follow the outsourcing of the technology). The map illustrates the explained procedure.

Regarding (C) it should be noted that ICT2 has a explicit mobility policy for transferring the knowledge within the company. ICT2 promotes strongly the geographical mobility of the R&D employees, who are encouraged to spend a couple of years in one of the subsidiaries. This is not un-problematic, as one of the South African interviewees indicates.

Vinny Perumal (Strategic Business Adviser for the Vice-President, ICT2 Sub Saharan Africa) explains that having expat employees is very expensive and this is one of the main reason for reducing them in SA. He emphasizes the policy of ICT2 for its staff not remaining in on site for more than two years. He states that this is a risky business because although the employee learns a lot in the new location, he/she runs the risk of not being able to find his/her job back when the two year mobility has finished. The reason for having a two years period is stated as "they move people around so you grow in terms of not getting bored, in terms of your career." During this period the expats also train the local people, which has also been the case in SA and makes it possible for local people to take over the jobs. This policy of mobility is used both to upgrade competences when local competences are below what ICT2 commands elsewhere but also to transfer "ICT2 way of doing things", the culture and procedures of the organization.

The CEO of ICT2 in Sub-Saharan Africa refers to the fact that the senior management team is not situated only in one country and they are required to move to different counties. This is seen as a policy toward broadening the future outlook on ICT2 in Africa. He states that

"the policy is because Africa is so diverse that it is difficult to run the company in such a vast changing business arena, if all the people are based in one location. because so much changes so quickly, you really have to be on the ground and spreading us around our management decisions are better informed because we don't have just the SA perspective we have a broader outlook.".

Pre-development activities are the core of ICT2's coordination between the headquarter and subsidiaries. In this company, if an idea is small and incremental like changing the design of a product then the decisions on how to proceed with the production is made at a local level by the expert committees. This may take place at any subsidiary. However the larger and more radical technological ideas should be sent to the product council in Sweden where the product development decisions will be made and special funds will be allocated to the subsidiary. As stated by the vice-president R&D (HQ, Sweden): "we find predevelopment globally"

South Africa is a good example of how a subsidiary proceeds when they do not have an R&D lab. The Commercial Management of ICT2 in Subsaharan Africa explains that depending on the type of problem, there are different reporting approaches. The problems are send to Sweden, however if a technical problem exist within the network they will interact with sites that are having "daylights" at the local time. This system which is known as "sun concept" will make it possible to find solutions to the problems 24 hours a day. Different sites are the "problem" repositories that at the end of the day will send the issues to the R&D sites.

4. Conclusions

The case of ICT2 clearly illustrates that there is not one single reason why a company decides to locate an R&D lab in a certain country. It is a combination of factors that include firm strategy, environmental conditions and the characteristics of the potential locations in terms of markets and skill supply.

In terms of the strategy, ICT2 decided to respond to the increasing technological complexity of their IT solutions as well as to the need to reduce costs (due to the crises) by reducing the number of world R&D sites while increasing the individual size of the remaining ones. That is, instead of having a wide network of R&D centres worldwide, the company decided to concentrate in a limited number of sites. The selection of the sites seems to respond to a double strategy: some of the sites has been selected because they have excel in very specific competences (like Bangalore in India or Ireland) while some others are a combination of the willingness to position themselves in a larger market (also in India) while accessing a broader base of domain competences (Beijing).

In terms of the environment one can identify the decline in the number of graduates in tertiary education in Sweden, the increasing technological complexity (related to their strategy to enlarge the remaining R&D sites) and the higher costs of research as the drivers for the strategy of ICT2 to locate one of their most important R&D sites outside Sweden, in particular in China.

With regards to the environment, it is important to make a clear distinction between the decline in the number of graduates in Sweden and the opening of R&D sites somewhere else in the world, as the new sites are not a substitute of the R&D center in Stockholm- so, one cannot say that it is the scarcity of graduates in Sweden what has encouraged ICT2 to open a site in China. It is the combination of the decision to concentrate in few R&D sites, the access to a very large market as well as the availability of competences in a variety of domains that has made Beijing a more attractive location for a world R&D site than, for example, South Africa.

This leads to the third factor, the characteristics of the host location. The most important driver is still the market, that is, being **close to an important market** for the company. Currently India is the second largest market of ICT2, while China is one of the fastest growing ones and one considered strategic by ICT2. Second, the access to competences is an important factor, that is, the availability of a **large** pool of qualified human capital **in an array of domains** needed to provide technologically complex solutions to clients. In fact, competences in the subsidiaries are so important for ICT2 that subsidiaries playa double role: the adapt existing products to the local markets but they also develop new solutions (in terms of products and services) that can be further developed for global markets. It seems that between China, India and South Africa, only China fulfils this criterion as India is considered by our interviewee as specialized in a narrow set of competence (mainly regarding software development).

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[i] This section has been taken from the WP3 report "GINs and the Swedish National Innovation System".

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

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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: ICT2, ICT3 and ICT4. ICT2 was established in 1876, and has been a well-known brand name for decades. By contrast, ICT3 grew from a small company into a global multinational corporation in less than a decade only in the 1990s. As a global company, ICT4 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 – ICT2, ICT3 and ICT4 – 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

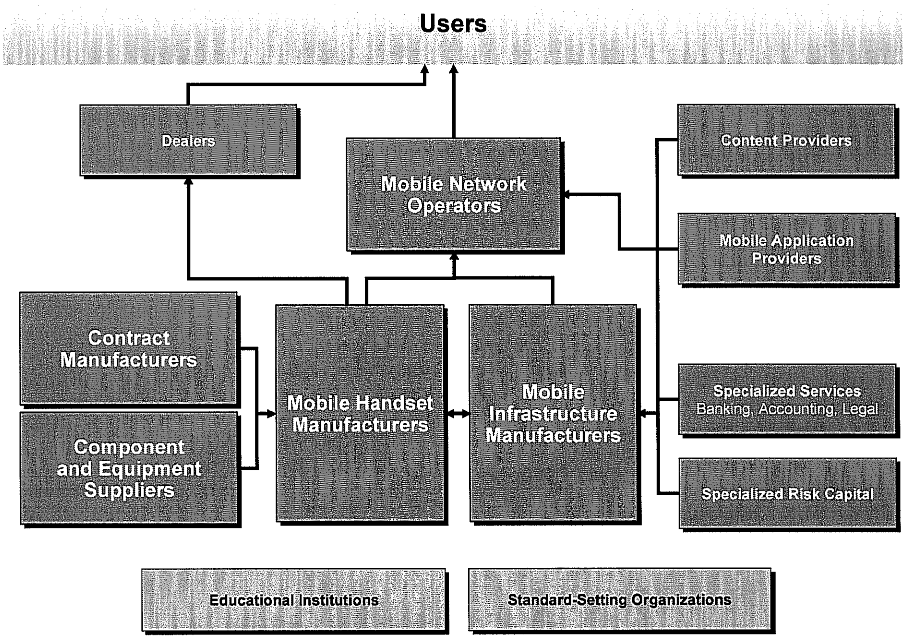
2.1. The global telecommunications equipment production

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 a 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, ICT2 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 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

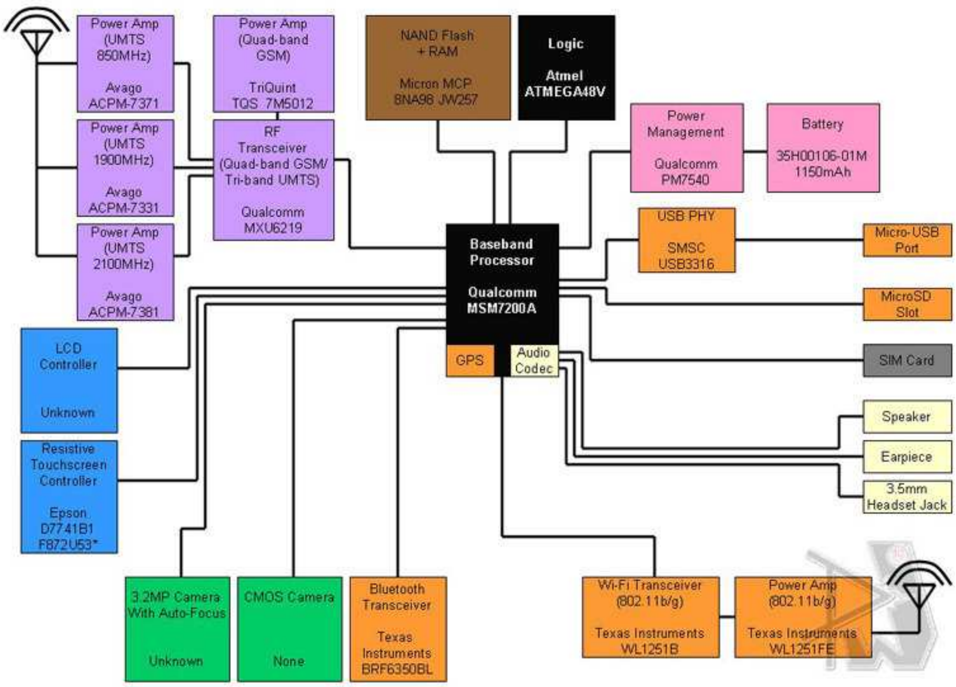
[1] At the time of the development of the original GSM standards, no one could properly estimate the future importance of the mobile data communications. Therefore, the original GSM standard foresaw only the possibilities for a very limited (9600 bps) speed of data communications. The shift from the 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.

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

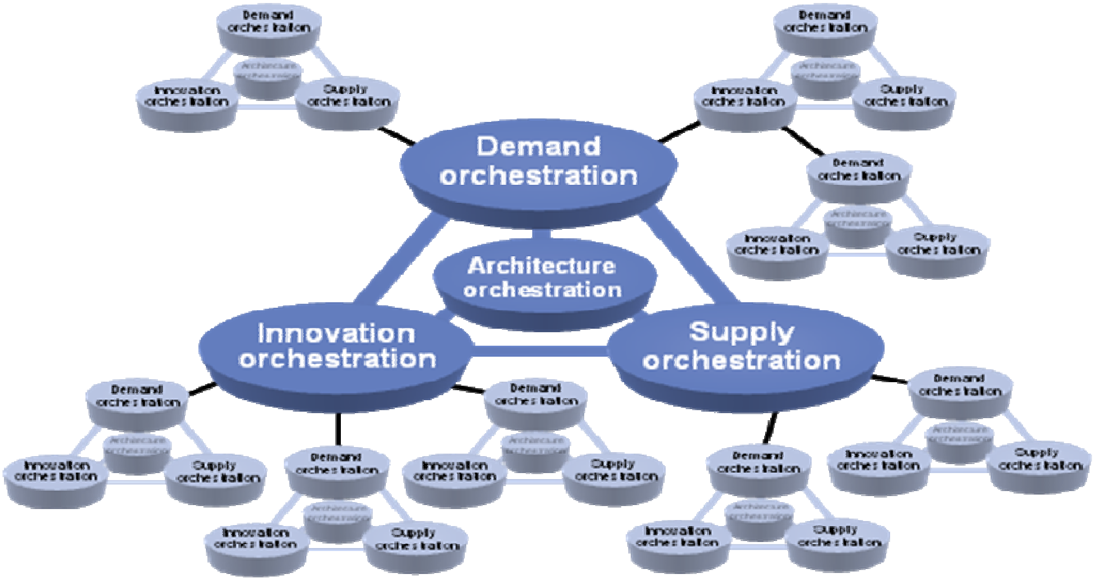


Source: iFixit 2010.

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

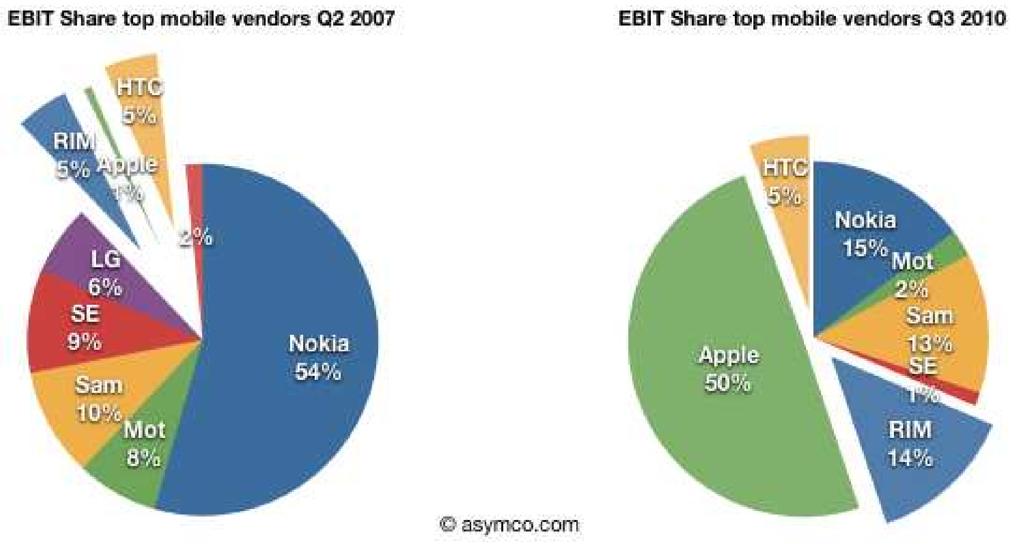


Source: Ollila 2011.

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).

[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:

Source: Asymco 2010.

Nokia's and Sony Ericsson's recent failure to capitalise on the smartphone 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 handsets produced by Nokia, Sony Ericsson and others. The development and maintenance of applications that run on multiple similar but mutually incompatible 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 dominant 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 partnership with Microsoft, another ailing giant that has failed to establish its software stronghold in the mobile telephone industry (Bloomberg 2011)[3].

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.

[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 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, ICT2 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.

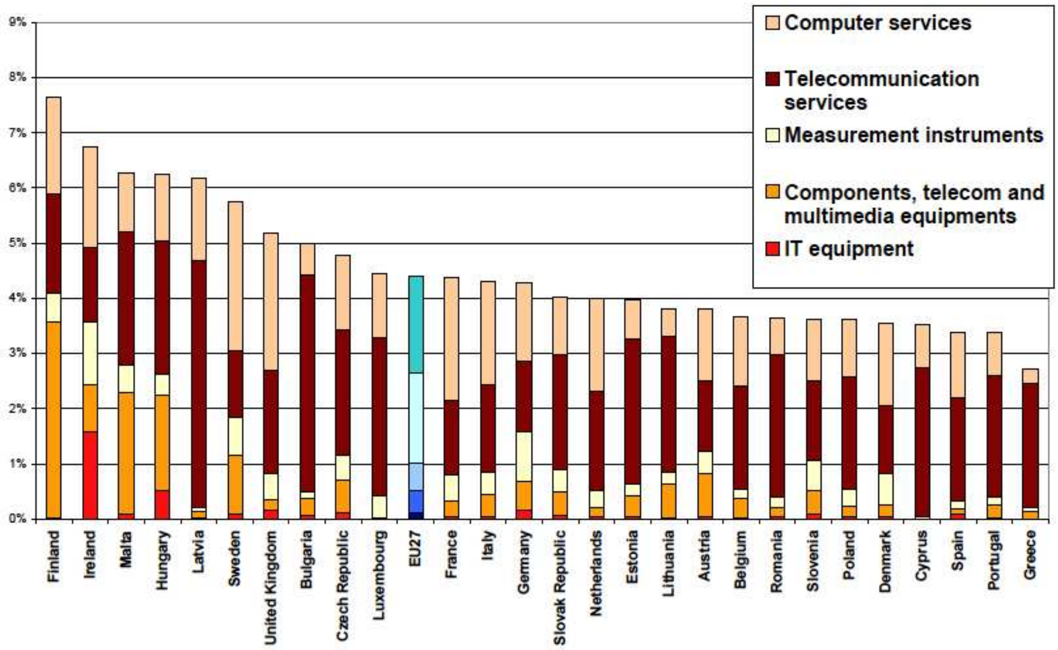
The different market dynamics and smaller production volumes imply, in turn, different location choices for the development and manufacturing of the infrastructure equipment as compared to the handsets.

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 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).

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.

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



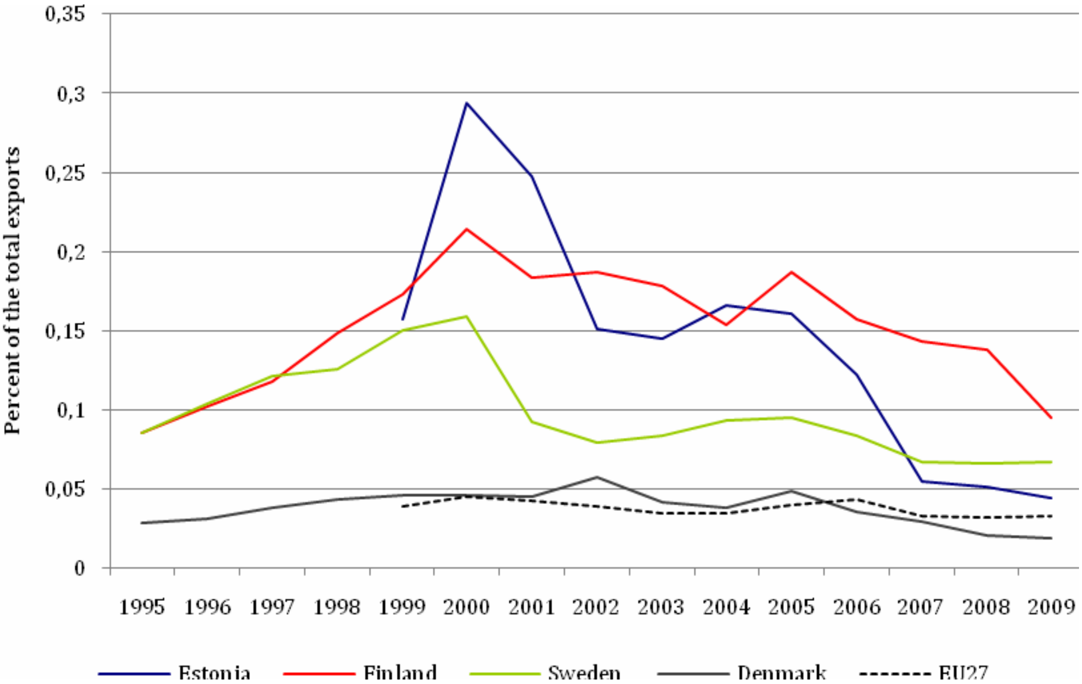
Source: Turlea *et al* 2009: 46.

