Analysis of Estonian IT Sector Innovation System:

Estonian ICT cluster: Present State and Future Outlooks

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1. Overview of Estonian ICT sector

The evolvement of Estonian ICT sector throughout the last decade has been gradual, from low value added computer assembling activity to higher value added software production and telecom services. The ICT market is shared between few large corporations, which consolidate a substantial economic power and account for a dominant part of the entire Estonian ICT sector, and many small IT enterprises with lower market relevance, who specialise either on subcontracting, sell hardware and software or develop niche products. It is estimated that Estonian ICT sector comprises of 350-400 enterprises, whilst majority of these are active in wide area of parallel activities, meaning that specialisation is not common practice amongst Estonian ICT related SMEs[1].

According to EITO 2000 Yearbook the estimated market for ICT products and services in 2000 was 537 million EUR (MEUR), with telecom market totalling 368 MEUR. Up to the year 2000 the growth of ICT market has been relatively fast with annual average of approximately 20% and higher. However, in 2001 the growth rates are expected to decline to 9,2%[2]. Software and services are expected to slide from 38,2% in 2000 to 21,2% in 2001, whereas telecom market growth declined to 9,9% in 2001 from 15% year before. It is noteworthy to highlight that telecom, being the engine of ICT sector growth, is experiencing gradual stabilisation and even saturation in some domains (f.i. internet subscribers). Thus, further developments in ICT sector are very much dependent on how dynamic is the growth in computer services and software, though in 2001 the share of software and services in total ICT market was relatively low 10%.

Below, a brief description of the eight most influent ICT companies is presented. These top 8 enterprises account for up to 80% of the total Estonian ICT market and thus shape to a large extent main trends and developments occurring in ICT sector. The companies under observation are Elcoteq Tallinn, Estonian Mobile Telephone, Estonian Telephone Company, Radiolinja, Ritabell, JOT Estonia, Tarkon and MicroLink.

Elcoteq Tallinn – a subsidiary of Elcoteq Networks Corporation with headquarters located in Finland. Elcoteq Tallinn manufactures primarily electronic subassemblies such as mobile phone's electronic parts and accessories, but also provides engineering and after sales services. As majority of the production is subcontracting work to Ericsson Corporation and Nokia, sales and performance of Elcoteq Tallinn has been substantially reliant on the large scale subcontracting orders. Moreover, as Elcoteq is by far the most influential actor on Estonian ICT landscape, accounting for 83% of total Estonian ICT exports[3], the company has direct impact on the growth rates of the whole ICT sector. Though, such kind of heavy dependency on one exporter is harmful for the entire economy, as it makes ICT export particularly vulnerable to the developments taking place within a single company.

Elcoteq Tallinn is the leading exporting company in Estonia - in 1998 and 1999 the export from Elcoteq Tallinn was 350 MEUR, while the year 2000 witnessed almost threefold export growth to approximately 1 billion EUR. However, global slowdown on telecom markets in 2001 has vigorously affected Elcoteq's business, which has resulted in unused capacities such as conserved new plant in Tallinn and remarkable downsizing in personnel. At the beginning of 2000 Elcoteq employed as much as 3600 persons, while in August 2001 the number of employees has dropped to 2000. According to Estonian Business Registry the turnover of Elcoteq Tallinn was 25,9 MEUR, which obviously did not incorporate the transactions between the subsidiary and headquarters.

EMT – the largest Estonian mobile operator EMT is fully owned by Estonian Telekom, where the ownership is divided between Sonera (24,5%) and Telia Corporations (24,5%), and

[1] here and further the data is based on questionnaire results, if not indicated otherwise
[2] by the time the survey was published the official data for 2001 was not available
[3] estimation of author based on Statistical Office of Estonia and publicly available materials

Estonian State (27,3%). The rest of shares belong to other private and corporate investors and are traded on Tallinn Stock Exchange.

EMT's main field of activity is the establishment and maintenance of mobile communication networks and systems, and the sale and management of related services. As for 1999, the turnover of the company was 106 MEUR (20% of the ICT market turnover and 29% of the total telecom turnover) and the number of subscribers exceeded 320 000[4] at the end of 2000. This figure gives EMT strong leadership as compared to other telecom operators, with subscribers based market share approaching 60%.

Eesti Telefon (ET) **–** ET is another company belonging to Estonian Telekom holding group. The ownership structure is analogous to that of EMT. ET as a private company was established in 1993 and has operated most of the time under the concession agreement conditions stipulated with Estonian government in 1992. Year 2001 marked the end of the concession, when free access to the market was enabled.

ET is primarily specialised on offering data communication, internet and telephone solutions to companies and households. Eesti Telefon has also established itself as the market leader for internet dial-up service and ADSL connections.

ET is a substantial employer – in 2000 total of 2900 persons were employed by the company. However, inner restructuring process has had an effect on the number, as in 1998 the company employed 3700 persons. Total turnover of 171 MEUR in 2000 makes ET the largest company on domestic ICT market, accounting for 32% of total ICT market and 46% of telecom market.

Radiolinja Estonia **–** Radiolinja is a private capital based international telecommunications company founded in 1994 by Elisa Communications, Finland. Radiolinja offers a variety of telecom services with main orienation on mobile communication solutions. As for the end of 2000 Radiolinja Estonia had 137 000 subscribers, which comprise 25% of total number of mobile communications subscribers. By turnover, with 16 MEUR in 1999 Radiolinja Estonia had 7% of entire Estonian carrier services market. Radiolinja is the fastest growing telecom company in Estonia, gaining both high new subscribers rate as well as turnover growth rates. In 2001, revenues increased by 60% as compared to the same period in 2000, amounting already 40 MEUR.