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 ICT2, 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 ICT2 in Sweden. Estonia's exports in the telecommunications equipment have also predominantly to do with the two above-mentioned companies. Their manufacturing service provider ICT3 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 ICT2 and ICT3. Thereafter, we contrast these with ICT4, 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. ICT2 and ICT3 located primarily their manufacturing activities into Estonia, while Estonia has been since the very beginning the location of ICT4'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]

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 ICT4, 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

[5] Estonian Research Portal that is for public sector institutions the interface to national R&D funding. See: http://www.etis.ee.
[6] Helger Lipmaa, data last modified 1 July 2009, http://research.cyber.ee/~lipmaa/cites/php/estcit.php.

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.

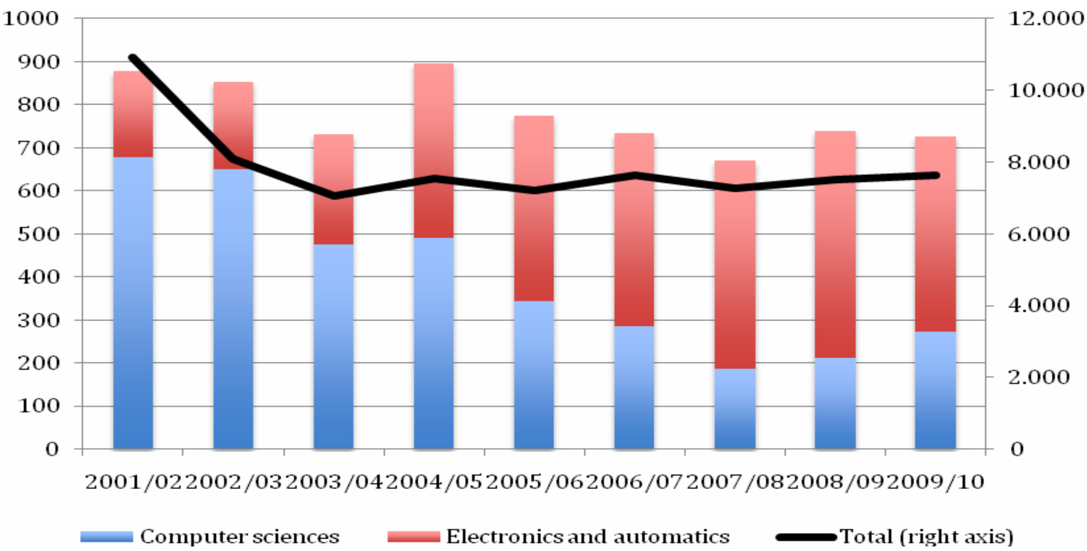
Estonia does not possess, similarly to most of the newer EU member states, a highly R&D intensive ICT and electronics industry. Foreign investment enterprises, which are responsible for the vast majority of electronics exports, have located only relatively less demanding production functions here. Furthermore, 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-Paternò-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. 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

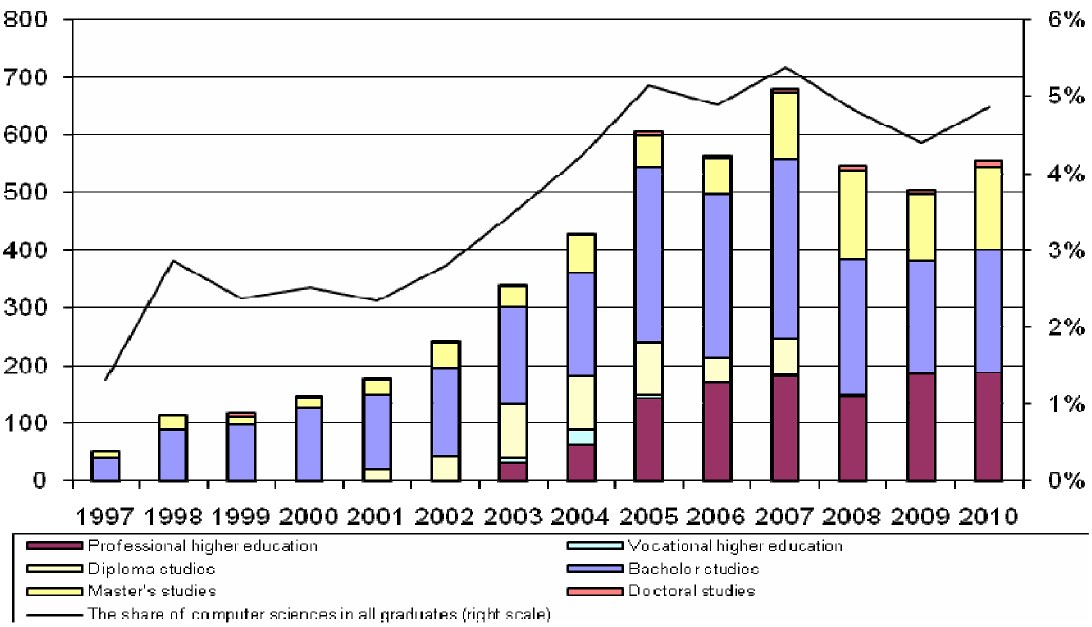


Note: On the both scales the number of graduated students is indicated.
Source: Estonian Ministry of Education and Research 2011.

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

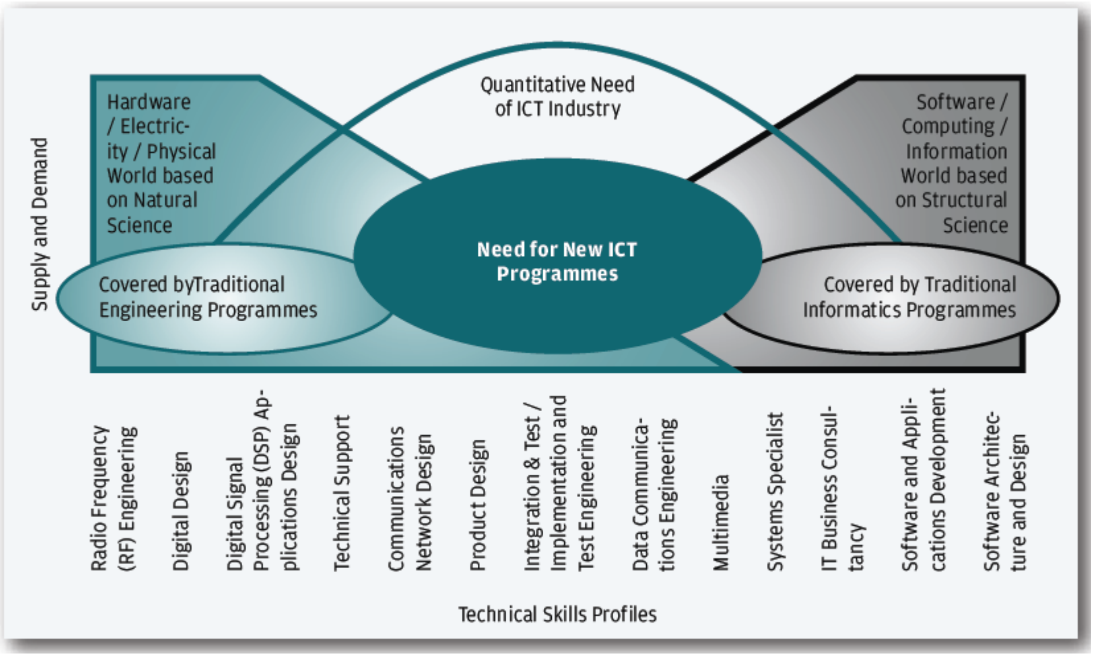


Note: The above data refers to the graduation in the computer sciences.
Source: Statistics Estonia, 2011.

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

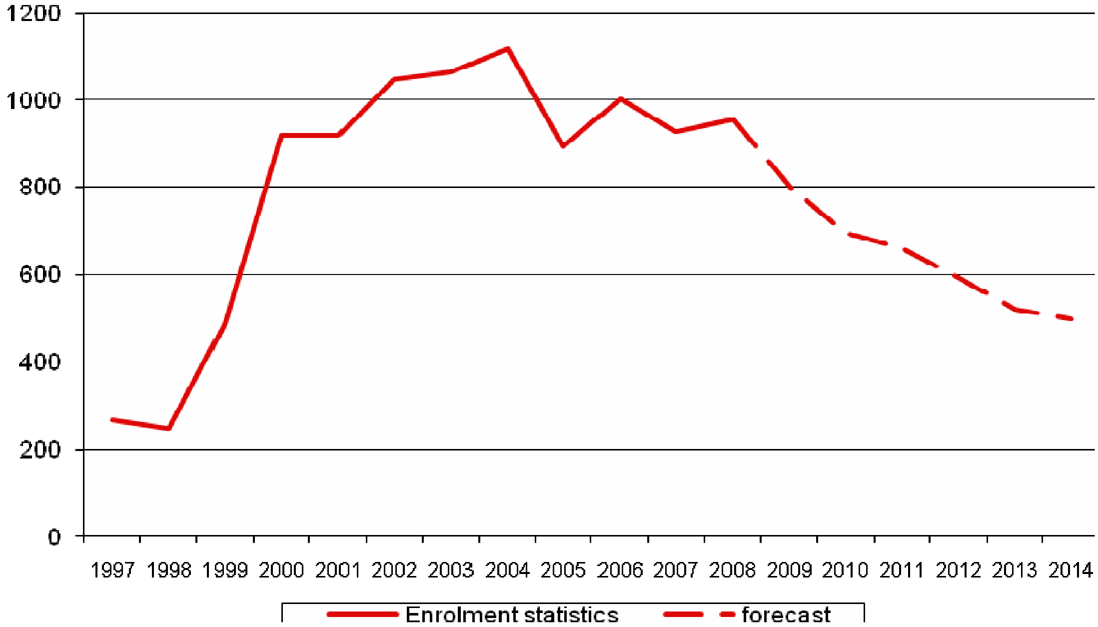


Source: Career Space and International Co-operation Europe Ltd 2001

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 ICT2

ICT2 was founded in 1876 as a telegraph repair shop. In the early 20th century, ICT2 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 ICT2'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 ICT2's most important partner in Eastern Europe, as it started to produce telephones under a licence from ICT2 and under the ICT2 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.

ICT2 was one of the pioneers of the Nordic Mobile Telephone (NMT) and GSM telephone systems in the 1980–1990s, when two Nordic firms were the global market leaders in manufacturing mobile telecommunications equipment. ICT2 continued to offer exchanges and other infrastructure equipment for fixed telecommunications and special radio communications networks.

These were the main products ICT2 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 ICT2 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, ICT2 handed the manufacturing of mobile telephones over to a dedicated company – a joint venture between it and another large global player – when the consolidation of the industry started in the 2000s. Furthermore, an ICT2 subsidiary company also started to sell mobile telephone components and kits to third parties. ICT2 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.

ICT2 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 ICT2 equipment, the share of the various value added services such as network planning and systems integration started to increase in sales. For example, ICT2 Estonia started to serve network operators in Denmark, Sweden and Japan in the early 2000s.

Today, ICT2 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 ICT2 Estonia serves the other Baltic and Nordic firms within the ICT2 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, ICT2 Estonia has focused predominantly on sales and service functions in Estonia for two decades. ICT2's R&D and product development activities continue to take place in its major corporate development centres outside Estonia. ICT2 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 ICT2 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 ICT2 brand name. Such cooperation with Regio as a local partner has, however, been mostly handled directly from Sweden.

However, the profile of the ICT2 organisation in Estonia changed significantly when ICT2 acquired a major share of the ICT3 facility in Tallinn in 2010. ICT2 has had ICT3 as a global manufacturing partner for two decades. Even though ICT3 manufactured for ICT2 in Estonia, there was no direct business between the subsidiaries of these two firms in Estonia. With this recent deal, ICT2 took over the facilities and personnel that ICT3 used for offering ICT2 electronics manufacturing services. For ICT2'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 ICT3's global network that the global economic crisis brought about in 2008–2009.

The number of ICT2 employees grew considerably with the acquisition and expansion of manufacturing activities in Estonia. ICT2 Estonia had about 100 employees in 2007–2008. The number of ICT2 Estonia employees increased, however, with the acquisition of the ICT3 plant and the transfer of the more than 1200 related personnel to ICT2 at the beginning of 2010.

Earlier, ICT3 manufactured equipment for the 2G and 3G mobile communications networks as well as for the fixed broadband networks in Tallinn for ICT2. 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. ICT2 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 ICT2's local key customer.

More broadly speaking, the specialisation of the Tallinn plant in ICT2's global production network did not change after the change of ownership. The Tallinn plant continues to provide electronics manufacturing services for ICT2, just as it did under ICT3's ownership. As previously, ICT2'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.

ICT2 does not disclose the exact production figures for the Estonian plant, but it is still obvious that ICT2's contribution to Estonia's foreign trade is massive. According to Veiko Sepp, CEO of ICT2 Estonia at the time of the interview, ICT2 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 ICT3

ICT3[7] was founded as a subsidiary of a Finnish company in 1984, to support the parent corporation's development and production of electroluminescent displays. However, this business did not develop as initially hoped, and some free capacity became available in the subsidiary company. Meanwhile, another large ICT corporation in Finland and ICT2 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 the subsidiary company became an electronics manufacturing service (EMS) provider, with the other Finnish ICT corporation and ICT2 as its largest customers in the early 1990s (ICT3 2010a).

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

In 1990, in preparation for a merger with a third Finnish industrial conglomerate, the parent corporation restructured itself and registered its different business operations as separate companies. The subsidiary was renamed ICT3 through this process. The new corporation that emerged as the result of the merger, did not however consider microelectronics to be its core business, and ICT3 went through a management buy-out in 1991. This was the beginning of ICT3 as an independent enterprise with both the Finnish ICT company and ICT2 as its key customers.

In the early 1990s, when Swedish and Finnish entrepreneurs were the first to invest in Estonia, ICT3 started pilot production in Estonia already in 1992, and formally established a subsidiary in Estonia in 1993. This was ICT3'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 ICT3 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 ICT3 itself had no say either.

In 1996, ICT3 Tallinn started to operate as the repair centre for GSM mobile telephones9. Already in the following year, volume production of GSM mobile telephones was initiated, and ICT3 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 ICT2 had subcontracted the whole production of a specific model of mobile telephone brought ICT3 to a completely new level of collaboration with its clients. Most notably, the Finnish ICT company soon also followed suit. What followed can be characterised as a true co-evolution of the major brand names and ICT3 as an EMS that was an integral part of their value chain. By the late 1990s, ICT3 was producing mobile handsets in Estonia for two market leaders of the time.[10]

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,

[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.

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, ICT3 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 at their new markets was the main driver of ICT3's very rapid globalisation. To finance the expansion, ICT3'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 ICT3 became a truly global corporation. By the end of 1999, ICT3'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. ICT3'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 ICT3 for transferring any specific production line from one site to another. As opposed to some other multinational corporations, the individual units within ICT3 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, ICT2, as the part of streamlining its value chains, moved the manufacturing of its mobile telephones from ICT3 Tallinn to St. Petersburg (Russia).

Also, a number of mergers and acquisitions took place between ICT enterprises. The establishment of a new parent company from the joint venture, and the subsequent sale of ICT2's own mobile telephone manufacturing plants to a competitor was, further to the general market downturn, another major blow for ICT3 (ICT3 2010a). Despite the above, in Tallinn (and in other sites) the manufacturing of ICT2 mobile network equipment and the Finnish ICT company telephones continues for the time being.

Initially, ICT3 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, ICT3 bought the R&D unit of the Finnish mobile telephone and telematics company Benefon in 2002 (ICT3 2010a).

In the 2000s, ICT3 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, ICT3 started to further its own design, R&D, engineering and after-sales services. Special New Product Introduction (NPI) centres were established within ICT3 to strengthen the co-operation with clients and their design houses in testing prototypes and making preparations for actual production.

Although ICT3 had all the capabilities for designing mobile telephones, and even developed at one point in time one handset for ICT2, 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

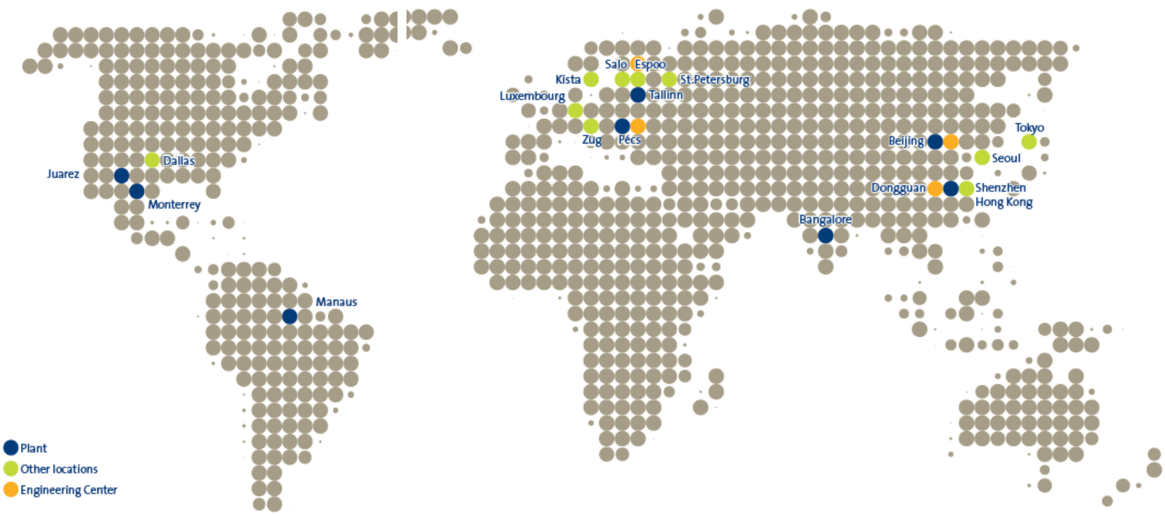
EMS business on all fronts in the 2000s. For example, the Finnish company started to source some of its printed circuit boards from Foxconn (Hon Hai) and GKI in Asia, and handled the manufacturing all together in-house in Brazil. In the mid-2000s, it continued to streamline its supplier network, and gave a preference to larger vertically integrated suppliers such as the Foxconn and BYD. As a result ICT3 was eventually forced to downsize significantly its handset business from this company (Seppälä 2010).

ICT3 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 ICT3 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 to Luxembourg in 2008.

The recent global financial and economic crisis brought about another restructuring of the ICT3 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 ICT3 Tallinn plant, which earlier served ICT2, was sold to ICT2. With this transaction, some 1 200 employees of ICT3 Tallinn moved also to ICT2 (ICT3 Annual Report 2009). After this transaction, ICT2 continues to produce 4G (LTE) mobile network equipment in Tallinn, for which TeliaSonera in Sweden is one of the most important customers.

In response to the above, ICT3 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 ICT3's clients. Further to this, ICT3 has established itself also in the production of flat screen TVs. (ICT3 2010b) In Europe, the plant located in Hungary is ICT3’s main mass production plant, while ICT3 Tallinn with its approximately 300 staff continues to cater for smaller niche markets.

Figure 11: The location of ICT3 sites



Source: Annual Report 2009.

Overall, in a global comparison, ICT3 still continues to be a fairly small electronics manufacturing service provider. ICT3 revenues were 1500 million euros in 2009 (ICT3 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 ICT3 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 ICT4

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. ICT4 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. ICT4 was founded in 2003 by Swedish and Danish entrepreneurs. ICT4'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 ICT4, 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, calls to and from regular telephones, video calls, etc.) and support for additional devices (Apple Mac, Linux, special ICT4 Phones and ICT4 application for various smartphones) appeared.

ICT4 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 ICT4 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. ICT4, which offered initially only voice calls, has also differentiated itself increasingly from the competition by offering video and multi-party 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. ICT4 was also the first to utilise networked flat screen TV-s, which have started to include built-in ICT4 software since 2010.

ICT4 had already 75 million registered users by 2005. As of 2011, ICT4 has more than 560 million registered users. The "cross-border traffic routed by ICT4, 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 ICT4 calls are actually video calls today (ICT4 2010, Tuaw 2011).

Figure 12: International long-distance calls and ICT4 traffic 2005-2010.

Source: Telegeography 2011.

ICT4 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 ICT4's immediate success. Soon, as ICT4 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 ICT4 for approximately 2.5 billion U.S. dollars of upfront payment (eBay 2005). In connection with this deal, an ICT4 office was also set up in the United States, close to eBay's headquarters. The ICT4 office in the United States continued to operate as a marketing, sales and support office servicing the Americas. More recently, general management of the business line was also moved to the U.S., as the Americas are globally the largest market for enterprise communications, and some of the ICT4's strategic partners for this business line, e.g., Avaya, are also located there.

Smaller ICT4 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 ICT4 enabled devices, including flat screen TVs, in Asia (Figure 13).

Figure 13: The location of ICT4 sites

Source: ICT4, October 2010.

Even though PayPal, another eBay firm, proved a good payment partner for ICT4, eBay itself was not able to build major synergies between its main business line and ICT4. Furthermore in 2008, a legal dispute emerged between ICT4 and its original founders over the rights to ICT4's underlying peer-to-peer communications technology. This contributed to the lessening of eBay's interest in ICT4 even further. Eventually, in November 2009, eBay sold 70% of ICT4 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, ICT4 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 (ICT4 2010). These plans were, however, cancelled, as ICT4 and Microsoft entered into a definitive agreement in spring 2011,whereby Microsoft will acquire ICT4 for 8.5 billion dollars. Once approval is received from the regulators, ICT4 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 ICT4 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.

ICT4 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 ICT4 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, ICT4 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 ICT4's rather unique management model, where the various multidisciplinary teams operate indeed in most cases within ICT4 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.

ICT4 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 a Norwegian start-up, a provider of voice technology for the Internet, in April 2006 is an example of the flexibility companies like ICT4 exhibit in attracting the very top talents11. The main motivation behind this acquisition was really the knowledge and talent this Norwegian company had regarding audio-video codecs12 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 ICT4 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 ICT4 unit, a close exchange of information also takes place there with different research institutes and universities across the globe.

"ICT4 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 ICT CEO] 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

ICT2, ICT3 and ICT4 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 ICT2 and ICT3 primarily manufacturing and various support activities in Estonia, while ICT4 has its main software development centre located in Estonia. The structure of the labour force of these firms is, accordingly, also very different in Estonia. Manufacturing floor workers constitute a significant share of ICT2's and ICT3's employees in Estonia. Contrastingly, ICT4 chiefly employs engineering

[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.

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 ICT3 personnel that operate today's ICT2 plant in Tallinn. Therefore, most ICT3-related observations simultaneously also reflect human resource development that has taken place in relation to the plant in Tallinn now owned by ICT2.

In the early 1990s, when ICT3 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 ICT3 manufacturing flow worker has 5-6 years of work experience in the firm. With the cyclical downturn in the industry, ICT3 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.

ICT3 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 ICT3 and ICT2 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 ICT4, 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 ICT4.

5.2. Technical and supervisory level

In ICT3, 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 ICT3. 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 a university of Applied Sciences, 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 ICT4, 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 ICT3, a possibility for technical workers to become engineers, in case they acquire more knowledge and experience.

This is why ICT4 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 ICT3 and ICT2 manufacture their products. In ICT3, 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 ICT2 between the R&D and product development that takes place outside Estonia, and the manufacturing that takes place in Estonia.

From the mid-2000s ICT3 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 ICT3 with the transition of most of ICT3's previous activities and staff members to ICT2 in 2010. Currently, ICT3's engineering facilities are very tiny in Estonia. ICT3 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 ICT3's 300-person workforce in Estonia.

ICT3 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 ICT3 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 ICT3 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 ICT3'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 ICT3 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. ICT4's main engineering facilities are, as discussed above, largely located in Estonia for historic reasons. This is where software development in ICT4 was initially established and additional engineering workforce was recruited as necessary.

The Global Learning Zone is, as discussed above, the key learning resource within ICT4. All the various training possibilities are communicated across all ICT4 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 ICT2'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 ICT3. 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 ICT2, 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.

ICT3 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 ICT3. 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 ICT4 different is that it grew very rapidly from a small start-up firm to a major global actor. Initially, in ICT4, 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 ICT4, 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 ICT4 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 ICT4 that require additional workforce.

Centralised HR management, including personal development and training activities, has also been instituted in ICT4. The internal organisation of ICT4'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 ICT4, 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 ICT4. 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 ICT4, mostly United States-based external experts have been used.

ICT4 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 ICT4 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 ICT4 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 ICT4'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 ICT3, manufacture various products that are developed by major industry leaders, such as ICT2, 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). ICT3'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 ICT2 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 ICT3 in Estonia

Source: authors.

ICT4 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 ICT4. Much less formalised forms of learning by doing, interaction within the different ICT4 offices and ICT4's outside partners, as well as corporate education and training resources, continue as much more important sources of inspiration for ICT4's software developers (Figure 15).

Furthermore, it is perhaps the key lesson from the case of ICT4 (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 ICT4 in Estonia

Source: authors.

The cooperation between ICT4 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 results13. Instead, ICT4 has, as discussed above, acquired the required talents rather aggressively,

[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.

where they could be found more easily and quickly, relocating, if necessary, the persons concerned to one of its offices.

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. 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 time14 15.

The Nordic mobile telephony industry pioneers 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 ICT3 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, major producers globalised very rapidly, also thereby bringing about the globalisation of their manufacturing service providers and service centres like ICT3. It was the very closely-knit business relationship between ICT3 and its key customers that did not allow ICT3 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, 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.

[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).

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 ICT2, ICT3 and ICT4 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. ICT2 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. Together with the Finnish ICT company, ICT2 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 ICT2'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 ICT3'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 ICT4 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 ICT4'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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Agro-food. Case study from a leading Scandinavian ingredients firm

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1. Executive summary[1]

This case study looks into the North–South relations in the global innovation network of a large Scandinavian ingredient producer, Agro1. The first part of this paper provides background on the company, the internationalization of its market, production and innovation activities. The company is a large and highly innovative firm, anchored within the Scandinavian agro-food innovation system, which is currently undergoing a global restructuring, including increased internationalization of innovation activities. Looking from the analytical point of view of Global Innovation Networks (GINs), the development of the firm from being an integrated company to becoming a highly internationalized knowledge-intensive one will be a part of this story (*the I: innovation*), as will the entry into new locations in emerging markets (*the G: global*) and its patterns of collaboration within and beyond its (global) value chain (*the N: network*).The first section of this paper presents the background of the company and the push-factors behind the internationalization of R&D and other innovation activities in the company.

Thereafter, the focus will be on this company's recent entry into the national innovation system of South Africa. This will be covered as follows:1) a short introduction to the location attractiveness of South Africa as an entry point into the African markets; 2) a presentation of the South African context, focusing on the elements that constitute location attractiveness in the food industry; 3) the current research activities in South Africa. Finally, the conclusion underlines the importance of differentiating between different types of locations and their attractiveness. One strand of the company's global innovation network is a purely home-exploiting strategy in which the company follows customers into new markets; in this case, the African market. Another strand includes home-augmenting strategies, where the company taps into external sources of knowledge through joint ventures and take-overs of developers of ingredients, i.e. for specialized local raw materials.

2. Company background

Agro1 is based in the agro-food industry and used to be a key player among the Scandinavian ingredient producers. It was originally a co-operative that developed into a world leader in ingredients and sustainable bio-based solutions for the food industry and other agro-related industries. The products are predominantly within biotech, and most are knowledge-intensive. Some products are highly specialized ingredients for leading firms in the food industry, such as emulsifiers, stabilizers, enzymes, cultures, protectants, sweeteners and sugar; the company supplies ingredients for products such as ice cream, cheese and bread. Hence, although not supplying directly to the end-customer, the products reach the global market through leading international food producers.

This company is one of the largest producers of ingredients in the world. It has mainly grown by take-overs and mergers, nationally as well as internationally. As explained by a manager: "Within

[1] Due to confidentiality agreements, the name of the company remains with INGINEUS. The case study is based on in-depth interviews with the company in Scandinavia (five interviews in the headquarters and the company network) and in South Africa (two visits to the South African affiliate), and on knowledge obtained from the corporate website, the media and company reports.

our niche, we are the leaders in the global market. Even though we are not a mega-company in terms of employees or market size, we are the leading company within our areas,” (interview, innovation manager). It was only in the late 1980s that the company emerged from sugar and spirit operations that were largely focused on the Scandinavian and EU markets. Following that time, the company decided on global food ingredients as a new strategic focus barely a decade and a half ago. Compared to many other companies in this sector, its global footprint is therefore of recent vintage. However, it pursued this strategy aggressively. In the early 2000s, the company acquired an internationally leading producer of industrial enzymes and bio-chemicals based abroad. This is one of the main milestones of this company’s internationalization strategy.

The company is research intensive and has a strong focus on intellectual property. Last year, the company spent more than 6% of its revenue on R&D. It has a high ranking in the international ‘patent board scorecard’ published by the Wall Street Journal. Every year, the company introduces approximately 700 new products. It holds more than 9,000 patents, which puts it in the top ten product innovators worldwide in the food, beverages, and tobacco category. Its innovation workforce numbers some 1,200 people:870of these work in R&D and the rest in application and customer service. 23% of the innovation workforce holds a PhD, and 44%aMaster’sdegree. The R&D platforms used to be spread widely, close to the largest markets, but have recently been centralized and are now concentrated in: the US, Central America, three in Scandinavia, the UK, the Netherlands, France, Singapore and China.

The products are sold globally, reaching a market of more than 40 countries, and the company is very globalized in terms of its market. Approximately 40% of the revenue comes from Europe and another 40% from North America; the remaining 20% is generated in Latin America and Asia Pacific. Among the largest world regions marketwise, market growth rates are highest in Asia Pacific (8%). However, the growth rate is 15% outside these three regions (Rest of the world, e.g. Africa). Seemingly, the current markets have matured and the company is exploring possibilities in new regions, as we will investigate later in this paper with the recent investments in South Africa.

Specialized knowledge is of high importance when the company collaborates with its customers. Since the products in the company relate to knowledge of ingredient solutions for the costumers, this knowledge is often developed and distributed with the customers. The innovation and R&D departments have a number of researchers who are familiar with food production, and often have long-term experience in the food industry. In other words, the company holds a high level of technological specialization, attractive to its customers. Many employees come from the more specialized segments of the food industry –as do those working in the sales teams. Hence, a large proportion of the employees have some technical educational background, including the sales teams. Since most of the business takes place in collaboration with the customers, i.e. leading firms in the food industry, the location of specialized staff mirrors the location of these companies, which are highly internationalized.

The internationalization of R&D has required new tools of communication and new strategies of co-ordination. To facilitate cross-location collaboration, the corporate culture has been transferred to and implemented within the different R&D departments with minor local adjustments. As researchers often work together in teams across national boundaries, this common culture is important. The culture is defined using the following key phrases: “designed for innovation”, “encourage willingness to take risk”, “curiosity”, “freedom”, “trust”, “networks”, “supporting entrepreneurs”, “willingness to change”, “room for all”, “open-mindedness”, “experimenting at all levels”. Accordingly, it takes time and effort to impose this organizational culture outside Scandinavia. A newly hired employee undertakes approximately two years of training before becoming an expert in finding solutions. One of the initiatives for generating innovation is the appointment of ‘CreActors’, which are internally-appointed professional consultants with the task of assisting creative employees with new ideas and helping them to advance those ideas within the company.

Still, most innovation takes place in collaboration with customers, and often takes the form of incremental innovation; e.g. minor adjustments to existing products. This is generally how the food sector is characterized and often works – limited radical innovation. A radical innovation is made when an invention is approved by the Innovation Co-ordination Committee (ICC). ICC ensures that the same structure and approach to project management exists across research centers. ICC has six members and collaborates closely with the management team, bridging basic research and innovation breakthroughs with the top management. This is where funds are allocated for projects at a pre-market stadium – to generate and prioritize ‘breakthrough’ innovations.

The global market for food ingredients is estimated at US$24bn. This company’s products compete in market segments that account for about US$10bn, with this company as the largest player overall. Competitors include Cargill (US), Kerry (IE), Huber (DK/US), Cognis (D), Chr. Hansen (DK), ABF (UK), and Tate&Lyle (UK). Industrial enzymes turn over some US$3bn globally. From outside Scandinavia, other important enzyme manufacturers include DSM (NL), AB Enzymes (D), BASF (D), Shin-Nihon (JP), and Amano (JP), plus smaller players. Moreover, this company is very competitive and holds a very strong market position. The frontier in food ingredient research is very varied. Food processors continuously demand new products. Accordingly, ingredient and enzyme companies need to anticipate future needs and identify technological opportunities relevant to the customers some three years ahead of time (i.e. the time necessary to develop the product). To this end,they also scan the world for new technologies as well as developing them in-house. The company has generally grown through takeovers, and uses venture capital to buy equity in promising start-ups. In order to keep track of new tendencies, the company’s innovation experts regularly and actively attend scientific conferences, such as IUFOST.

The company has more than 60 subsidiaries and holding companies in more than 40 countries, the large majority of which are located in Europe, followed by the US and Mexico. This reflects their geographic turnover. Africa is in the ‘rest of the world’ category, which accounts for less than 3% of turnover. In Africa, Egypt has a sales office, but the major operation is in South Africa – both Johannesburg and Cape Town – from where the company supplies 50 countries in sub-Saharan Africa. At the same time, some developing countries evidently show high growth, which is why the company has an increasing presence in Asia and Latin America. For example, in 2008 the company set up a research center in Shanghai, which is projected to become one of the world’s leading enzyme discovery units.

There is no question that this company is part of a GIN. Alongside its 40 production plants in all continents except Africa, it operates 21 R&D and application centers. Each R&D center has a specific competence (e.g. dairy processes and ingredients). Senior members are highly specialized in a particular area. When one center develops an innovation that it believes to have potential, it transmits it to the other centers for industrial application. If that proves successful, the innovation is rolled out across the group. Centers are not just supply-driven but also work on demand –also, production facilities can make requests to centers to work on a specific problem. In order to facilitate knowledge diffusion, the company employs a tool called Knowledge Search. This is a web-based platform, a Google-like search engine, allowing employees involved in innovation and application to access the company’s stock of knowledge.

The company engages in an innovation network beyond its value chains, and has R&D collaborations with numerous universities and research centers all over the world:

Collaboration with universities happens mainly when we are going into basic research. We also source from universities. We have certain competencies that make us an interesting partner for the universities. If we have a topic we would like to know more about (for example, why meat is so easily spoilt), we collaborate with relevant universities to solve this issue. One part of innovation is the development of new knowledge and the other is applying this to our customers' needs. Collaboration with universities is important in the development of new knowledge. In regard to application, the focus is more on recruitment of experts within products for new potential markets.