Tele2 (OÜ Levicom Broadband) **-** TELE2 is a telecommunication company providing telephone, Internet and cable TV services. Owners of Tele2 are TELE2 AB and Levicom International Holdings BV. TELE2 entered Estonian mobile communication market in 1999 by aquiring ownership in Q-GSM, operated by Levicom Broadband. In addition to involvement in mobile communications market, Tele2 has been actively fought for the position in distance call market. The 9 month consolidated turnover of the Group in 2000 was 3 MEUR.

JOT Estonia **–** JOT Estonia is a company established in 1997 via foreign direct investment from JOT Automation Group (51%) and JOT Robotics (49%). Main field of activity of JOT Estonia is embedded in industrial automation production, which is entirely channelled to exports. JOT Estonia relys much on subcontracting work to telecom companies, though presently a reoriantation on automotive electronics devices production is pursued. Export revenues and turnover of JOT Estonia amounted in 2000 for 37 MEUR[5]. JOT Estonia is one of the largest Estonian ICT exporters, and leading company in industrial automation domain. JOT Estonia employs alltogether 200 people as for 2001.

Tarkon – majority shares owned by Swedish capital Hallbergs-Sekrom Fabriks AB as a result of privatisation in 1996. Formerly, Tarkon was a military control apparatus plant and manufacturer of black boxes. Today Tarkon performs relatively imporant role in Estonian electronics industry. Likewise most of other local electronics plants, Tarkon is also orientated on subcontracting. Most of the subcontracting is done to Scandinavia, while largest partners

[4] Source: Statistics on subscribers: Estonian Informatics Centre (www.eik.ee)
[5] Estonian Investment Agency

are Elcoteq and Ericsson. Tarkon's turnover for 2000 exceeded 11 MEUR and export 7 MEUR[6]. Tarkon is an employer for 600 people.

MicroLink[7] **–** the company was founded in August 1991. Up to 1995 MicroLink's activities were concentrated on PC assembly and wholesale and retail distribution of computer equipment in Estonia. Over the years the Company built an extensive resellers' and maintenance network across the Baltic countries. In 1995 MicroLink expanded its activities into system integration and Internet businesses, which soon became the core activities of the Company.

Due to increasing competition and diminishing margins the Company decided to exit from wholesale operations by selling it to global distribution firm CHS Electronics in the end of 1996.

Presently, Microlink is the largest Estonian IT company in the domain of retail distribution of computer equipment. In the PC assembly market Microlink holds leading position in Baltic states with 20% of market share. Annual turnover of Microlink is 46 MEUR, including Baltic transactions. Total number of employees in Microlink is around 250 people.

[6] Estonian Investment Agency
[7] Annual Report 2000, MicroLink

2. Introduction to cluster logics

2.1. Cluster concept and main determinants of competitive advantage

The conventional paradigm of competition has gradually shifted from autarkical entity centred business logic to industry- and economy-wide multilateral interactions' based one. Ongoing global convergence between different industries, so-called clustering process is a genuine evidence for that. Clusters play significant role as geographically concentrated competition domains, where shared infrastructure, complementary expertise and business activities alongside with sophisticated competition relationships generate synergy in the form of higher productivity, know-how spill-over and innovative incentives. OECD characterizes clusters as networks of production of strongly interdependent firms linked to each other in a value adding production chain (Boosting innovation…, p.9). According to cluster logic, interaction between different economic units departs more and more from the vertical industrial structure, with horizontal relations gaining ever-increasing importance. Aside of harsh competitive relations co-operational initiatives are becoming more common. Faster convergence process is typically encompassed by enhanced economic efficiency, since cross-sectoral collaboration on the basis of complementarities and best competence create necessary grounds for further synergy.

Cluster approach in analysing economic competitiveness has a number of advantages compared to plain sectoral approach, as flexibility of analysis is not limited to intra-industry relations alone. It is important aspect when conducting innovation studies, as innovation is typically generated in a system of comprehensive networks. Frequently, these networks have far-reaching access to a number of actors across different sectors.

Traditionally, clusters uniformly incorporate different fragments of the whole production value chain. M. Porter outlines value chain comprising of primary activities and support activities on Figure 1 (Porter 1998). Adapting the model to ICT sphere one can define activities like content creation, deliveries and consultancy as inbound logistic to operations; production, packaging, design and services as operational activities; collection, storing and distribution as outbound logistics, while marketing and sales involve gate-keeping and terminal vending. Certainly, such classification is bounded with subjectivity and value chain can be different conditional on the specific cluster identity.

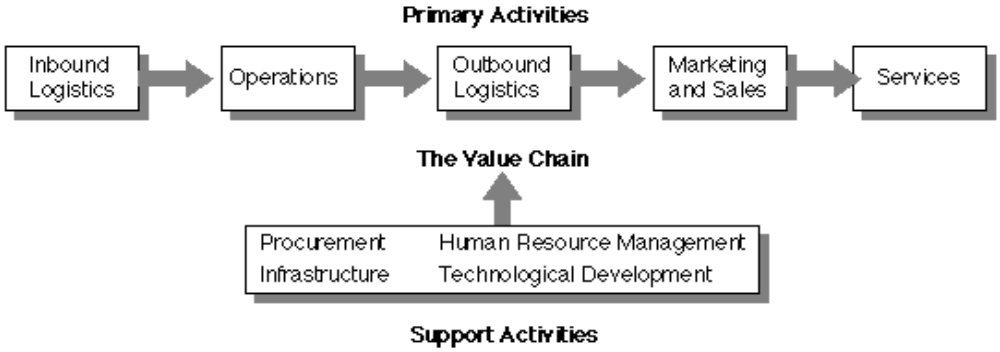

Figure 1. Porter's value chain

The related identity of these activities within the complete value chain indicate that the convergence is most likely to happen within above domains of different sectors, whereas ICT sector as a part of larger cluster has central position mostly in production, distribution and marketing. Other elements of value chain are usually provided by related industries such as publishing, advertising, art and culture on content side and manufacturing industry, banking etc. on applications side.