What needs to be established, therefore, is whether locations in **developing countries** are part of this GIN, either through an evolution from a global production network or in a more ad-hoc fashion of tapping into new knowledge. The latter seems to be the case, as the customers' locations are the determinant of the location of suppliers. Tastes and texture preferences vary according to relatively local markets, as do the available raw materials and their quality. One way in which developing countries can be identified as part of the GIN is if they host an innovation center. This applies, for example, to China, with the aforementioned center in Shanghai, and to Brazil. In a more indirect way, subsidiaries can be part of the GIN through the way in which the company creates knowledge (home-augmenting) and manages the knowledge diffusion process (home-exploiting). Knowledge Search allows internal researchers to explore internal knowledge systems across the R&D platforms. In addition to the knowledge sharing, the company posts success stories to encourage people to do a little extra for the company.

Both types of R&D and innovation (application and basic research) take place at a global level. The company has strong principles in terms of how it organizes globally:

We need to organize globally. In particular within food, as food types and tastes are very regional products. There are huge differences and also similarities. The large companies make the same products all over the world, but the products are indeed adjusted for local preferences – more than you would think. Besides the large companies there are many small- and medium-sized food producers, which are really locally-oriented. To meet their needs and get them as customers, we need to develop local raw materials, flavors and textures. Food quality also varies a lot. So we need to be local.

According to the company, there are no real 'push factors' in the internationalization of innovation beyond the national innovation system around the food industry. The incentives for internationalizing research are not related to the cause of cost reductions. Qualified people abroad, even China, earn as much as those in Scandinavia and besides, find that highly qualified people and partners are readily available at home. In other business areas than innovation and R&D, the company has experienced push-factors. One example is within accountancy, which has been moved to Eastern Europe to save money. The company engages actively in industrial clusters at home. There are many good niches for food in the home economy, plus very qualified suppliers of machinery etc. with whom the company collaborates closely. Together with suppliers of machinery, they have developed package solutions, for example in ice cream, for producers who want to go into ice cream. At home, the company works with the 'Knowledge Innovation Community' (KIC) established by the European Union, aiming at generating a critical mass. One of the local universities is also an important agent in this. Moreover, the company is embedded in the national innovation system and the innovation networks that come from it.

2.1 Having the 'best brains' is an important parameter of competitiveness

So far, the company has very little activity in Africa at the moment. However, it is in the process of buying a local player in South Africa. This will potentially bring some possible innovation activities. Otherwise, the company has a tiny laboratory in South Africa supporting bread-producing customers operating there. In particular, the company is working on solutions to get low quality wheat rising with yeast:

Generally, the raw materials for food in South Africa are of a very different standard than what we usually deal with, which is a huge challenge. However, our customers are moving into South Africa and we want to follow with some local solutions to the problems they face there. It is not always enough to send a technician from home. Having said that, we also prioritize having a critical mass of people more than local presence. So operations are specialized and we have developed a system of exchanging knowledge so that a problem in the bread industry in South America may be solved byour specialized team in Canada.

Over the last decade, this company has shifted R&D into **emerging economies** in the South: China is an upcoming major player in biotechnology, which is why the company has placed a large R&D center there. In China, the universities produce a number of highly qualified PhDs every year, creating an exciting environment for the food industry. To establish this center, researchers from US spent 3–6 months at the China site to help in developing the culture etc. Prior to setting up an R&D unit, the company had been present in the Chinese market since 1997. India is a good place to source IT, but,so far, this company has not really established there. Establishing R&D abroad can also be a recruitment strategy. Attracting the right people from abroad into the R&D facilities can be difficult, as the flexibility for getting foreign employees to the national innovation system is limited and not all good knowledge can be generated within one location.

There are different methods for identifying the best researchers. One is 'The Knowledge Award', which was launched in 2004 and awards students for innovative food and beverage products. This strengthens the company's relations with universities and produces a good input into the company. Last year, the prizes went to Clemson University, Washington State University and the University of Arkansas. Another award is given every year to a young researcher or institution in the home economy. Finally, 'The China Award' is a competition among students from eight universities in China where the students are asked to apply the products of this company to Chinese food products.

The more the company engages with diverse markets, the more it realizes the need for specific solutions for local products and related problems. Therefore, the company internationalized innovation and developed its global reach from exporting products into adjusting products for the local markets. After some expansion, this process ended. It was costly to have so many research facilities, and the company found that it had too many research locations around the globe. Today, the company has fewer R&D centers, and they are predominantly located where the company already has other functions. The main reason is that, although research needs to be independent at a certain level, the customers mean a lot to the company. A large part of the product development comes from collaborating with customers.

2.2 The location attractiveness of SA for Northern food-producers

South Africa is the second largest receiver of foreign direct investments (FDI) in Africa, and hence is seen as a regional growth location. Compared to the other BRICS countries, however, South Africa receives the least FDI, and the growth seen in the other four BRICS (Brazil, Russia, India and China) has so far not been matched in the South African location (Roodt 2010). However, in the African context, South Africa stands as the country with most subsidiaries of multinational corporations (MNCs). In 2008, South Africa hosted more than 640 MNC affiliates. Most of the FDI originate from Europe (87.3%) and the US (8.5%) because of their traditionally strong ties with South Africa. One important issue is the removal of 90% of the trade barriers through the recent Trade, Development and Co-operation Agreement (TDCA) between the EU and South Africa (Olympio et al. 2009 in Roodt2010).

Relevant factors for South African location attractiveness are the political stability and sustained economic growth over the last decade. South Africa has developed a strong national system of innovation in the region (Roodt2010) and a platform for market entry into Africa for leading global firms. The South African agro-food industry is an important trading partner because of, among other things, its counter-seasonality to Europe and its well-developed infrastructure. One of the more recent and important developments is the establishment of a cold chain in the South African transport sector.

South Africa is also home to several large agro-food companies, of which some have become global players. One of these is the beer producer, SAB Miller – today, one of the largest beer brewers in the world. Some agro-food firms have also exported knowledge services, such as Illovo Sugar and Bosch Engineering in the sugar-milling field. In South Africa, it is notable that a number of companies have extended their reach in agriculture-related investments, such as the former Anglo-American entities of Mode (forests and paper) and Tongaat-Hulett (sugar). Some major international agro-processing companies with a presence in South Africa include Unilever, Coca-Cola, Parmalat, HJ Heinz, Kellogg, Nestlé, Danone, Cadbury-Schweppes, Virgin Cola, McCain Foods of Canada, and Pillsbury (Roodt 2010, US Department of State 2009). This presence is a clear indicator of economic development and stability as well as a high growth rate in the local market (Collinson 2009).

Moreover, South Africa is a net exporter of agricultural products and, with only few exceptions, is self-sufficient in primary foods. With over 4000 food production companies, the country has the most developed food processing and manufacturing sector in Southern Africa.Agro-processing contributes 10% to GDP and employs 5% of the economically active population (DTI 2006). The food part alone accounts for more than 3% of GDP (Henderson 2010).[2]Consequently, the sector has attracted a number of international and local companies that use South Africa as a base to reach the domestic market, as well as other countries in Africa (Republic of South Africa 2006; see Table 1). The major players include Unifoods, Nestlé, National Brands, Tiger Brands and Premier Foods, Clover, Pioneer Foods, Foodcorp, Illovo and Langeberg Holdings. Furthermore, the increasing presence of food products from multinationals in domestic markets has intensified local competition, and places pressure on local firms to innovate in terms of what products they currently offer and how they produce them. Whereas large agro-industrial firms have the resources to invest

[2] Agro-processing here also includes non-food products such as fibre, (bio)fuel, and industrial raw materials.

in process and product innovation, smaller firms do not always, and their linkages with larger firms are generally weak (Felgenhauer and Labella 2009), meaning that some local players are becoming increasingly vulnerable.

Table 1: International and local companies operating in the South African agro-food industry

Company	Country	Industries
Unilever	Netherlands	Processed foods
Coca-Cola	USA	Beverages
Parmalat	Italy	Dairy, beverages
Nestle	Switzerland	Processed foods
Danone	France	Dairy, beverages
Kellogg	USA	Cereals, processed foods
HJ Heinz	USA	Processed foods
Pillsbury	USA	Beverages
Virgin Cola	UK	Beverages
Cadbury-Schweppes	UK	Processed foods, beverages
Minute Maid	UK	Beverages
McCain Foods	Canada	Processed foods
Dole	USA	Fruit and vegetables
Del Monte	USA	Fruit and vegetables
Catmark	France	Fruit and vegetables
South African Breweries	UK	Beverages
Bulmers	UK	Beverages
Tiger Brands	South Africa	Cereals and beverage, culinary, confectionary and healthcare products
Premier Foods	South Africa	Processed foods
Clover	South Africa	Dairy products
Pioneer Foods	South Africa	Cereals, processed foods
Foodcorp	South Africa	Processed foods
TongaatHulett Group	South Africa	Sugar
Langeberg Holdings	South Africa	Processed foods
National Brands	South Africa	Processed foods
Illovo Sugar	South Africa	Sugar

Source: Emongor (2008)

The growth of the domestic market over the years has compelled both foreign and local MNCs to explore opportunities in neighboring countries. For example, SABMiller originated in South Africa and now has brewing and beverage interests in 30 African countries. The agro-food industry is important, and the combined revenue of the 111 largest African agro-food companies places the sector second after the oil, gas and fuel industry in the continent (Felgenhauer and Labella 2009).

The competitive dynamics of the agro-industrial sector have resulted in an unprecedented need for specialized professional competencies, including in new bio- and nanotech materials and applications. The level and magnitude of professional expertise that is available to enterprises largely determines the position within the sector's increasingly globalized value chains. The education systems of most developing countries are not, however, producing sufficient numbers of graduates with the skills required to meet the technical and competitive challenges posed by a rapidly evolving agro sector, in part because their curricula are slow to adapt to technical change characterizing the industry (Wilkenson and Rocha 2008).

A recent study of agro-food companies in the Cape Town region (Lorentzen et al 2010) in fact reported problems with human capital at different levels. The firms interviewed – which included both subsidiaries of foreign MNEs and South African MNEs –learn from external knowledge which they access through their group, in the form of equipment imports, or atinternational trade fairs. A central element in both their strategy and their success is that they invest in learning and upgrading. This takes different forms, including in-house research on higher quality or new products and packaging. R&D alliances with international leaders, including parts of the same MNE group, lead to advanced knowledge absorption by the local partners. This is not an automatic process, but the outcome of systematic searches. The location-specific asset that allows for such partnerships to materialize is the relatively low cost of R&D personnel compared to advanced economies. Proximity of involved firms and tertiary education institutions, especially Stellenbosch University, facilitates localized knowledge spillovers in the form of a better understanding of what is technologically feasible in connection with what is commercially desirable.

Most firms employ processes that are based on capital equipment that is world class. Its introduction is often facilitated by engineers from the foreign manufacturer, whotrain local operators. Hence, the production environment is little different from that of their advanced peers – this also explains why products developed in South Africa by a MNE subsidiary are subsequently introduced to other parts of the world through the group (Lorentzen et al 2010).South Africa's sugar industry is one of the most cost-competitive producers in the world and, since 2009, South Africa has had duty-free access to the EU market, creating significant export opportunities for the country (Roodt 2010).

2.3 Internationalization of innovation in South Africa

The affiliate of our case company in South Africa (hereafter: SA Affiliate) is responsible for 50 countries in sub-Saharan Africa. It is headquartered in Johannesburg, in part because it is easier to access those markets from Gauteng than from Cape Town. SA Affiliate supplies all major food processing companies with high-technology ingredients. Hence, its portfolio does not include any standard commodities, but only more sophisticated ingredients such as: bacteria required to turn milk into yogurt or cheese; enzymes to make bread or detergents; hydrocolloids to make jam; and so on. SA Affiliate is a technology-intensive company, a fact that is reflected in its personnel: all sales people have technical degrees in food technology or similar. This allows sales people who are in contact with customers to evaluate their needs jointly with them, and develop new products and processes.

SA Affiliate differs from other subsidiaries around the world in that, to date, it has never had separate application or innovation staff from the sales personnel. ("Application" refers to changing processes or otherwise fixing problems at a customer's site.) However, this is now changing in the sense that SA Affiliate has recently hired dedicated innovation and application staff.

Like all other subsidiaries, SA Affiliate sources its entire complement of ingredients from the Group's over 40 factories around the world. To date, there has been no manufacturing facility in Africa; hence, SA Affiliate does not produce, but at most blends ingredients sourced from the group. Still, blending is a high-technology activity that takes place using pharmaceutical equipment, owned by SA Affiliate, in Cape Town. The plant is geared to allow for contamination-free production of ingredients in sterile and dust-free environments. Most of the blending takes place on behalf of bakeries. Blending is idiosyncratic in that it corresponds to local needs. For example, a bakery will give SA Affiliate a new type of flour, which then needs to be matched optimally with a number of high-tech ingredients to create the best possible recipe. SA Affiliate has a very short turn-around time: testing some thirty possible blends, sampling and delivery of the final mix to the bakery is done within 24 hours after delivery of the new flour. This is an area where SA Affiliate aims to add to the group's knowledge base; more about this below.

Although recipes are made for local equipment, nutritional requirements and tastes –and thus the resulting product is unlikely to be attractive to external markets –it is possible for the group to learn from SA Affiliate's processes. The group has an international knowledge base, accessible to key personnel around the world, that records any relevant technological innovation. The group also has 'expert teams' with members from around the world (in baking, dairy, and so on) that interact on a bi-monthly basis. In the past, this system did not really pay attention to activities at SA Affiliate because it was run by and for application staff, which SA Affiliate did not have. Due to the blending process referred to above, this is now changing. Hence, SA Affiliate is increasingly involved in the GIN part of the company, not just marketing.

The turn-around time of SA Affiliate's blending processes is much faster than at any other plant within the group. Average turn-around times are four weeks; two weeks was hitherto acknowledged as extraordinary. The reason for the superiority of the process lies in the trade-off between scientific analysis of the flour, including several repeated trial bakes over time (which is time-consuming) on the one hand, and tacit knowledge whereby experts with a lot of experience can select the most suitable blends from a portfolio of 32 batches of test bakes on the other. Criteria include, among other aspects, softness, resilience and crumb structure. This does not deny the role of science, but scientific analysis of flour has limitations: it cannot accurately predict how a specific type of flour will behave in a bakery. Hence, blending involves a certain amount of trial and error anyway, and it is this experimenting and learning that the application of tacit knowledge can speed up.

The origin of the 24-hour process lies with a South African company founded by two New Zealanders, which was taken over by the company in 2007. The local company had been very successful, but lacked resources to grow. A year and a half after its takeover, its business volume had increased fivefold. In fact, in its baking business, SA Affiliate has grown much faster than any other part of the group; so much so that it is considering building a second blending plant in Gauteng. The Group now plans to make the originators of the new process visit other plants around the world to explore a possible application elsewhere. Hence, there is knowledge transfer from South Africa to the rest of the world, including to developing countries.

The main reason that, to date, there has been no R&D and application center in South Africa is that the company only set up its South African operation in 2000. Until 2003, it employed a mere 13 people between Cape Town and Johannesburg. By 2010, staff complement had risen to 78. Growth in turnover has been similar. Hence, there is now an opportunity to establish innovation activities in South Africa, and this will in fact happen shortly, with a focus on baking and dairy industries. The relevant personnel joined SA Affiliate in August, and the new center will initially have seven people responsible for innovation and application. It will be one of the smallest centers in the group.

SA Affiliate tries to deal with the skills shortage in the country by identifying the resident most highly qualified core group of experts (which, for example, in baking amounts to a mere eight people) and employing them all. It also absorbs knowledge through acquiring smaller, knowledge-intensive companies. For example, in the past it bought Innovative Ingredients, a Cape Town-based producer of bakery enzymes, and Bakesure, a Zimbabwe-owned premix supplier to the bakery trade (South Africa's industrial bakery market is the fifth largest in the world). In August 2010, it acquired a small product development company focused on customized products and technical expertise for the food industry. Its portfolio includes stabilizing systems, compounds, concentrates and sauces. In this acquisition, the company pursued both the local skills and the relationships cultivated by the local player. In fact, it bought into the regional agro-processing innovation system in the Cape Town region (Lorentzen and Muller 2010). Furthermore, the local company had well-established contacts with the relevant departments in the local universities, and has helped a local equipment supplier manage its contract research in its major target markets of the US, UK, and New Zealand.

2.4 The establishment of a GIN, internationalization of innovation

In previous work on internationalization of innovation in the agro-food industry, two models of internationalization of innovation were identified. The first model implies a reorganisation of innovation processes at a global scale, involving techno-scientific networks of specialized knowledge actors for research and development beyond the Triad regions (EU, US and Japan). This constitutes the capital G in relation to global innovation networks (GINs). The second model implies a stronger internationalization as Europeanization of innovation, mainly in the form of product development with actors in their regional innovation systems; this will constitute the lower case 'g', i.e. innovation networks that are not so global as those with a capital G. In terms of innovation – the 'I' in global innovation networks, the capital I is used for companies that organise innovation across their global R&D and production sites and introduce new-to-the-world innovations. The lower case 'i' is used for companies – or networks – that predominantly internationalize their innovation in order to adapt their products to new markets. Finally, for network – the capital 'N' is used when companies engage in collaborations beyond their own value chain, e.g. with universities and other research institutions, while lower case 'n' indicates that the network mainly includes suppliers and customers.