Value chain incorporates both vertical and horizontal relations between different sectors, underlining the necessity to approach the concept of competitiveness not solely on the basis of a single economic sector, but more broadly focusing on whole set of relations this sector

has with other economic domains. These interrelations determine the position and competitiveness of an entire cluster. More specifically, Porter defines four broad attributes, which shape economic environment in the form of efficient cluster-based network, and contribute to the emergence of national competitive advantage. These determinants are observed in the context of a certain economic domains, the cluster, which represents a value adding chain of activities frequently spanning over different sectors. The four cornerstones for gaining sustained national competitive advantage are embodied in the:

a) factor conditions that are present in the economy and used in the value adding chain;
b) demand conditions that pose the direction for further product development and the characteristics of the entire value adding process;
c) firm strategy, structure and rivalry that determine the level of competition within cluster and reinforce innovative incentives;
d) and related and supporting industries, which interact with the observed cluster and thus have substantial influence on its performance directly as well as indirectly.

These attributes are combined in a diamond shaped figure presented below.

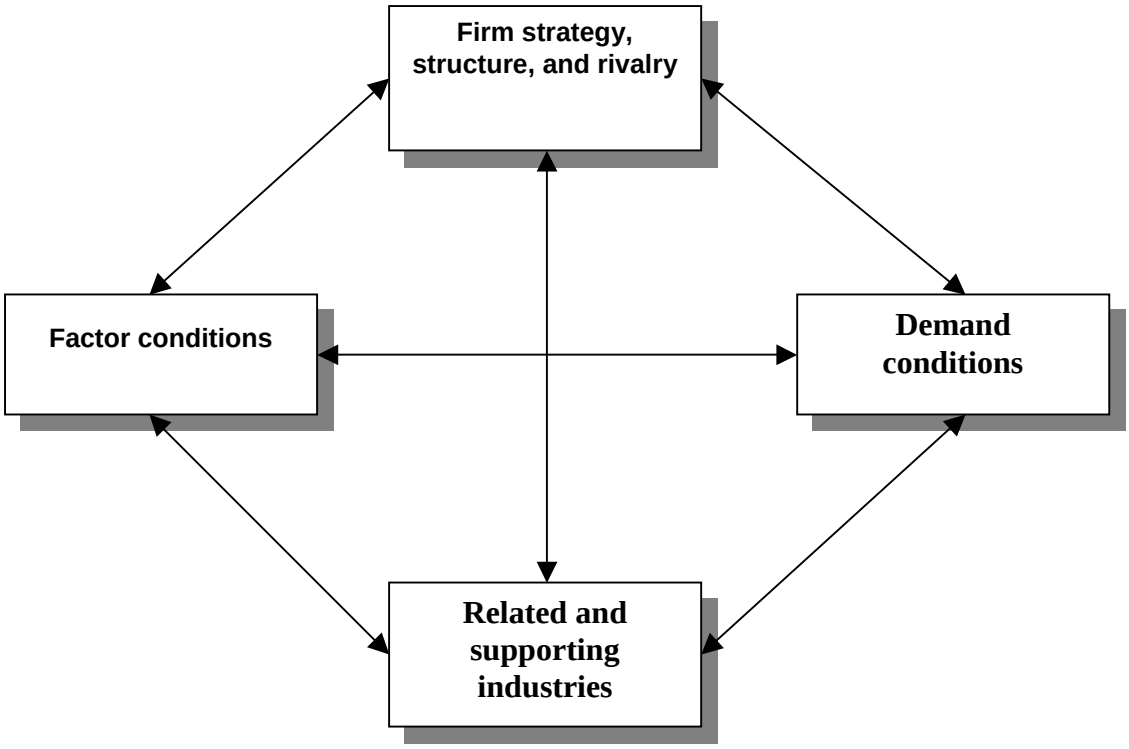

Figure 2. Porter's Diamond (Porter 1998)

First of all, factor conditions describe nation's position in factors of production, such as skilled labour or quality of infrastructure that are necessary for competing in a specific industry. The stock of factors at a given time is less important than the extent they are systematically upgraded and deployed. Local disadvantages in factors of production force innovation, and this innovation often leads to nation's competitive advantage. In context of Estonian ICT cluster, a brief description of ICT cluster relevant factor conditions are partly presented in chapters 2 and 3 of the paper "ICT, Innovations and Innovation Policy: The Case of Estonia". Main production factors outlined in the chapters have been created through dynamic evolvement and concern primarily IT skills and substantial foreign direct investments.

Second broad determinant of national competitive advantage are home demand conditions for the industry's product or service. According to Porter, more demanding local market leads to national advantage. As well, trend setting local demand plays important role in contributing to international competitiveness. Demand conditions are outlined in the present paper in chapter 2.2 (cluster description and chart) and 4.1 (export activity).

The third determinant, related and supporting industries affect national advantage in two main ways: when local supporting industries are competitive, firms enjoy more cost effective and innovative inputs. The effect is even strengthened, when the suppliers themselves are strong global competitors. Related and supporting industries are also outlined on the figures 3 and 4 and chapter 2.2 of the present study.

Finally, firm strategy, structure and rivalry is the context in which firms are created, organised and managed as well as the nature of domestic rivalry. While at a single point in time a firm prefers less rivalry, over the long run more local rivalry is referred to be better both for the enterprises and economy as the whole, since it puts pressure on firms to innovate and improve productivity. In fact, high local rivalry results in less global rivalry. Also, local rivalry forces firms to move beyond basic advantages that a home country may enjoy, such as low factor costs. The essence of IT firms' strategies is touched upon in chapter 2.2 of the paper "IST R&D and innovation in Estonia", the structure of ICT market and extent of rivalry is highlighted in chapter 1 and 3 of the present paper.

It is worthwhile to point out that all these determinants in Porter's diamond contribute to the national advantage most, when they are linked and reinforced in integrated manner. It is primarily the case, where appropriate measures should be elaborated and deployed by the state innovation policy with the purpose to establish favourable environment and foster the interaction between these determinants. Therefore, it is not enough to view the mentioned aspects separately, instead there is a necessity to approach them universally. Also, in Estonian context one has to consider a number of other factors that are characteristic to our economy, therefore it is imperative to apply somewhat more flexible approach in analysing ICT cluster, which is further on integrated with Porter's diamond.

Below several competition attributes will be analysed, including outlining the value added chains within Estonian ICT sector and cluster, general overview of different ICT fields presented, competitiveness issues based on net export potential and productivity analysed. Finally, in chapter 6 all these elements are combined into one visible figure and put into Porter's diamond context.

2.2. Convergence in Estonian ICT cluster

A practical approach in assessing the extent of interaction between different industry groups is based on Input-Output (I/O) table analysis. Input-output analysis focuses on trade linkages between industry groups in the value chains of the economy (OECD p. 14). On one hand, the matrix table illustrates relations on supply side of economy indicating the origin of input to different sectors; on the other hand use of sectoral output is highlighted across represented economic sectors. However, as the collection and presentation of input-output statistics for Estonian economy is not formally practiced yet, the following analysis is based on individual questionnaires validated on a sample of resident IT companies.

Figure 3 illustrates aggregated results of the questionnaire via visualized linkages between various business activities. Percentage values show the share of relevant sector or segment either in total inputs to a sector or share of a buyer industry in realized products and services. For instance, 34% figure left of telecom equipment section marks the share of telecom sector goods in total purchases of telecom equipment industry. Thus, figures and interrelations left of ICT sector graph illustrate input from other sectors to the ICT sector. Figures on the right mark output from the different ICT sector segments. This way, 20% figure right of telecom equipment segment denotes the share of manufacturing industry in total purchases of telecom equipment goods. The percentage values have primarily representative function, giving broader imagination about the extent of convergence process. Figure 4 illustrates cluster relationships based on turnovers. Basic relationships remain the same in both cases: typically the more converged are sectors between themselves, the higher turnovers are generated in the system. However, one should not interpret the above figures in this specific case as final ones, since they might embed statistical errors.

Referring to the figures 3 and 4 the driver segments for Estonian IT sector are telecommunication services, telecom equipment production and computer services. Telecom spans over both IT hardware as well as software and services field, and produces a substantial output in terms of ICT production. Computer services is a generic heading for a number of sub-activities that all embrace primarily immaterial aspects of adding value i.e. maintenance, integration etc. That is also the reason why this sector is overwhelmingly interconnected with the rest of business activities.

At more precise observation it is possible to deduct that convergence process is relatively intensive between electronics and computer services sector, but significant linkages can be detected also with wholesale and retail and banking domains. Banking performs an underlying role as IT solutions elaborator as well as user, although the figure does not reveal it clearly. The reason is most probably derived by the fact that banks host their own IT departments, which supply majority of necessary solutions in-house. Rather evident sub-clusters have formed between manufacturing, electronics sector and hardware production, but also governmental structures, IT software and telecom services.

The performance in ICT cluster is based to a large extent on the developments in telecom, as telecom provides substantial input to computer services and equipment production. Important role in ICT cluster's development can be also associated with governmental structures, which obviously are target groups for several IT sector's segments such as software production. Thus, these linkages refer to considerable interdependency between described sectors, and provide insight to overall development prospects for the whole IT cluster. These dominating segments are the drivers for further development, and problems within one of these areas might paralyse the proper functioning of the whole cluster. Therefore, from policy planning and economic point of view it is important to consider the above indicated linkages, and apply more coherent approach in defining the rules and regulations in shaping information technology driven business environment.