While this company is one of the most internationalized Scandinavian companies in innovation, this internationalization varies according to specificities at the different locations. In locations with large markets, availability of human resources and existing research environments that can supplement those already accessible to the company, like the US and China, the company has established research facilities that engage in application as well as basic research for their global operations. Hence, seen from the home economy, the company performs well both in terms of home-exploiting strategies (i.e. expanding the market for existing products) and in home-augmenting strategies (i.e. tapping into new knowledge). For the locations of basic research, this company has a strong international profile across the globe; it is Global with a capital "G". The innovation activities carried out both include application of products to new markets and generate innovations for the future; innovation is with a capital "I". Finally, the innovation activities predominantly take place in collaboration with customers. However, the company maintains strong relationships beyond its value chain, with universities; therefore, the network is with a capital "N". In other words, it has, over recent decades, developed into a key player in its GIN – which is of major importance for sustaining its position in the ingredient and enzyme markets. This is supported by initiatives for creating a strong company culture and by developing and enhancing communication across innovation sites.

Zooming into one link in the developing global innovation network, their emerging engagement in South Africa, provides interesting insights into the importance of which location is in focus. Having said this, SA Affiliate isnot involved in basic research, but has recently geared up to do applied research and development with relevance for the group. Its GIN has a capital "G" (due to the global knowledge presence of the group on which SA Affiliate can draw and to which it will contribute), a growing "i" (because it has just established an innovation-and-application unit that will work on bakery and dairy projects), and a medium-size and also growing "N" (in the sense that the emerging innovation portfolio implies that it will work more intensely outside the Group, i.e. with external partners such as universities). The GIN relations this company has established in the South African location is so far a GiN.

3. The agro-food GINs and their impact on South Africa[3]

This section will reverse the picture and consider the above story from a South African perspective. What is the impact of the company's entry into innovation in South Africa in terms of upgrading local players?

In South Africa, the company has 61 employees located in Cape Town and Johannesburg. South Africa is the biggest market in sub-Saharan Africa, making up 85–90% of sales, followed by Nigeria and Kenya. The company opened the South African subsidiary in 2000. In August 2010,it acquired 100% of a local Cape Town firm, SA Affiliate. SA Affiliate offers customized ingredients solutions, and primary markets are dairy and fruit juices. Before being purchased, about 25 people were working at SA Affiliate. About 20 of them were based in Cape Town, with a few sales people based in the Eastern Cape and Johannesburg. Ingredients were bought from most of the ingredient suppliers in South Africa, such as the case company.

3.1 How innovation worked at SA Affiliate

When SA Affiliate started out, about 80% of its revenues came from consulting fees, project management, project work and other services. As clientele grew, a larger share of revenues came

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[3] Research for this section was conducted by Luke Muller, May 2011.

from supplying products. By the time SA Affiliate joined the case company, about 90% of revenues were brought in from product sales.

SA Affiliate does “straight” development and charges a development fee and product development and supply toa customer; the development fee is forfeited and revenues are earned from supplying ingredients. Newly developed IP is then kept, to retain value within SA Affiliate’s products. Supplying customers with ingredients or a solution provides a stream of revenue over the lifespan of the product, whilst services charge a once-off fee only.

There was a production component within SA Affiliate prior to joining the case company, but this was mainly outsourced. SA Affiliate stuck primarily to its core business of product development. Once a product was developed, production was outsourced to contract blenders in Johannesburg. SA Affiliate would then supply the product to clients. For example, SA Affiliate would develop a yogurt stabilizer for a customer; the recipe would then be sent to a contract blender in Johannesburg, and SA Affiliate would deliver the final product to the customer.

3.2 Why and how the case company bought SA Affiliate

When the case company bought SA Affiliate, they acquired its local R&D capacity. With the case company being based in Europe (Scandinavia), the South African and African market is very different. The company was buying not only skills, but also insight into the local market conditions, and the company believes that sub-Saharan Africa has potential for growth (along with other emerging markets). The capabilities that the case company was looking for in SA Affiliate were high-level technical and scientific capabilities rather than the production capabilities. When it comes to initiating new products and services, what really matter are capabilities. When the company merged, there was a shift in the responsibilities of top-level skills in South Africa. Responsibilities became more specialized in a larger company.

SA Affiliate cannot always refer back to the headquarters to provide solutions. The distances still create time lags where information is hard to convey or knowledge is tacit. SA Affiliate kept its R&D capacity after joining the case company; it still performs R&D for dairy products at the innovation center formed by the case company in Cape Town. The same was done for baking R&D: this aspect of the innovation center was formed by a company run by two New Zealanders, which was also bought by the case company. The current innovation center was created by bringing together the R&D capacities of these companies. The innovation center is now looking to expand further, into meat, breweries and beverages.

The case company was interested in both SA Affiliate’s in-house skills and skills networks when buying the company. SA Affiliate partnered with Stellenbosch University, the University of the Western Cape, the University of Wisconson and others. If there is a lot of troubleshooting and analytical work to be done, SA Affiliate finds it helpful to work on the project in collaboration with a university.

3.3 How innovation now works in the new subsidiary

The development of a stabilizer or blend in South Africa takes place through innovation in the development division. The recipe is then passed on to the manufacturing arm of the case company. Turnaround times for research have slowed down since the takeover because quick decisions cannot be made without first motivating for a project. On the other hand, it can be beneficial for skills recruitment to be part of a large company: people are less apprehensive about working with a global company than with a smaller private company. However, networks for exchanging knowledge and building intellectual property (IP) did not change following the takeover. The case company was keen to continue those relationships, especially since they are important for developing products specific to local needs. Adapting to local needs is also important for expansion into sub-Saharan Africa.

Collaboration and knowledge exchange with the headquarters is done almost on a monthly basis. Previously, when developing a product, SA Affiliate had to start from scratch, but it now has access to the global network and can see whether similar products have been developed around the world. Having access to this information speeds up the development process substantially. The South African subsidiary exchanges knowledge with the regional headquarters, so SA Affiliate reports to e.g. Brazil. There is presently a lot of interaction with Brazil for product development. If Brazil cannot assist South African operations with a product, then the knowledge base of any of the other regions can be exploited. The access to other regions is horizontal, and does not go through the Brazilian headquarters. Once a month there are formal reports about developments across all centers, but the knowledge base can be accessed whenever the need arises. There are also meetings, at least twice a year, of the innovation personnel in South Africa, Brazil and elsewhere. There have been numerous cases where IP from South Africa has been used in Brazil. For example, the yogurt market in South Africa is well established, and Brazil has often used South African IP to develop yogurt products. The IP was developed by SA Affiliate, and now belongs to the case company globally. But because the IP was developed in South Africa, the South African subsidiary is the first port of call for developing related products.

Changes and innovations are generally incremental at the 'shop floor' level. When new products are brought into production, the changes at the shop floor level are generally not too drastic. This is due to a combination of the nature of the product and the way engineering and processes are set up to keep changes at higher levels in the company. Because of the scale of operations at the case company, production techniques cannot easily be interchanged. Previously, SA Affiliate was more flexible, and could change production techniques without incurring major capital costs.

3.4 The introduction of a new product or process: how capabilities are upgraded to meet the new technology

South Africa has been used as a pilot project for a new-to-the-world concept developed in the home settings of the company, in Scandinavia. The concept was taken to customers, trials were run with an application specialist in the plant, and the product was evaluated with a university to predict the outcome. If a new product is developed, and there are changes to production in terms of engineering, SA Affiliate can go in-house, but more often the customer prefers to use their current supplier. Most of the engineering required will then take place with the supplier. For new products, the application specialist will make a lot of recommendations for the plant and application. Evaluations, such as shelf life, are done with a university.

When introducing a new product or process, allocating resources and finding sufficient investment for projects is the main constraint. The decision to invest in a project is often based on previous experience and gut feelings. Developing protocols for a new project takes time. The industry is also constrained by there being many followers and few innovators. Typically, clients will want to see evidence of new products working elsewhere in the world before trying to sell them locally.

3.5 Skills

The major skills constraint is to try to find skilled people with experience. There is little formal dairy food science training anymore. It is difficult to hire individuals who understand the practical implications as well as the theoretical side. Hiring skilled managers is not a problem; there is an adequate supply of managers and project managers. Lower skill levels (supervisory and technical) are not in shortage, but it is important to have training programs in place, whether internally or externally.

The South African subsidiary has supervisors for production and quality. Varying degrees of skill are required. Shift managers and production managers generally have diplomas. Production managers will have a degree. Production is not as specialized as product development in dairy, where a production manager will have higher levels of training. Blending is quite a simple operation. The value added is in the product development and R&D.

Turnaround does tend to be quite high at lower skill levels. Typically, people have just come out of university and stay on for four or five years' experience. Being a dynamic company with a lot of exposure means that people will often get about four years' experience before moving on to other offers in the industry. The case company also offers a wider variety of career opportunities for employees, specialized careers in research, more generalized careers, technical sales or sales, whereas there are fewer opportunities in a smaller company. The larger company is much more rewarding in terms of career opportunities.

4. Conclusions

The case company, Agro1, has expanded its GIN into South Africa, allowing SA Affiliate to exploit IP from all over the world when introducing new products into sub-Saharan Africa. On the other hand, acquiring SA Affiliate offered the case company an opportunity to augment its innovation capacity (especially in dairy products) and enter the growing sub-Saharan market. SA Affiliate also had existing knowledge networks that the company continues to use. Skills shortages are not a major constraint at any of the skill levels, although it is difficult to find skilled personnel with experience. The largest constraint to innovation is investment capital for new projects.

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A case of globalising capabilities in a multinational company from the German automotive industry

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1. Introduction

This case study aims at looking more closely into the various ways how a medium sized multinational from the German automotive industry, Auto1, has developed its capabilities to produce sophisticated products abroad and currently extends its capabilities to tap into hot spots of knowledge in emerging economies for innovative activities. Capabilities in the meaning of this case study mainly refer to the spatial distribution and local development of human resources within the company and their purposive development by strategic action. The case study attempts to match two views on recent changes in skills and knowledge within the global network of the multinationals' subsidiaries. One perspective is from the headquarters on long-term strategies, the company's self-understanding and recent learning in organization of innovative activities. The second perspective is from the global South, from the managers of a subsidiary, in this case from South Africa. Both of these perspectives are based on personal interviews with managers from the company at each location. As multinationals tap into a heterogeneity of locations abroad in allocating production and innovation to emerging economies, this matching applies more to production than to R&D. Nevertheless, the case study will also look at another location adding new capabilities to the company in innovation, i.e. Pune/India. While the South African location cannot be considered as a hot spot of knowledge as the term is currently used in the literature, Pune certainly has emerged as a hot spot both in automobile production and software technology, recently (Kuwajima, H. et al. 2010, MIDC 2010).

The paper proceeds as follows. Section 1 introduces Auto1 and its main technological capabilities. Section 2 discusses the various forms of being embedded in the home country society from which the company benefits both in productivity and innovativeness. Section 3 and 4 draw on a recent difference seen by scholars dealing with global knowledge networks in multinational companies and the opportunities of being embedded in hot and blind spots of knowledge in the global economy (e.g., Manning et al. 2010). In section 3, taking a blind spot as an example, we analyse skill and knowledge formation at a single company production site in South Africa. From the different plants the company has in South Africa we chose the largest plant which mainly produces parts for exportation to Europe and other continents. This site is different from most other sites abroad as the company generally assembles its products nearby their OEM clients in a follow-the-client strategy. Section 4 will look at a recent investment of the company at a hot spot, e.g. Pune in India, where increasingly R&D services to the home R&D centre and other locations are allocated. Section 5 will draw some conclusions upon the kind of global innovation network and the role of human capital therein, in search of explaining the global shifts in the company's organisation by push and pull factors.

2. The company

Auto1 is typical of many German automotive suppliers having emerged from a small scale crafts shop to a large, international producer within more than one century. The company entered the automotive sector during the 1930s in producing heatings and sound absorbers. As one of the Volkswagen suppliers from the beginnings the company grew up in the rhythm of the growth of the German automobile industry after 1945. The current main product line for the passenger car sector, the commercial vehicle sector and the aftermarkets was added at the beginnings of the 1970s. The

1980s laid the ground for the current position as a market leader in technology and a European company. A R&D centre at the headquarter's site was established and the company started an extensive internationalisation process in sales agencies and production plants abroad. During the 1990s, the company further extended its activities to Eastern Europe, South Africa and the US and became a world technology leader for special parts in diesel engine technology for passenger cars. In the first decade of the 21st century, a second technology centre was established in the US in 2002, and the company became fully global in opening sales offices, production plants and small R&D offices in India, China, Russia, Korea, and Japan. Additionally, the company extended its technological capabilities in system's integration and electrical products for busses by taking over some German companies by the end of the decade. Just recently, a joint venture with other large German automobile suppliers has been created for the development and production of similar products for non-road vehicles (construction and agricultural machinery, commercial vehicles). Furthermore, the company recently took over another small company for lightweigth design and customized volume production. As a result, the company steadily increased its capabilities in new technologies related to its core competences and increasingly added capabilities in automobile electronics and alternative energy products. Nowadays, the company claims to be "the only producer of a complete product portfolio on all alternative powertrain technologies in what concerns the heating", i.e. one of their core competences (Annual report 2009). The company sells to original equipment markets and aftermarkets in all these product lines. It is present in more than 20 countries across the world, mostly through customized production, sales and service subsidiaries.

This paper will look more closely to the largest production line of the company. Although the company has started with products for passenger cars – and still is a major producer of these today – development and production of similar products for heavy commercial vehicles is more challenging (and probably more profitable). Production for passenger cars is subject to standardisation, principles of mass production, and dependent from the model cycles of the OEMs. As a consequence, product lines have a lifetime of 4 to 5 years, according to the passenger car OEMs product cycles, during which only minor technological adjustments are required. Technical requirements to products for commercial vehicles are more challenging, due to the long running period and more severe running conditions of trucks and due to strict environmental regulations at the US and European markets.

The company grew up to a medium-sized international firm of about 5,600 employees, with an annual turnover of about 1.9 Billion € in 2010. Notwithstanding the fast globalisation process during the recent decades, the company still generates 76% of its gross income in Europe, 19% in America, and only 5% in Asia, Africa and Australia. The company continues to be family based, recently two family members of the 5th generation entered the board. This is what is called a typical "Mittelstand" firm in Germany being present at the world markets but strongly based in Germany (and Europe). As will be seen in the following, the company sticks to "local" resources and relationships in innovation activities and is rather reluctant in "globalizing" innovation.

From this brief description of the technological competences of the firm two conclusions can be drawn concerning human resources development. First, as products have become so complex and production aims at high quality, the requirements to the workers and the supervisors at the shop-floor matter seriously. This translates into a high esteem of the German system of vocational training and causes a problem in countries which do not offer a sophisticated system of technical education and training. Second, innovation created in the R&D centres and its implementation at the factories refers increasingly to the capacities of the engineers and their internal and external knowledge linkages.

3. A strong company's home embeddedness

The company is strongly embedded into its regional environment. This applies to skill formation and appointments at each level of qualified labour force. As the company considers its products rather complex and, consequently, asks for a qualified labour force at the shop floor, it profits from the German dual vocational education and training system which provides both a broadly qualified labour force at the shop floor and broadly qualified supervisors (the masters). The company takes care about getting apprentices of satisfying qualification and in sufficient number, for example in offering short term internships to schoolboys and schoolgirls or sponsoring teaching material at schools. So, in Germany, particularly at the headquarter's and the central production sites, the company tries to come into early contact with young people at school in order to raise children's interest in technical education. The company offers a fairly large number of apprenticeships which even increased during the crisis in 2008, promotes skilled persons to get the supervisor certificate ("Meisterbrief", master certificate) and to continue studying at the nearby "dual" university for an engineer's degree. This "dual" university is a new form of university for applied sciences in Germany, at which companies can send part-time student-employees and have an influence on the curricula in terms of requirements to their specific technological practices.

The strong home base in labour force qualifications may be one reason why the company still has the bulk of its production in Germany. Another is that technological capabilities lay, at first, in the production of the main parts of the components, and, second, in the assembly of these parts to components to be delivered just-in-time to an OEM's assembly plant. As a consequence, parts production may remain concentrated in Germany while components assembly may be internationalized or even "globalized". The global centre of production planning for the commercial vehicle markets – and the largest plant for these products – is located in another state in Southern Germany. Here, nearly one third of the 1,200 persons employed are (technical) office staff, many of them at the engineers and supervisors level (technician, foreman). Assembly plants for components are different as they generally are small plants, sometimes with less than 20 employees, where the manager is the only engineer pursuing all tasks of production planning and production supervision. During the recent crisis, the home base of the company was even strengthened. Using the new German labour market regulations, i.e. subsidized short labour regulation, the company rather saved its labour force (only -5.7%), mainly in reducing the number of temporary staff. It was the explicit aim and policy of the company, to "preserve the proven permanent staff as far as possible" (Annual Report 2009, 14).

R&D is even more concentrated geographically. Basic research and development is only pursued at the headquarter's R&D centre in Germany. Its personnel was about 3.8% of the total labour force of the company and the R&D expenditures about 5.9 % of the annual turnover (in 2009). The latter figure is a statistical artifact as the company faced a tremendous decrease in turnover from 2008 to 2009 (by 40%) but reduced the R&D budget only by 4% (R&D expenditure in 2008 3.7% of annual turnover).

This R&D rate makes clear that the company is not a high technology firm according to the innovation literature, as many other German automotive suppliers. It seems to be in contradiction to the fact, that the company is world market leader in some technologies. This can be explained by the particular competences of a system supplier who has the capacities to combine different technologies, among them high tech. For example, the company has formed four teams on different technologies – so-called "competence centres" – on fixing technologies, welding, automation, and canning and jig making. These teams form the organisational backbone of the company's technological knowledge. They collaborate within the R&D department and across to production planning locally and globally.