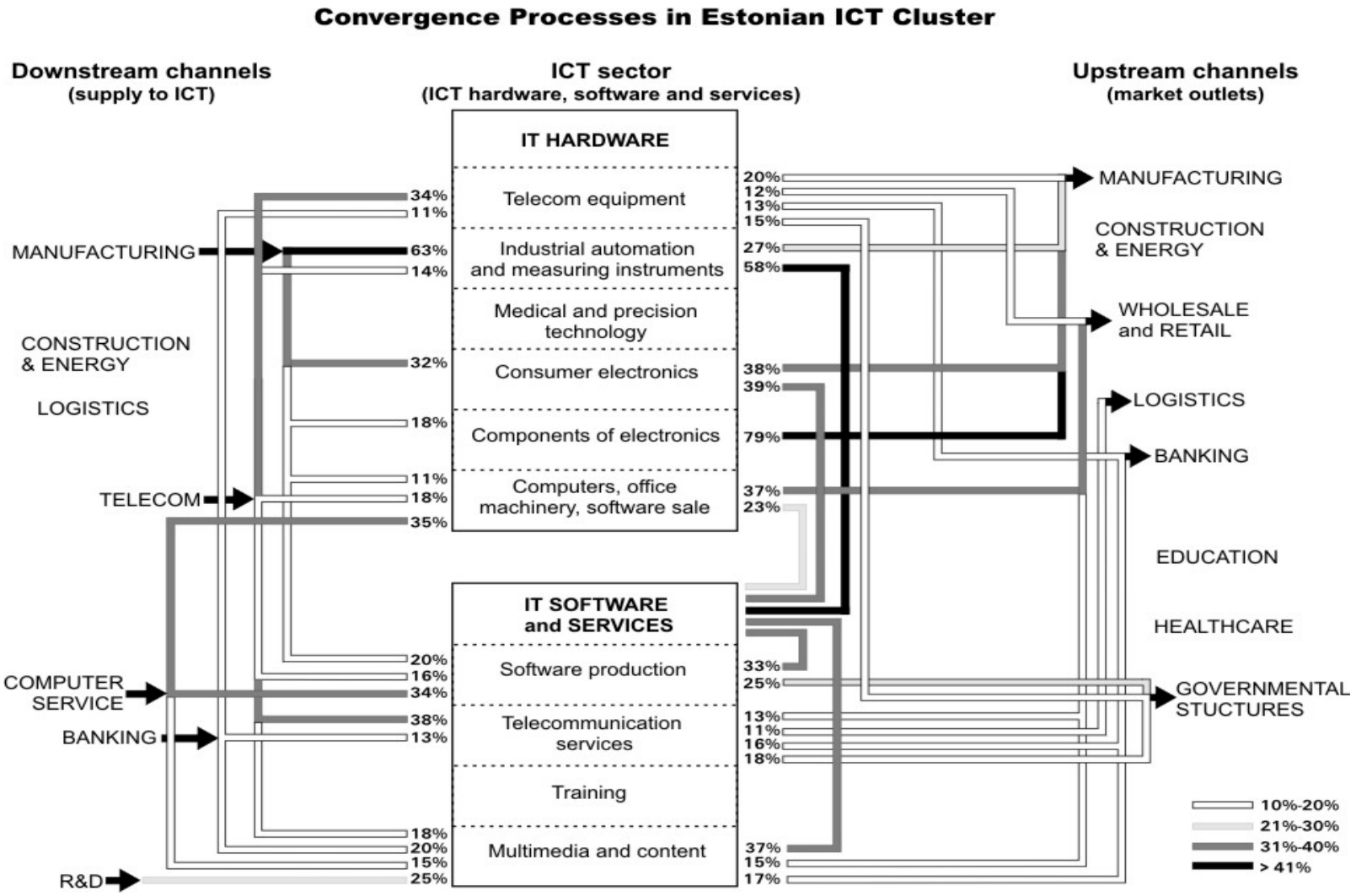

Figure 3. Estonian ICT cluster by convergence

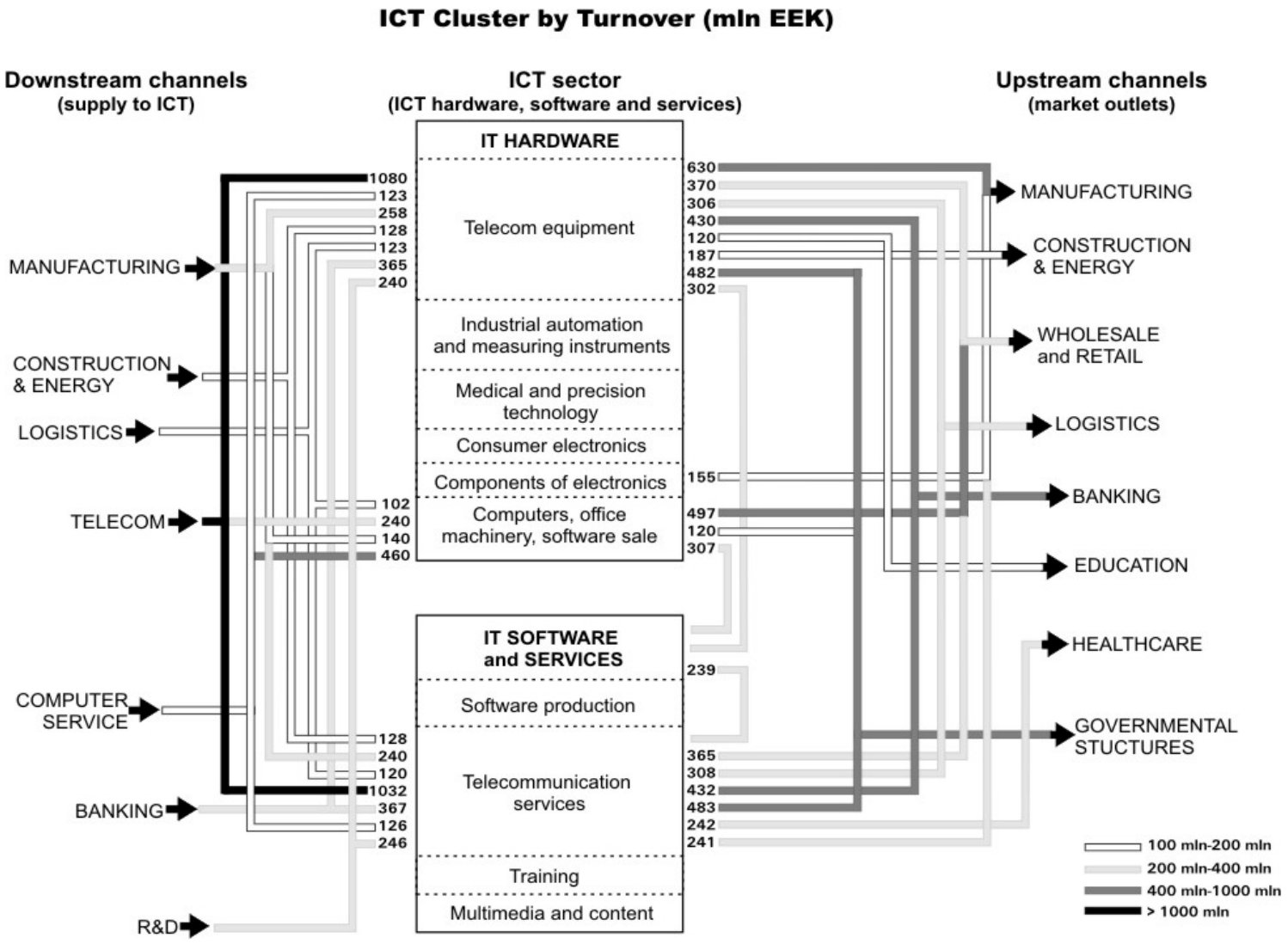

Figure 4. Estonian ICT Cluster by turnover (year 1999)

3. Main features of the Estonian ICT cluster

According to the findings above one could define Estonian ICT cluster comprising of IT hardware production that incorporates also electronics sector, IT software production and services, but also some fields of manufacturing, banking, wholesale and retail and governmental structures as final users. Table 1 presents general overview of the characteristic aspects of these subsectors.

Estonian ICT sector in figures (year 1999/2000)

T a b l e 1

Indicator/ sub-sector	*Market size MEUR*	*Exports MEUR*	*Employment*	*Education level*[8]			*Foreign capital*[9]	*Sub-contracting*	*Concentration level*
				A	B	C			
Telecom equipment	125	1000	3850	59	36	5	●●●●	●●●●●	●●●●●
Industrial automation	31	28	600	61	35	4	●●●	●●●●	●●●●
Consumer electronics	1.9	1,7	150	67	30	3	●●●	●●●●	●●●
Components of electronics	13	6	850	88	11	1	●●●●	●●●	●●●●
Computers and office machinery	105	5	1100	55	42	3	●●	●	●●
Software	13	3	1200	38	45	17	●●	●●●	●
Telecom services	220	3.9	4500	63	32	5	●●●	●●●	●●●●
Multimedia and content	0.65	0,04	100	85	15	0	●	●	●●

[8] A – other (%)
B – diploma and/or Bachelor (%)
C – Master and/or Doctor (%)

[9] ●…●●●●● – insignificant…strongly significant

Telecom equipment – telecom equipment industry's role in Estonian economy is reaffirmed by the substantial revenues that it generates, as total market for the equipment products[10] exceeds 125 MEUR[11]. Most of the production is channeled to exports – largest contribution to overall 1 billion EUR exports is made by Elcoteq, which accounts for approximately 96% of the total exports figure. Telecom equipment sector is the largest employer in ICT sector, offering job for more than 3850 workers. It is relatively knowledge intensive sector with 36% of people with diploma or B.A. degree and 5% possessing M.Sc. or equivalent[12]. Telecom equipment sector interacts with a number of other business activities, primarily with business and workflow management support, but also with customer relations, financial management and electronic transactions. Main products or services provided by the companies are multimedia-content and information systems next to telecom equipment and services. Most competitive one out of these is telecom equipment.

Predominantly, firms belonging to the sector have an experience as a subcontractor. Majority of orders are placed by Finnish and Swedish enterprises. On average subcontracting revenues constitute about 90-100% of turnover of smaller businesses. Yet, companies based on local capital are also less subcontracting orientated with the share of 20-30% of turnover. On the other hand, telecom companies are active in subcontracting other companies – their share of subcontracting costs is between typically 5-20% from turnover.

About half of telecom equipment providers are owned by foreign capital, ownership share is frequently 100% with owners originating from either Sweden or Finland. Approximately one third of telecom equipment enterprises have units abroad. However, headquarters are most common channel of internationalisation, meaning that the production plants here are mostly local representations. Few enterprises have headquarters in USA and other countries, as referred in the questionnaire. Sales representations or agencies are rare. Aside of Elcoteq a large share of equipment is produced for domestic market.

In the cluster framework main products demanded, but also supplied by other sectors are telecom equipment related. Communications and Internet was also mentioned on both input and output sides. As figure 4 indicated interactions are tight with manufacturing and computer services sectors.

Industrial automation and measuring instruments – turnover in industrial automation and measuring instruments sub-sector is nearly 31 MEUR, and exports 28 MEUR, both figures as for 1999. The latter number indicates that electronics sector on the whole is significantly export orientated. The sub-sector employs 600 persons, 450 of these being active in JOT Estonia and AS Aswega. Analogously to telecom equipment sub-sector 35% of personnel have either a diploma or B.A. and 2% of Master or equivalent. The sample of the enterprises revealed also 2% of PhD or equivalent. The companies are engaged in warehousing and logistics as main service line, but also business process support activities. As expected main own production consisted of measuring, control and precision instruments, which are also referred as their most competitive products. Consumer electronics were indicated as well.

The share of subcontracting is rather large in the sub-sector as about 80-100% of revenues are generated by contract work. Orders come from different, mostly neighbouring countries – Sweden, Finland, Germany, CIS, Denmark. Likewise telecom equipment industry, industrial automation is active in subcontracting other local companies – about 10% of their turnover is spent on outsourcing. About 50% of the companies are controlled by foreign capital with headquarters in Finland, Sweden and Germany.

[10] Estonian Telephone is included with 900 employees and 640 mln Euros related to telecom equipment

[11] Here and further turnovers are calculated based on Estonian Business Registry sample selection. Sample comprises more than 90% of the whole ICT sector.

[12] Employment statistics and distribution according to education are aggregated based on questionnaires and public materials.

In terms of input-output products industrial automation sector has indicated consumer electronics and telecom equipment, which is exchanged primarily with manufacturing sector.

Consumer electronics – there are relatively few consumer electronics enterprises present in Estonian ICT industry, thus the market size of the sub-sector is insubstantial 1,9 MEUR. Most of the production is exported to Sweden, exports account for 90% of the turnover. Consumer electronics companies employ alltogether 150 employees, whereas 30% of them hold B.A. or diploma and a small fraction also Master's degree. Vocational education is by far most common to a worker in consumer electronics segment – the share of such workers is 60%.

Business process management and decision support are the main lines of servicing activities. The sub-sector produces next to consumer electronics also computer and office machinery, precision-, control-, industrial automation instruments and medical technology. Subcontracting is important aspect in consumer electronics production, as most of turnover comes from subcontracting. Around 10% of total turnover is also spent on outsourcing.