Furthermore, the company has maintained a strict control on R&D processes through allocating new product development mainly to the German R&D centre. It was only fifteen years after this has been established that the company erected another technical centre at the North American continent, nearby Detroit, which is said to be a nearby "independent" R&D centre. However, when it recently came to the development of a new system for an US heavy truck OEM, according to new requirements on environmental protection (EPA 10), which was rather new for the world, the American technical centre had to collaborate strongly with the German R&D centre. Furthermore, the company has established several R&D offices in main markets across the world, such as in Europe (UK, France, Italy, Russia), Asia (South Korea, China) and, recently, in Brazil. As a consequence, the company has a strong multinational but not a global strategy for R&D organisation.

Very recently, the company opened another, yet small R&D centre at Pune/India which is one of the main automotive production regions in India, and simultaneously established particular relationships to a local engineering services provider for outsourcing some design activities.

In innovation management, the company recently launched a new tool which applies for all innovative procedures at the main R&D centre. A phasing of innovation procedures from a first step to getting impulses from everywhere possible to ongoing evaluation and selection, modelling and, finally, transferring the innovative idea to the customer advisory services department for acquisition (and final steps of customized production) has been introduced, mainly based on own reflections and discussions. Once again, it could be claimed that the company behaves like German Mittelstand does, i.e. preferring in-house development. For sure, the first step of this innovation management procedure takes full advantage of broad information on technological issues available in Germany, such as information from clients, conferences, journals, and more or less nearby universities. The company hosts a number of diploma and PhD students from (mostly technical) universities for writing their theses on a technical problem area the company is interested in. Linkages to universities are specific to the product of the main plants which means that they mostly are "local" according to the location of the plant. At each location in Germany, the company can link up with nearby technical universities. Obviously, the learning capacity of the company in terms of innovation is largely based on the main R&D site in Germany and its regional external relations. It seems that there is a clear centre-periphery gradient between basic innovation at home and customized applications to "local" markets – which mostly means OEMs at their market – abroad.

As a result, the company can be described as a strongly home-based player at world markets. R&D is strongly concentrated at the headquarters which is clearly shown by employment figures in R&D. The German R&D centre has more than 300 employees and the US-based R&D centre 60 employees while 8 further R&D offices across the world sum up to 33 employees in R&D. The governance of global production is similarly concentrated as global production planning is allocated to the German primary plants according to the product lines.

4. Improving the capabilities at a blind spot of parts production in South Africa

South Africa was one of the first investment locations when the company started to go beyond Europe and the first in an emerging economy. It seems that the company followed their German clients in the premium segment who have produced in South Africa for a rather long time (see Barnes/Kaplinsky 2000). But additionally to small component assembly plants near the OEMs – what could have been expected – the company invested into a large parts production plant at a different location where availability of a pool of skills at low costs matched with proximity to some OEM assemblers.

This South African subsidiary was the first in this product line in South Africa. With about 1,000 persons, it is also the largest in the country, for the simple reason that most other South African plants do components assembly. The company's South African component assembly plants employ less than 50 persons each.

The sector in South Africa has grown rapidly in scale for two key reasons. The first of these – but a minor one – is proximity to platinum resources and availability of several suppliers from the chemical industry. Of far more significance is the Motor Investment Development Plan (MIDP) which was launched by the South African government in the mid-1990s (Barnes/Kaplinsky 2000, 799). Under the terms of this programme, OEMs in South Africa and probably some major components assemblers earned an import rebate (e.g. on other components) if they considerably sourced locally. The MIDP was extended until 2012. It has now been replaced by the Automotive Production and Development Programme (APDP), which offers similar levels of benefits to firms, but with a greater emphasis on investment and production volume than on import/export complementation. The company's products are rather expensive components of the car which must be assembled locally but need importation of very different parts. Hence, investment in some parts production both for the domestic market and exportation was and still is rather profitable. As parts production is subject to scale economies, production for the domestic market is very small. 98% of their output is exported, either to Europe or to Asian countries such as China, India, Korea or Japan. Domestically, the subsidiary supplies indirectly, through the assembly plants, to the local German premium OEMs such as Daimler or BMW.

As a consequence, the plant is under particular pressure from the company. As direct delivery times to OEMs in export markets would be too long the plant focuses on standard products with a certain value added. It benefits from rather low labour costs but has to achieve high quality objectives as the distance to customers does not allow for a retouch. Aspects of process and quality control figure high in running the plant. It seems that the management is quite successful herein, as it claims that reject rates are the lowest in the company; in some cases also scrap rates are lower. The subsidiary benefits more from productivity improvements than low wages. Hence, locally designed improvements are mostly in processes, not products.

Under these circumstances, skills and skill upgrading are crucial for the long-run survival of the subsidiary. It is, however, the responsibility of local managers to appoint and to train the local labour force. As a consequence, the management in the South African plant mentioned above appoints operators at the shopfloor only if they have a matric certificate, i.e. if they have passed twelve years at school. Even this qualification is considered rather low and new operators only become productive after in-house training. The organisation of this training is a local task.

Operators have to pass a generic induction process on basic work principles (such as "Six Sigma") and the particular technology of the product and get further training on the job.

Skills availability at higher levels in the South African plant is problematic. At the supervisory level, the South African subsidiary seems to face some shortages, in particular concerning qualified electricians. Headhunting is a problem, as there are several firms competing for a small pool of skills. The subsidiary draws on internships of students from the nearby Nelson Mandela Metropolitan University (NMMU) for appointments. At the engineer's level, search for qualified engineers is difficult, too, particularly in process and industrial engineering. Engineers are only appointed if they have already work experiences.

When a new product is launched a task force from the German headquarter offers short-time training at the plant. In fact, the company has established "global support teams" whose members travel around the world for training into new product lines and for removing serious mechanical faults. The latter is due to the fact that qualification requirements have been shifted from the worker to sophisticated equipment (automated machinery) in order to enable low skilled workers to handle the machinery.

It comes with no surprise that the South African subsidiary only plays a limited role in the company's global innovation network. There is, in general, very little product innovation and limited process innovation. The South African subsidiary has contributed to process improvements in two of the four areas of technical competence which have been defined as core competences by the headquarters. This was done in co-operation with local suppliers. However, innovation pushes generally come from the headquarter, both in product and process innovation. The company has established global support teams for technological improvements with local engineers forming part of the teams. These engineers generally get further training by short term travels to the headquarters.

5. How to integrate a hot spot into the company's R&D system? The case of Pune, India

Rather recently, the company started production at Pune, India, and then established a small R&D centre of less than 10 engineers nearby. It is nevertheless larger than those R&D offices in, e.g., Japan, Korea, Russia or Brazil which mainly function as observing post and sales office in these markets. Engineers in the Pune R&D centre need to have competences in different technological areas related to the products as they are responsible for adapting products to local market conditions.

At the same time, however, the company established another kind of relationship to Pune in design activities. The company invested into close relationships to an Indian engineering service provider in order to outsource and offshore some low valued engineering tasks in design. These are usually standardized work tasks for engineers forming part of a broader design process based on (non-standardizable) engineer's experience. Standardization here means a well defined problem and clear-cut definition of work loads. Examples for low valued engineering tasks are calculations, re-drawings and simple design. The company tries to extend this outsourcing/offshoring for reducing R&D costs and in case of bottlenecks at the German R&D centre. At first sight, it seems easy to relocate these tasks abroad, as part of an internal division of labour in R&D. However, communication among engineers in this field of technology across borders, cultures and languages needs careful organisation. The company chose the way of selecting and training boundary spanners from the host country. Engineers from India were appointed and stayed for a year or more at the headquarters in Germany for collaborating on different projects in the R&D department. So, they experienced "learning by doing", considered necessary by the company. As one manager pointed out: "we are going to India via an Indian. Direct communication of a German with counterparts in India is less effective compared to an Indian in Germany who tells his Indian counterpart what is required. Only this works". As the company still needs only a few boundary spanners to India, these engineers simply form part of a project team at the headquarters. There is no general programme to train boundary spanning as some other German automotive suppliers start to implement. The company, however, increasingly trusted in the capacities of the Indian service provider to send qualified engineers to Germany.

Hence, the company has appointed a number of engineers from those foreign countries which are seen as strategic market areas (for the future). These engineers either continuously stay at the headquarter in order to maintain the day-to-day contact to foreign subsidiaries or pass various departments at the headquarter for a year or two before they are returning into their home country where they act as "receiver" (of the company's orders) und "transmitter" (to their own staff abroad). The procedure applies to India, Russia, and China, i.e. very large future markets in automobile production. In order for learning processes through direct interaction to be effective, also the engineers at headquarter had to be prepared, e.g. in language and intercultural skills.

While the instrument of selecting and training boundary spanners may be – and increasingly is – implemented for all R&D offices in emerging economies, outsourcing to India may have a special and more far-reaching implication. We might be observing the beginning of a new international division of labour in product development, new to the company and probably rather new to the market. We see no reason why the capabilities of the company's own R&D centre in India could not be matched with those of the engineering service provider for relocating more sophisticated R&D tasks in the long run, all the more as they are geographically close to each other.

6. Conclusions: in what sense global innovation networks of the company?

It has become clear from the previous that Auto1 is a global market leader in different automotive systems which is present at all continents (except Australia). Although not a high tech firm, it continuously develops new products which have a long life cycle. Innovation impulses for new products mainly come from the market, i.e. OEMs and their R&D centres. Thus, proximity to the OEMs headquarters and central R&D labs matters most. Most of this is based in Europe. If innovation impulses come from abroad, it is through the demand of powerful customers (such as in the US). The company widens its technological experience into new fields, particularly by recent takeovers and by a joint venture with large system suppliers in Germany.

Hence, the company is a strong case of a home-based player who carefully controls innovative activities from its headquarters. Investment in production facilities abroad is mainly driven by the pull of demand from the market, i.e. large OEMs most of which are clients in the home country Germany since long. Another yet weaker and more exceptional pull seems to come from state incentives as with the example of the South African MIDP giving rise to the particular case of relocation of parts production to a non-European location. R&D is even more concentrated in Germany as most of the R&D subsidiaries across the world are simple observing and marketing posts.

Interestingly, the company has started to outsource and offshore some standardized activities in engineering to Pune in India. By this, the company follows the example of some other very large German automotive suppliers who already have relocated engineering to own subsidiaries in Pune. The current outsourcing of simple engineering tasks to an Indian engineering service provider meets two targets, i.e. capacity enlargement of R&D when bottlenecks appear at home, and cost reduction of standardized engineering work. To reduce the difficulties and costs of cross-border communication the company benefits from a policy to invest in inpatriates, i.e. engineers from the host country, as boundary spanners. However, the company still is in a learning phase how to govern innovative activities across the organisational, geographical and cultural borders and might be very cautious in allocating more sophisticated tasks to engineers in emerging economies. Hence, there is innovation and there are innovation networks in the company but they are not global.

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GINed for innovation, technological up-gradation and capability building. The case of a truly global, innovative and networked firm

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1. Introduction: the analytical context[1]

Global Innovation Networks (GINs) are global networks in which some knowledge-intensive activities are based in developing countries. They differ qualitatively from the better known global production networks (GPNs) where Northern MNEs traditionally control the key technological assets, while outsourcing the supply of parts and components or assembly to contract manufacturers.

GINs have attracted scholarly attention given their importance to understand the innovation process and therefore for their implication for innovation policy, both in northern and southern countries. Literature has specifically focused on the identifying the inducement mechanisms driving the formation of GINs and on assessing the impacts of GINs on the host countries.

Concerning the inducement mechanisms, research has identified a set of "centripetal forces" (which induce the firms to centralize the R&D activities in the headquarters) and "centrifugal forces" (that work towards the dispersion of R&D activities across different locations beyond the home country). The "centripetal forces" include: 1) the need to protect firm- specific technology as relocation of R&D that could lead to unwanted R&D leakage (Rugman, 1981). Steele (1975) argued that, firm specific technical advantages tend to evolve from and mirror home market conditions and that the need to retain and strengthen such advantages necessitates continued close contact with the domestic market. 2) the significance of scale economies in R&D and the difficulties in achieving minimum scale in case of decentralized laboratories[2]. 3) Some of the pioneering studies also found the high cost of co-ordination and control (Vernon, 1974) as a centripetal force. The "centrifugal forces" include: 1) demand-oriented factors, that emanate from the need to be nearer to the export market. Often, the transfer of manufacturing technologies from the parent firm calls for substantial adaptation to suit the local market conditions. In such a context, firms resort to the setting up of local R&D units oriented towards adaptive R&D. This happens particularly in countries with a large domestic markets or where required/induced by specific government regulations. 2) supply-side factors, and specifically the access to scientific and technological skills and infrastructures that are available in the host countries at more advantageous terms than in the home market.

The unprecedented increase in the pace at which GINs are being formed (UNCTAD 1995; Ernst 2011) suggests that certain factors are changing the balance of centripetal and centrifugal forces in favour of centrifugal forces (Albuquerque *et al* 2011), thereby compelling firms to locate their R&D activities outside their home countries. The improvement in the information communication infrastructure (lessening coordination and administration costs); the heightened risk and complexity in developing technology along with shorter product life cycle; and the policies that liberalized trade and investments may all have played a role. Key importance has been attributed to the growing availability (at a lower cost) of human capital and skilled manpower in southern countries such as China and India, particularly in a context signed by the escalation in R&D costs at home and intense competition in domestic and global markets (Stembridge, 2007).

[1] This paper is based on the inputs provided by the INGINEUS research team in Sweden and China
[2] Empirical evidence on the adverse effect of scale economies on internationalization however, remained inconclusive (Granstrand et.al. 1997).

The relocation of R&D activities by the MNEs in a globalised world is seen as a strategy to exploit regions' differential advantage in production and in R&D (Cantwell 1995). As a consequence the process of GIN formation is often considered as a mutually beneficial game wherein both participating parties tend to benefit. Developing countries increasingly welcome, and in a sense compete among each other to participate in, GINs given its potential for building and sustain their innovation capabilities.

This paper analyses the relationship between the innovation and business strategy of a northern ICT multinational enterprise (MNE), and human capital in the host northern and southern countries. It studies the implications of this relationship for the constitution of global innovation networks (GINs) and for their impacts on the host countries. A key issue concerns the difference between competence and capability. While competence (akin to invention) indicates the potential, capability (akin to innovation), indicates the actual scenario (Cozzens and Kaplinski 2010). Unravelling the innovation strategy of the firm against the backdrop of the availability of competences, the paper intends to analyse how and to what extent the presence of the MNE may contribute to turn available competence into innovation capability in the host countries.

The reminder of the paper is organized as follows. Section 2 provides an overview of the competencies as manifested the supply of skilled manpower in a northern (Sweden) and two southern (India and China) host countries wherein the company operates. Section 3 presents innovation strategy of the firm and locates the nexus between globalisation of innovation, competence and capability building in the host countries. Section 4 draws the conclusions.

2. Competencies for innovation in the host countries

In the discussion that follows, we deal with the availability of skilled manpower as an indicator of competence (while transforming it into actual capability will depend on a host of factors).

2.1 (Higher) education in Sweden

Sweden higher education system includes three types of Higher Education Institutes (HEIs). Universities (Table 1) and University Colleges are the most important. The University Colleges provide degrees at graduate (University diplomas and Bachelor degrees) and post-graduate level (Master and Doctorate). Contrary to Universities, most of the Colleges specialize in just one academic discipline (Chaminade 2011).

Table 1: Number of students enrolled in the 10 largest Swedish Universities (2008).

University	Number of Students FTE
Lund University	24600
Gothenburg University	24100
Stockholm University	22400
Uppsala University	19900

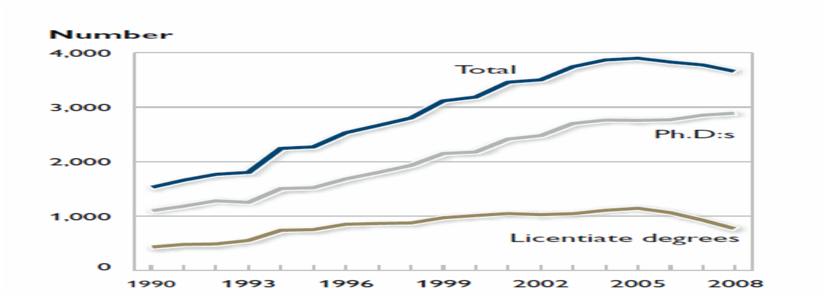
Linköping Univ.	16900
Umeå	15600
Linnaeus Univ.	15000
Royal Institute of Technology (KTH)	11700
Chalmers	8471

Source: Swedish Higher Education Authority (2009)

The R&D system is completed by a number of R&D institutes. While relatively small when compared to those in other OECD countries (the bulk of public R&D is routed through the University system), they play critical role in different industries[3]. ì

The tertiary education in Sweden at present could be divided into three phases: Bachelor, Master and PhD. Available data indicate that the total number of degrees awarded has increased steadily until early 2000s. It has then levelled off and decreased after 2005 (particularly because of the number of degrees to the first and second phases. The number of doctorates has slightly increased - see Fig 1).