On output side the companies mentioned telecom equipment, IT hardware, communication and Internet services as well as audio-video broadcasting next to consumer electronics. As to input consumer electronics and audio-video broadcasting were distinguished. Both output and input are closely related to manufacturing sector.

Components of electronics – this domain is considerably larger than consumer electronics, with market turnover of 13 MEUR and exports of 6 MEUR. Companies belonging to the class are medium sized with lower knowledge base, as about 80% of employees have vocational education. Alltogather the sub-sector employs 850 persons. Most important actor in the industry is AS Harju Elekter that accounts for 75% of the turnover and 80% of employment. Main products encompassing components of electronics production are precision-, control- and automation devices, the latter ones are considered to be also most competitive.

Subcontracting, analogously to previously described segments is rather important source of income (appr. 60% of turnover). Orders originate mainly from Finland and Germany. Foreign capital is dominating (80-100%), owners coming from Finland and Germany.

Interaction with manufacturing sector is sustained by supplying IT hardware and telecom equipment, and buying consumer electronics as well as broadcasting.

Computers and office machinery – the sub-sector of computers and office machinery is dominated by small enterprises with average employee number less than 20. The sub-sector employs somewhere around 1100 workers as for year 2000. Total turnover of the computers and office machinery class is relatively large - 105 MEUR, though export activity is insubstantial, only 5 MEUR. About 40% of overall employees have vocational education, another 40% diploma or B.A. The share of other degree holders is marginal. Most common service lines that are related to computers and office machinery are financial management, business process support, and decision support systems. Own products comprise of a variety of computers and office machinery that are considered most competitive ones alongside with several software products. Other products offered by the sub-sector are IT hardware, multimedia and content, but also IT services.

Subcontracting share in total turnover is relatively modest – 15%. Main contractors come from Estonia, Sweden and Finland. Most of enterprises belonging to computers and office machinery group are based on domestic capital.

Computers and office machinery division is clustering with computer services, wholesale and retail, and manufacturing. Main input products purchased by the enterprises are telecom equipment, IT hardware, IT software and Internet and communication services. On the other hand, output products are IT hardware and software as well as communication and Internet services.

Software production – software production companies are relatively small, having on average 30 employees (total number in the sector is approximately 1200), though quite

knowledge intensive, as they employ to extent of 45% of B.A. holders, 10% of Master's and 7% with Doctoral degree or equivalent. Turnover generated in software production is modest 13 mln Euros and export only 3 MEUR.

Software production is typically core activity for the enterprises, encompassed by a number of other complementary business lines such as computer and office machinery sales, sale of electronic components and consumer electronics as well as telecom equipment. Generally, most of the complementary activities of the companies can be associated with predominantly outsourcing and information systems, but frequently business systems enter the scene.

Main activities of software producers concentrate on product development and system integration. In terms of consultancy the fields of information services, databases and e-commerce are most important. Product development and application is performed mainly at information systems and data communication networks, but also outsourcing, and system integration in business applications, information systems as well as databases. Data communication networks, information systems and databases are most common products for system maintenance. Software is produced typically for at least three different target groups, thus niche products are rather rare. Financial management alongside with business process support, customer relations management, electronic transactions and logistics are rather popular activity domains for software producers. Most competitive own products are typically financial management oriented applications as well as IT services.

Approximately 60% of software producers have experience in subcontracting, though subcontracting is not dominant source of income for the companies. In terms of those enterprises, which have subcontracts, average revenue constitutes about 40% from turnover. Orders originate primarily from Finland, Estonia and Sweden.

The extent of internationalisation is mostly limited to the local branches of Swedish, US and Finnish companies. Selected companies have also sales representative or agencies in Great Britain, USA, Latvia. Average exports are near 25% from turnover.

Software production has converged with governmental structures and financial services on outbound, and computer services, manufacturing sector as well as telecom on inbound side. Input products for software production sub-sector are IT hardware, communication and Internet services, but also software from other business entities. Output is naturally related to software in the first place, communication and Internet as well as IT hardware are complementary products in a wide range of offerings.

Telecom services **–** telecom services are offered primarily by large companies. Telecom market size as for 1999 was approximately 220 mln Euros, thus very close to the estimates given in EITO's 2000 yearbook (226 MEUR). The sector employs 4500 persons, being by far dominating field in the whole ICT domain. Most prominent actors are EMT (Estonian Mobile Telephone Company) as well as Estonian Telephone, which account for as much as 85% of the whole telecom services market (184 MEUR). 32% of employees hold B.A. or diploma, 46% vocational education and 5% Masters and Doctoral degree owners.

Telecom operators are also relatively actively engaged in telecom equipment sales. As to the rest of complementary activities software products and services are offered. Telecom operators are active in consulting trust and security technology field, issues related to data communication network and information systems. Product development, systems integration and maintenance is performed mainly in the field of communication network, but also security technology.

66% of telecom operators or ISPs have subcontracting experience, while majority of orders come from Estonia and Finland. On the other hand, telecom sector is active in subcontracting other companies, priority is given to domestic ones. Foreign capital is essential in pursuing telecom related business activities, 2/3 of the companies are thus owned by foreigners. Foreign investments have come from Finland and Sweden, to the lesser extent also from USA, Netherlands and Canada.

Telecom services sub-sector is interacting primarily with banking sector, governmental structures, wholesale and retail as well as logistics on sales side, main supplier to the telecom services is telecom equipment industry. Telecom equipment, communication and Internet, as well as audio-video equipment were mentioned on both input and output side.

Multimedia and content **–** this class incorporates small enterprises with total turnover of 650 000 EUR and employment of up to 100 person. 45% of them with vocational education and only 15% B.A. or diploma. A large share of undergraduates is employed by multimedia and content sector, up to 40% of total employees. Multimedia and content sector is active in product (web applications) development and consultancy, whilst main lines of activities aside of content providence are related to software outsourcing, information systems and databases as well as e- or m-commerce applications.