Fig:1: *Number of degrees awarded in tertiary education*

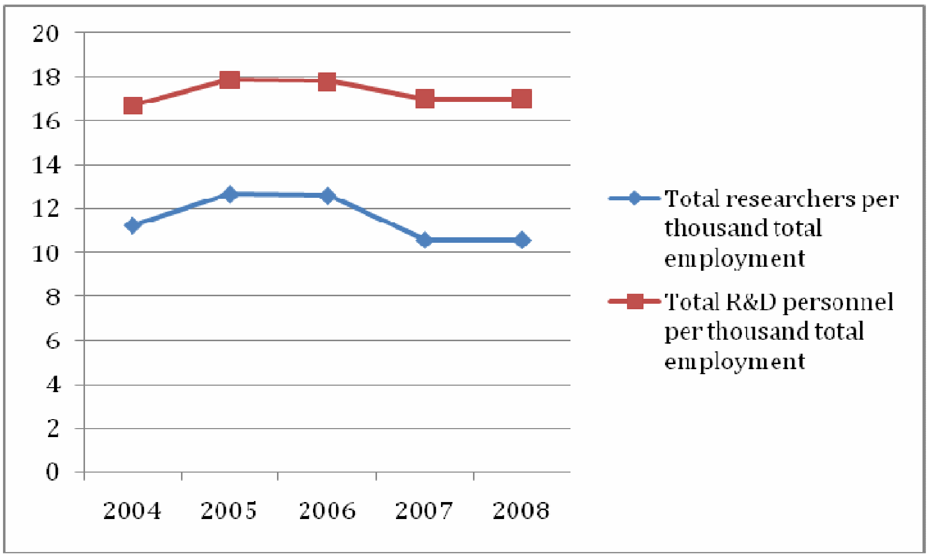


Source: SNAHE (2010) quoted in Chaminade 2011

The decline in the number of students enrolled in tertiary education in Sweden, if structural and long-term, may have an impact on the availability of researchers and R&D personal in the Swedish innovation system (Fig. 2) and therefore on the innovation capability of the country.

[3] Some of the most important ones are the Swedish Defense Research Agency (FOI) (aprox. 1250 employees), the industrial research institutes (jointly owned by the government and industrial associations, employing aprox. 2100 employees) and other government research institutes and agencies like the Swedish Institute for Infectious Disease Control or the National Institute for Working Life, employing aprox. 430 researchers full time (VINNOVA, 2006).

Fig 2: Total Researchers and R&D personnel per thousand total employment 2004/2008).



2.2. (Higher) education in China

Since the formation of People's Republic of China (PRC) in 1949, the structure of China's education system underwent major changes with the objective of ensuring equal opportunities for all. As a result, there has been significant increase in the enrolment in education. To be more specific, in 1949 the net enrollment ratio of school aged children was only about 20% (and about 80% of the Chinese population remained illiterate) and by 2007 it increased 99.5%. Equally remarkable has been China's achievements[4] in the sphere of higher education.

China's tertiary education is currently articulated in three types of HEIs: universities (multidisciplinary HEIs performing education programs and research in multiple domains of knowledge), academies (focused on particular areas, such as natural sciences, social sciences, agriculture etc), and "institutes" (providing education services in certain narrow areas, such as Chinese traditional medicine, music etc). Some key universities and institutes are directly under the Ministry of Education or other state ministries, while the others are usually under local government.

As per the latest available data, China has 1867 HEIs, of which 85 per cent (1591) are state-owned and the remaining private (Indicators of Education in China, 2007). Out of the total HEIs, 40% are in natural sciences & technology, and only 20% in social sciences (art, political science and law, finance & economics, language & literature), indicating the high priority being attached to science & technology education. Most of students (25.29 million, equivalent to 93.6% of total students) are

[4] In May 1998, China's former president, Jiang Zemin, put forward the famous "985 Program" at the 100th anniversary celebration of Peking University, which means China will develop a number of world-class universities in order to achieve modernization. By now, there are 34 universities including Tsinghua University and Peking University on the "985 Program" list.

enrolled in government-owned institutes. The Gross Enrolment Ratio (GER) in higher education is at 23%, among the highest in the developing world

Research institutes are an important source of skilled manpower at post-graduate level. The Graduate University of Chinese Academy of Sciences (GUCAS) is known as the biggest post-graduate education institutions in the world. By now, GUCAS has more than 30 thousand enrolled post-graduate students (accounting for for more than 3% of all the post-graduate students in China. In particular, GUCAS PhD students account for more than 8% of all PhD students in China).

Secondary vocational education[5] is an important source of skilled manpower for blue collar jobs. During the rapid manufacturing-led economic growth of 1980s and 1990s, the enrolment rate for secondary vocational education was higher than for senior general education and higher education. More recently, however, enrolment for secondary vocational education has been declining, mainly because of growing demand for highly skilled manpower induced *inter alia* by the globalization of R&D activities by MNEs and industrial and technological upgrading within the country. Overall, there has been a shift from secondary vocation education towards higher education.[6]

Overall, the performance of China in the sphere of higher education is impressive.

2.3 (Higher) education in India

Indian experience is comparable to that of China in many respects but not as impressive in terms of the ultimate outcome. From the colonial rulers India inherited a stagnant economy, poorly endowed with human capital, and with illiteracy rate at 85%. Given the high rate of illiteracy at the time of independence and the imperative of skilled manpower to achieve the desired economic transformation (Government of India 1958), the planners adopted a strategy where both primary education and higher education were promoted with an equal vigour.

The Science Policy Resolution (GoI 1958), which laid the foundation of India's national system of innovation, noted that India's enormous resource - manpower- would become an asset in the modern world only when trained and educated. This stand led to substantial investment in education, to address both the issue of widespread illiteracy (primary and secondary level) and the growing demand for highly skilled manpower for a growing economy (higher education level).

These initiatives resulted in a remarkable increase in the Gross Enrolment Ratio (GER)[7] at the elementary level over time from about 32 per cent in 1950-51 to nearly 95 per cent in 2005-06. However as per the latest statistics available (2005-06) the GER at secondary and senior secondary level is at a much lower level of 52.2 per cent and 48.5 per cent respectively (GOI Ministry of Human Resource Development 2008).

The higher education system is basically a three tier one with each level producing different levels of output. The first tier includes the premier institutions in the country whose main objective is to

[5] This consists of Regular Specialized Secondary Schools, Adult Schools, Vocational High Schools and Skilled Workers Schools

[6] Apart from the Government institutions there is a growing number of private schools in China. In 2007, there are 95200 private schools in China ranging from preschool education to higher education as well as vocational school.

[7] GER is the total enrolment of pupil in grade or cycle or level of education, regardless of age, expressed as percentage of the corresponding eligible official age-group population in a given school year.

produce world-class manpower and undertake research. These institutions are established by the Parliament/state legislatures as "Institutions of National Importance" and funded by the Ministry of Human Resource Development under the Central Government. Important institutions in this list are the Indian Institutes of Technology. The second level of institutions come under the university education systems that consists of over 350 universities. Universities can either be established by an Act of Parliament or by the state legislatures[8]. The university system in India operates through teaching and research departments within as well as through affiliated colleges. These affiliated colleges are of three type viz., government run, government aided and private self-financed. The third level includes the so-called "deemed to be universities" (institutions that are conferred the status of a university because of their long tradition of teaching, or specialisation and excellence in a particular area of knowledge). Universities, Institutes of National Importance and deemed to be Universities are all degree-granting institutions.

The growth of higher education in India has been phenomenal. In 1950-51 India had only 27 universities, 370 colleges for general education and 208 colleges for professional education (eg engineering, medicine). By 2005-06, the number of colleges for general education increased to over 11 thousand, professional colleges to 5284 and that of universities/ deemed universities and institutes of national importance to 350. It may be noted that the number of professional colleges has recently been growing much faster than of the other HEIs. Specifically, the number of professional colleges increased by a just over four times over 1950-1990, and by almost six times during the 15 years (1990-2005). On the contrary, the number of colleges for general education increased more than 13 fold over the 1950-90 and only 2.5 times during the last 15 years. Thus it appears that there has been a marked shift since 1991 from general education to professional courses like engineering (mostly at the instance of the private sector). This could be attributed mainly to the growing demand for such manpower from the industrial and service sectors (like IT and software, both from the local and foreign firms).

Overall, the level of enrolment in Universities increased from 0.15 million in 1947 to 11.7 million in 2005 (of which 13 percent were in University Departments and the rest in affiliated colleges MHRD 2007). While this performance appears impressive in absolute terms, is far from what achieved by China (at least in quantitative terms). Section 2.4 before provide a comparative perspective on the two countries.

2.4 Competencies for innovation in China and India - a comparative perspective

Table 2 and Table 3 show the Barro-Lee indexes on educational attainment for, respectively, India and China over 2005-2010.

In India (Table 2) the proportion of population without no schooling above the age of 25 marginally declined from 46.8% in 2005 to 42.2% in 2010. Over the same period the percentage of population over 25 that completed tertiary education increased marginally from 3.4% in 2005 to 3.8% in 2010.

[8] Those established by the Act of Parliament are called the Central universities and the ones set up by the state legislatures are called state universities. Some higher education institutions are granted the 'deemed to be university' status by the central government through gazette notifications.

Similarly, the increase in the average years of schooling was also minimal (from 3.9 to 4.4). Overall, at least according to the Barro-Lee measures, India is still far from being a country with a large proportion of highly skilled manpower.

Table 2: India: Barro Lee Index on educational attainment for total population 2005 – 2010

Year	Age Group		No schooling	Highest level attained: Primary Tot	Primary Comp	Secondary Total	Secondary Comp	Tertiary Total	Tertiary Comp	Average Years of schooling	Population (1000s)
				(% of population aged 15 and over)							
2005	15	19	2.6	32.5	32.5	63.9	0.4	1.0	0.1	6.902	110072
2005	20	24	23.5	20.9	20.9	47.6	1.2	8.0	3.0	6.083	101182
2005	25	29	28.6	20.6	20.6	44.1	1.1	6.7	3.9	5.611	87787
2005	30	34	40.6	16.4	16.4	37.3	0.9	5.7	3.4	4.635	82999
2005	35	39	42.2	18.3	18.3	33.9	0.8	5.6	3.7	4.453	74572
2005	40	44	47.9	19.6	19.4	26.3	0.7	6.2	4.1	3.982	65646
2005	25	+	46.8	18.8	15.4	29.1	0.8	5.3	3.4	3.975	538366
2005	15	+	37.2	21.1	18.4	36.7	0.9	5.1	2.7	4.683	749620
2010	15	19	5.2	22.8	22.8	70.3	0.5	1.6	0.2	7.021	115383
2010	20	24	9.0	28.6	28.6	52.8	1.3	9.5	3.5	7.114	109275
2010	25	29	23.5	20.9	20.9	47.6	1.2	8.0	4.7	6.116	100009
2010	30	34	28.6	20.6	20.6	44.1	1.1	6.7	3.9	5.613	86338
2010	35	39	40.6	16.4	16.4	37.3	0.9	5.7	3.8	4.643	81433
2010	40	44	42.2	18.3	18.3	33.9	0.8	5.6	3.7	4.453	73015
2010	25	+	42.2	19.1	16.6	32.8	0.9	5.9	3.8	4.400	604417
2010	15	+	32.7	20.9	18.9	40.7	0.9	5.8	3.1	5.119	829075

In China, the picture emerging is much more impressive. In 2010, the percentage of population without schooling in China (Table 3) is much lower than in India (Table 2) across all age groups; the number of years schooling is higher (particularly for young cohorts); and the proportion of people in the age group 15-25 that completed tertiary education is 11.8% (Table 3) and only 3.7% in India (Table 2).

Overall, there seem to be a significant difference between India and China in terms of higher education outcomes. In this context, India seems to show a significant relative skill deficit (especially when considered in the context of the two digit growth rate that it is aspiring for). This implies that the commonly made statement that "India and China are countries with abundant supply of skilled manpower" has to be viewed with sufficient caution. According to current literature, the observed high "relative skill scarcity" in India is bound to have its impact on the firms (both MNEs and Local) operating in India. The case-study intends to shed some light on this issue.

Table 3: China: Barro Lee index on educational attainment for total population 2005 – 2010

Year	Age Group		No schooling	Highest level attained (% of population aged 15 and over)						Average Years of schooling	Population (1000s)
				Primary		Secondary		Tertiary			
				Tot	Comp	Tot	Comp	Tot	Comp		
2005	15	19	0.0	11.1	8.6	79.9	73.7	9.0	1.3	9.872	117234
2005	20	24	0.1	9.3	5.9	75.5	75.5	15.2	5.6	10.311	100115
2005	25	29	1.7	17.2	10.9	72.5	72.5	8.6	5.0	9.485	97360
2005	30	34	2.3	24.0	15.1	67.0	67.0	6.7	4.0	8.754	119970
2005	35	39	2.8	29.1	18.2	62.5	62.5	5.5	3.7	8.410	125373
2005	40	44	3.3	25.2	15.7	66.1	52.2	5.4	3.6	8.279	103573
2010	15	19	0.1	0.0	0.0	85.8	79.1	14.1	2.0	11.111	101995
2010	20	24	0.1	6.6	4.2	67.2	67.2	26.0	9.6	10.780	116599
2010	25	29	0.1	9.3	5.9	75.5	75.5	15.2	8.8	10.374	99322
2010	30	34	1.7	17.2	10.9	72.5	72.5	8.6	5.1	9.487	96523

2010	35	39	2.3	24.0	15.1	67.0	67.0	6.7	4.5	8.764	118961
2010	40	44	2.8	29.1	18.2	62.5	62.5	5.5	3.7	8.410	124163

3. The case study

This section draws from the interviews conducted with the MNE's senior officials in host northern (Sweden) and southern countries (India and China). We shall begin by introducing the firm and proceed to explore its innovation strategies, the implications for the constitution of a GIN and its bearing on the innovation competence and capability in the host countries.

3.1 A brief profile

ICT1 was founded in 1984 by a small group of computer scientists from Stanford University. It produced the first router in 1986, making different types of network that connect with each other reliably and thus contributing significantly to communications revolution. Over the years, ICT1 emerged as the worldwide leader in Internet Protocol-based (IP) networking solutions which has become an essential part of business, education, government and home communications. The product and process innovations by ICT1 enable its customers to harness ICT for increasing their productivity and efficiency. At present ICT1 is present in 165 countries with 550 offices and around 30 manufacturing sites across 165 countries.

Table 4 shows how ICT1 has been recording an impressive growth in sales (except in 2009, due to global economic crisis), consistently increasing the number of employees (to 72,600 in 2010). Also, ICT1 has the biggest Internet e-commerce site in the world. Over 90 percent transactions of its global business are completed on the Internet. As a global leader in fixed-line communication equipment, since its listing in 1990, the annual revenue of ICT1 has risen from $ 69 million to $ 40 billion in the fiscal year of 2010. In 2009, it ranked 57 in Fortune 500, and was chosen as the most respectable company in the world for the eighth time in Fortune. ICT1 has also got the honour of being the 17th in "2008 Global Top Brands".

Table 4: Sales and employment growth in ICT1 since 2005

Year	Sales (US $ Billion)	Sales growth (%)	Employment added
2004	22.0		
2005	24.8		
2006	28.5	15	11500
2007	34.9	23	11600
2008	39.5	13	4500

2009	36.1	-9.0	6600
2010	40	11	
Total employment in 2010			72,600

Source: Annual reports of ICT1

3.2 Innovation and capability building strategy within the firm

3.2.1 High R&D intensity

As a company operating in a high-tech industry with relatively short product cycle and fierce competition, ICT1 has been providing top priority for innovation. Since the company's inception, ICT1 engineers have been leaders in the development of Internet Protocol (IP)-based networking technologies. This tradition of innovation continues with industry-leading products in the core areas of routing and switching, as well as advanced technologies in areas such as Home Networking, IP Telephony, Optical, Network Security, Storage Networking and Wireless LAN. Indeed, R&D expenditure as a proportion of sales has been maintained consistently at two digit level, even in the year of economic crisis (see Table 5).

Table 5: R&D intensity in ICT1

Year	R&D Expenditure $ billion	R&D intensity (%)
2005	3.3	13.31
2006	4	14.04
2007	4.5	12.89
2008	5.2	13.16
2009	5.2	14.40
2010		

3.2.2 Innovation is not R&D alone

Innovation goes however much beyond investment in R&D only. Innovation is not conceived as technological innovation alone but also as business innovation Quoting from the interview in Sweden "The innovation is therefore driven by the transitions that are impacting our customers. Technology is just an enabler". This is also evident from statements in various annual reports and the initiatives undertaken.

> "In our opinion, the key to long-term success in the high-technology industry is ongoing strategic investment and innovation, and we intend to continue to take good business risks. Our innovation strategy requires a unique combination of internal

development, partnerships, and acquisitions. In our opinion, for companies to lead in the technology industry they must be able to do all three” (annual Report 2005)

3.3 Leader in network systems with a networked approach to innovation

ICT1 conceives innovation essentially as an interactive process. It is a typical case of open innovation within a global network. As clearly stated in the chairman address to the share holders (Annual Report 2010) “We have learnt much about the power of collaboration within our own company, and we are working to share this knowledge with our customers every day”.

3.3.1 Strong internal network

The importance of internal network to this strategy is best summed up from the following statement from interview: “Everyone of our 65.000 employees can interact with R&D….also the guys at technical operations support sales. Sales forces are important because they come back with the request of our customers. The most stupid thing is to create an R&D with its own world when you have 65000 employees that know what is happening. In our innovation process we included also the users directly influencing R&D. So forget about the R&D as a separate thing”. Further, “…each of the employees at ICT1 can contribute directly to our innovation on our website and gain a prize, or becoming manager directors etc. The success of this is that it was not a single guy coming with the idea but people working together. To collaborate they can also use tele-presence then we have a filtered process with boards”.

R&D labs are themselves a global network. While, the main R&D labs are located in Silicon Valley and in Bangalore, smaller labs have been established in other locations as well (including China and Europe). Overall, there are around 30 R&D establishments across the world.

Concerning southern countries, interviews reveal three main motivations for R&D off-shoring.

The first is to access to large and growing market, having direct knowledge of customer needs and showing high degree of commitment. “For a market like the size of China, you need to build products and have a manufacturing process aligned to the launching of these products into market, which allows you to be cost-competitive. You have to show all the time that you have a long-term commitment, and if you don't have a manufacturing and R&D presence and you're not actually coordinating those investments with what you're doing from the standpoint of sales and marketing, you will lose relevance”. A specific issue is to reduce R&D cost to compete against local low-cost competitors. This is important in China where ICT1 has at least 10 competitors and companies such as Huawei, ZTE, Juniper are challenging ICT1's position in some markets. By establishing a R&D center in China, ICT1 can reduce R&D cost by accessing local qualified R&D personnel; on the hand, it can develop new products according to the local market demands.

The second is to enable the firm to respond in real-time to transformations affecting nowadays societies. Southern countries is where change is currently happening. Education and health systems are changing, urbanisation is taking place (around 700 millions people will be organized in the coming 10 years in 20 important cities, in particular in China and India), new technologies are taken up (China is the fastest growing country with the adoption of network technologies for voice calls). This generates new demands and needs to which the company need to adapt. Research in these markets is necessary to enable real-time response to these changes, which can then be applied to northern markets as well. For instance, to respond to the urbanisation challenge, ICT1 opened a community innovation platform foundation in New Delhi and participated to build an almost complete new city in South Korea.

> So if you are asking where the developing part takes place or from where the smart ideas come from, for this specific transition related to smart cities, this is happening there and not here. This will drive the technologies, boxes and equipments that we have to deliver.

Similarly, the R&D centre in Shanghai will be geared to networking technologies for voice calls.

The third motivation is to access the large pool of local skilled people and talent.

> If you want the top talent in your company you need to provide them with flexible working spaces. Without the right talents you cannot be innovative. The reason why ICT1 opened a second HQ in Bangalore in India was not just to have sales office for 1 billion people leaving there, but to get access to the talent that you need.

In China, there is a large ICT1 R&D centre in Shanghai, where 66 higher educational institutions and 122 vocational schools are located (around 126,900 and 56,000 graduates per year, respectively). Conversely, the establishment of R&D centres in Europe seems to take place primarily through the acquisition of local firms with R&D centres that are then maintained. The acquisition of specialised knowledge held locally seems therefore the primary motivation (see also Section 3.3.2) driving offshoring. Presence in the market and fiscal reasons has also been mentioned.

3.3.2 Strong external networks

Consistently with its views on innovation, external networks are of essential to ICT1's strategy. A strategy of partnerships, strategic alliances and acquisitions is being actively pursued to this end.

3.3.3 Developing Partnerships

Partnership with public authorities are developed in particular in emerging markets like China, India, Mexico where the main societal transitions are going on, for example, for education or healthy issues.

> For fiscal 2006, we reorganized our sales theaters and added the Emerging Markets theater in order to take advantage of the growth potential of these countries. We met with government leaders around the world in countries such as India, China, Germany, Saudi Arabia, and Russia. Our conversations centered around how ICT1 could help their countries develop a stronger economy through Internet access to education, healthcare, and business opportunities. As these countries begin to deploy Internet solutions, they look to ICT1 as a partner and resource vital to their success. As a result, product revenue in ICT1's Emerging Markets theater grew 38 percent on a year-over-year basis—the highest growth percentage of all five theaters. Growth in Emerging Markets is the truest example of the power of the network now (Annual Report 2006).

A specific example is the initiative on smart cities (see Box 1), where ICT1 is providing the communication infrastructure for those cities. The smart cities are developed also in cooperation with other companies for example, a huge developer company.

Box 1:
Karnataka Government signs MoU with ICT1 to evolve an intelligent, sustainable city

On February 12, 2009 ICT1 announced a pilot program to assist the government of Karnataka in developing a road map for an intelligent and sustainable Bengaluru city.

As part of the Memorandum of Understanding (MoU), ICT1 will work with the Karnataka government to share relevant experiences and best practices from its work in other parts of the world, for developing a world-class urban infrastructure for the citizens of Karnataka.

This project is part of ICT1's global 'Intelligent Urbanisation' initiative announced today from ICT1's Globalisation Centre East, designed to help cities around the world use the network as the fourth utility for integrated city management, a better quality of life for citizens, and economic development. Bringing together a broad portfolio of products, services, partners and solutions across ICT1, the initiative is initially focused on intelligent, sustainable solutions for public safety and security, transportation, buildings, energy, health care and education.

This partnership builds on ICT1's technology expertise around the world in cities like San Francisco, Amsterdam and Seoul to help promote sustainable, intelligent urban development practices.

As part of the pilot program, ICT1 will work with Karnataka State Road Transport Corp. and the Karnataka police to improve public safety and security around one of the major bus terminals in Bengaluru. The project will help enable public safety and security at strategic points within the terminal, offering remote monitoring capabilities with real time information.

As part of this strategy, ICT1 is active in developing partnerships around key societal challenges both in India and China. In India, ICT1's Globalisation Centre in Bengaluru, established as part of a total investment in India of US$1.16 billion, is a showcase of the technology components of the company's Intelligent Cities vision. The initiatives at the campus include solar lighting and daylight harvesting, rainwater and treated sewage water harvesting for irrigation and fertilization, network-controlled lighting and HVAC systems, and a ubiquitous security system. Through the various programmes and initiatives that it has undertaken at the Globalisation Centre in Bengaluru, ICT1 is demonstrating its commitment to pollution reduction, environmental protection and continuous improvement in India. According to the website:

> ICT1 chose India as the location from which to expand its globalization vision because India has a highly skilled workforce, supportive government, innovative customers and world-class partners that already have global capabilities.

In China, ICT1's board chairman and chief executive officer announced on 1 November 2007 that innovation and sustainable development would become the strategic focus of Cisco's development in China, and committed to make an investment of 16 billion US dollars in China in the next five years, including a significant increase in local procurement, education, financing lease, R&D, as well as sales and service. On 16 April 2008, the CEO made his second visit to China, and announced the company's developing strategy and blueprint in the next stage. As an important step of "innovation and sustainable development", ICT1 will strengthen its cooperation with Chinese government and industries, and try to match with all-level goals of economics, society and environment in China".

3.3.4 Path dependency and acquisitions

Stressing the path dependency involved in the process of innovation, List (1841) remarked: "The present state of the nation is the result of accumulation of all discoveries inventions, improvements perfections and exertions of all generations which have lived before us; they form the mental capital of the present human race, and every separate nation is productive only in the proportion in which it has known how to appropriate these attainments of former generations and to increase them by its own acquirements".

It appears that the ICT1 considers innovation not only as interactive process but also path dependent. This is reflected in the firm's strategy of acquiring leading firms in specific areas, which in turn provide ICT1 with access to both the accumulated knowledge and human capital of these firms and to their markets.

At the beginning, acquisitions were mainly targeting US-based companies. Later the company started to acquire worldwide. To quote from the interview in Sweden:

> The fact is that we acquired more than 140 companies and all have their small R&D labs etc. So it is a constant process of integrating those companies and taking from them the right potential. For example in Belgium we acquired a company for video set up box , and we have an R&D centre in this company. So we are spread worldwide but the two main ones are in the two HQs. We are also present for example in China in Shanghai and in Beijing.

Table 6 shows that ICT1 continues its strategy of acquisitions. Indeed, 14 companies were acquired since 2008 (see table 6). It is evident that the acquired firms were leaders in the respective areas.

Table 6: Important acquisitions by ICT1 since 2008

Year	Name of the Company	Area of Expertise
2008	Cognio, Inc.	leader in wireless spectrum analysis and management for wireless networks
	Latigent, LLC,	Leading provider of web-based business intelligence and analytics reporting solutions focused on contact centers;
	Nuova Systems, Inc.,	Developer of next-generation products for the data center market;
	Securent, Inc.,	Leading provider of policy management software for enterprises;
	Navini Networks, Inc.,	A leader in the mobile WiMAX broadband wireless industry
	DiviTech, A/S,	A leader in the digital-service management market
2009	Post Path, Inc	leader in email and calendaring software
	Jabber, Inc.	Principal provider of presence and messaging software
	Pure Digital Technologies, Inc.,	Creator of the Flip Video family of cameras and a pioneer in developing consumer-friendly video solutions
	Tidal Software, Inc.	Developer of intelligent application management and automation solutions
	Starent Networks Corp.	Provider of IP-based mobile infrastructure

2010	Starent Networks Corp.	for carriers
	Tandberg ASA,	Leader in video communications
	ScanSafe, Inc.,	Provider of hosted web security
	CoreOptics Inc.	Designer of digital signal processing solutions.

Source: Compiled from the annual report of relevant years

3.3.5 Building strategic alliances

ICT1 has been very actively developing strategic alliances with other firms including competitors and other stakeholders. It is worth noting that in the United States ICT1 has partnerships/collaboration with Microsoft - one of the strong competitors in some areas. Microsoft is also a valuable customer of ICT1 for network equipments. This strategy is pursued in both India and China.

In India, ICT1 has forged firm collaboration with the largest IT Company in India which is a competitor of ICT1 in certain areas (see box 2).

Box2:
Strategic alliance between ICT1 and Tata Consultancy Services, India

On 10 February 2009 ICT1 and Tata Consultancy Services (TCS) announced their strategic alliance to develop and deliver information technology (IT) service solutions to help customers build or evolve next-generation data centres by taking advantage of the network as a platform. Under the agreement, TCS will build a new technology practice focused on ICT1's industry-leading data centre networking and security solutions. The companies also announced the formation of a ICT1® Technology Lab at the TCS campus in Chennai, India.

ICT1 and TCS are developing go-to-market solutions that meet the infrastructure and network requirements of global corporations. Both companies will invest in skills development and training labs to provide an end-to-end solution to meet customer requirements.

This strategic alliance illustrates ICT1 commitment to building relationships with new partners in emerging parts of the world that will take advantage of new virtualised approaches such as 'software as a service'.

The TCS and ICT1 strategic alliance will initially focus on India as well as mutual enterprise customers in the United States and the United Kingdom in the key verticals of banking and finance services, telecom, and government as well as small and medium-sized business.

The ICT1 Technology Lab in Chennai will allow TCS to develop network-based data centre solutions, test frameworks, develop skills and certify employees in ICT1 data centre technologies. The lab will also allow ICT1 and TCS to illustrate proof-of-concepts and IT and networking methodologies for client-specific business processes.

In China, ICT1 has close cooperation with local companies, most of whom are part of ICT1's supply chain, especially companies located in Guangdong Province. ICT1 hopes to make these SMEs part of ICT1 and help them upgrade. ICT1 has already made an investment of 700 million US dollars in many local companies, and has plans to make an additional investment of over $350 million during the coming five years.

3.3.6 Linkages with Knowledge generating organizations: Competence building in the South

Being a truly innovative, global and networked firm, the strategy of building and sustaining technological competence by ICT1 involves networking not only within the firm and other firms, suppliers and customers but also the other knowledge generating organizations like universities around the world. ICT1 collaborates with universities worldwide both for educational purpose (e.g. special graduated programmes) and also for innovation purpose. The main collaborations are in US and in India. ICT1 has dedicated resources, budgets and people to use for developing universities collaboration.

Special mention may be made of the Global Talent Acceleration Programme (GTAP), which ICT1 established in Amman, Jordan, and Johannesburg, South Africa, as well as in Bangalore and New Delhi in India (see box 3). Partnering with public and private institutions (such as schools, universities, businesses, no-profit and government organizations) the initiative aims at enabling new recruits (whose skills are generic) to develop the highly specialised skills needed by ICT1 (eg, networking).

As part of this strategy, a number of initiatives are being taken both in India and China.

In India, fully-fledged and formal linkages with institutions are yet to take place. There are many instances of interaction with academic institutions like the Indian Institute of Science Bangalore and there is a growing attention to it, but linkages remain mostly informal in nature, for instance, through highly knowledgeable persons who have joined from the academia or the participation of ICT1's personnel in research seminars, workshops, conferences. Interactions also takes place in the form of internships for students (approximately 150 to 200 or even more in some years). During the interview the ICT1 representative in India said that " I visit many campuses a year and I feel there is a lot of talent and quality in our colleges but if you ask whether the quality has deteriorated from past may be it is so. For instance the IITs which used to produce global business leaders about 10 years back are not doing that any more".

Box 3
ICT1 initiative to help meet demand for networking professionals

On 20 May 2009 ICT1 announced that the first cohort of students has graduated from the Global Talent Acceleration Programme (GTAP) Academy in New Delhi. The programme, launched last year in India, aimed at developing home-grown technical skills and popularize career certification thereby bridging the gap between demand and supply for industry-ready professionals in the networking industry.

The GTAP Academy in New Delhi is operated jointly by ICT1 and business partners Aricent and HCL. There are nine associate Customer Support Engineer (CSE) delegates graduating in the first Delhi cohort.

GTAP has particular relevance in India, where demand for networking skills could require an additional 118,000 professionals by 2009, according to a 2004-2009 IDC report on global skills. Designed to be sustainable, delegates receive a salary and go through training programmes in relatively small groups. This enables GTAP to put a strong emphasis on technical and professional training, mentorship and on-the-job training.

The GTAP programme leader at ICT1, said, "In addition to in-depth product and technical knowledge, engineers also require sophisticated management and communications skills. ICT1's Global Talent Acceleration Programme has been specifically designed to cater to this need and support the future growth of ICT1 service delivery in developing markets ".

Initiated in 2007, GTAP works towards accelerating business development and growth opportunities for ICT1 and its partners in emerging economies where technical resources are known to be scarce. GTAP trains associate and experienced professionals as network consulting engineers, project managers, customer support engineers, system engineers, and account managers, who subsequently can be absorbed into the professional workforce at ICT1, its partners, and the wider industry.

In China, though ICT1 has its own R&D center in Shanghai, it pays more attention to cooperation with local universities. It established the "Green Science and Technology Joint Laboratory" with Tsinghua University in April 2009, which focuses on developing wireless sensor networks and intelligent technology solutions to urbanization. In December 2009, it set up the "Next Generation Broadcast (NGB) Joint Laboratory" with the State Administration of Radio Film and Television. In February 2010, it set up the "Chongqing University of Posts and Telecommunications – ICT1 Green Science and Technology Joint Research Laboratory" with Chongqing University of Posts and Telecommunications. Besides, ICT1 is participating in important programs in China, such as next generation Internet, mobile TV programs, collaborating with the Research Institute of State Administration of Radio Film and Television. ICT1 also pays a lot of attention to educate and cultivate Chinese talents in networks. By the year 2011, ICT1 will build more than 300 ICT1 network technology colleges in many higher vocational colleges, aiming at increasing by 100 thousand students the total number of students trained in ICT1's network technology colleges. Finally, ICT1 spent 20 million US dollars on establishing Guanghua-ICT1 Leadership Institute jointly with Peking University. This is the first time that ICT1 built an international academic exchange platform with domestic education institutions oriented towards senior management personnel to cultivate international management talents.

3.3.7 The coordination of the network

The efficient coordination of the network is crucial to the company. A key factor is the move towards cross-functional integration. The company shifted from a command and control strategy to a strategy where each single employee of the group can participate in the innovation process (see the webpage in relation to the prize for new ideas). The innovation is then filtered through boards and councils composed by executives located in different sites. This strategy aims at mobilising all knowledge in the system, while acknowledging that the HQ in Silicon Valley cannot have good knowledge of what's happening everywhere. The keywords are "anywhere, anytime, mobility" (see interview in Sweden)

Communication among the group (in different locations) is done mainly at virtual level (tele-conferences with advanced techniques – e.g. TP rooms and holograms - allow the transfer of knowledge and meeting among people located geographically in different sites). Employees use shared ICT platforms for common work sections and communications (use of internal you tube, blogs etc).

Face-to-face contacts are not crucial to this. When the second HQ in Bangalore was settled down executives from US where sent to the new location. However, this was not because of the need to transfer knowledge (this happens through the networking anyway) but to show the commitment of ICT1 had with the new site (which require face-to-face contacts).

4. Conclusions

Literature argues that GINs have developed primarily because of the large availability of knowledge workers in the South, particularly as skill-starved northern MNEs are looking for new capabilities for promoting innovation. Against this background, this study deals specifically with two questions. First, is the simple availability of competence in southern countries actually driving the formation and substance of GINs?. Second, to what extent the innovation strategy of the firm is helpful in further strengthening the competence base in in those countries? To these questions, we have undertaken the case-study of a leading northern MNE having operations and undertaking R&D and other innovative activities in other northern countries and in southern countries.

Concerning the first question, the central message of the case-study is that the formation of the global innovation network is intrinsic to the innovation strategy of the firm. Enabling the firm to respond in real time to the societal transformations is the primary objective of such innovation strategy. To this end, innovation is increasingly seen as an interactive process wherein collaboration with users, suppliers, competitors and other knowledge generating entities like universities is as important, if not more, than in-house R&D activities (quoting from the Sweden interview: "changing from 'knowledge is our power' to 'collaboration is our growth' "). Internal development, acquisitions (particularly of niche producers of specific technologies), partnerships (with national and local authorities), and strategic alliances (including with competing firms) are the four pillars of this strategy. Overall, these processes are driving an in-depth transformation of the very organisational structure of the firm: from a command-and-control to cross-functional integration (where each employee contribute to the innovation process). In this context, the availability of skilled manpower in the host country is only a necessary but not a sufficient condition in the formation of GINs. Indeed, the skill gap between India and China (as highlighted in Section 3) did not seem to make an important difference in the location decision of ICT1. Other factors appear to play an important role as well. While closeness to large markets and cost factors (particularly in R&D) remain, the case-study stresses the importance of developing countries as sources of new ideas. Societal transformations (eg, urbanisation) are happening very rapidly in southern countries. Their markets markets have various kinds of customers, whose demands are very dynamic and changing. These customers can be regarded as critical ones globally, and the feedback from those market can be then applied into the whole world.

Concerning the second question, the case-study highlights a number of initiatives that the company is taking to help competence building in host (and specifically southern) countries. This includes interaction with universities and its other skill-generating activities. However, such initiatives appears to have the primary objective of developing the very specific niche skills needed by ICT1. Such relatively narrow focus may have the potential danger of locking up further development. This calls for policy and institutions in India and China to take an active role and harness the presence of MNEs for strengthening their competence base and making their innovation system more vibrant.