Subcontracting plays insignificant role in content sector with estimated revenues of 5% from total turnover. Main offers come from Estonia, though Finland, Sweden and Great Britain were present also on the list. The enterprises are dominantly owned by local capital, this is also the reason for modest internationalisation level. Another reason for modest internationalisation derives from the smallness and almost non-existing competitive advantage of the companies.

Output to banking and wholesale-retail sector comprised of telecom equipment, communications and Internet and IT software. Input from computer services and telecom was represented in the form of communications, Internet and IT software and hardware.

Manufacturing **–** manufacturing is one of the core sectors of Estonian economy. The share of manufacturing in GDP constituted 14,8% in 2000. Presently, manufacturing sector is regaining its lead as growth in the sector is supported by high foreign demand and enhanced quality of products.

Total demand for manufactured goods is primarily influenced by developments in such low-tech sectors like food, forestry, apparatus and machinery, and finally light industry. These industries produce about 70% of manufacturing sector's output. Main linkages between manufacturing and IT sector reveal in the apparatus and machinery domains, which partly covers also electronics industry. Manufacturing depends to a large extent on subcontracting – 47,5%, especially it is the case for apparatus and machinery sector.

Manufacturing sector has a set of relations with a number of IT sector sub-groups, such as telecom equipment production, office supply, industrial automation, but also medical instruments. Relations are evident for both inbound and outbound.

Logistics and communication **–** logistics and communications is rapidly evolving sector, whereas main drivers for growth emanate from transport servicing activities such as transit, and developments from telecom sector. According to Bank of Estonia in 1999 value added generated by logistics and communications constituted as much as 13,2% of total Estonian GDP.

Productivity in transport sector rose by 170% in 2000, earnings per employee on average 75%. Main revenues come from international cargo shipments (Bank of Estonia).

Growth in communications is derived by strong performance of telecom sector. Still, fast growth rates are gradually stabilizing as telephone market has been opened to competition and further drivers of telephone service price are to a large extent influenced by market forces. Productivity in communications sector rose 17% in 2000 compared to previous year (Bank of Estonia).

Logistics and communication sector has ongoing convergence mainly with telecom services, however dominantly on output side.

Banking – total assets of the Estonian banks comprised 69% of Estonian GDP in 2000, amounting 3,7 billion EUR. Loan portfolio of Estonian banks incorporates mainly

manufacturing sector, trade, business service and real estate. The banking landscape is well covered by Hansapank and Union Bank of Estonia, which account together for as large as 83,5% share (Bank of Estonia).

As the cluster chart indicates banking is strongly interrelated with telecom. Presumably, relations with telecom are derived from the joint projects with mobile communication operators.

4. Competitiveness of Estonian ICT Cluster

4.1. Net export approach

There are several valid analytical measures for evaluating cluster's competitiveness on international level. However, either due to the lack of relevant official information or high subjectivity only few of them are applicable in the present context.

Net export approach is regarded as a common practice in assessing cluster's competitive position, as the methodology enables to identify comparative strength of export activity. Prevailing exports refer to cluster's ability to serve relatively efficiently national and international markets, whereas dominating importing rates indicate either insufficient domestic supply or low status of local products. Still, when conducting further net export based analysis, it is imperative to consider the implicit drawbacks conveyed by the approach. On one hand, the indicator lacks time dimension due to the static character of comparison basis i.e. it does not consider dynamic changes in cluster's competitive advantage such as learning curve as well as other aspects of economic evolution. Net export approach gives primarily descriptive information about the current state in export-import dynamics, however does not outline any particular trends. On the other hand, legal restrictions imposed on imports affect value of net export positively, but do not actually reflect underlying competitiveness level of an economy.

In view of the above considerations further net exports based assessment of Estonian ICT cluster competitiveness is conducted. The calculations are based on current value statistics, since comparative analysis is performed between exports and imports primarily on one period basis, otherwise relative and comparable figures are used.

Table 2, compiled upon the data received from Estonian Statistical Office, indicates a steady rise in ICT cluster's exporting activity. Most vigorous growth is evident for ICT goods sector, where annual increase in exports exceeds constantly importing rate. It is primarily due to increased production output from export leader company Elcoteq, which alone accounts for 86% of the relevant export figures. Generally, the situation is analogous for ICT services sector, with minor exception to the magnitude of growth rates and different import-export values. This tendency may point to ever increasing competitiveness level of Estonian ICT cluster's output, as rising foreign demand for Estonian ICT products and services has driven nation's export activity, but may indicate alternatively also very low initial output, where even small advances have contributed to relatively large growth figures. The following analysis aspires to reveal, what are the genuine reasons for such unbalanced behaviour within Estonian ICT sector.

Indeed, referring to the data in table 3 one can observe rather large differences between initial relatively low bulk of exports and nearly twice as large imports, at least in terms of ICT goods sector, which is dominating segment of Estonian ICT cluster. In absolute figures advances in ICT goods and services exports and imports are of the same category, except for the year 2000, when exports growth held distinct lead. It is also remarkable that due to the fact overall deficit in ICT goods and services has become negligible for the first time during the observed period.

ICT goods and services export-import growth dynamics (in per cent)

T a b l e 2

	1997	*1998*	*1999*	*2000*
ICT goods				
Imports	57,2	31,1	-1,3	92,9
Exports	108,6	58,0	-0,7	160,8
ICT services				
Imports	83,9	18,8	87,4	-28,9
Exports	29,0	16,1	93,0	20,3

Source: compiled based on Statistical Office of Estonia, Bank of Estonia

Despite of large increase in compound exports, current value net exports in ICT cluster remain negative. According to the net export methodology negative net exports indicate lacking competitive advantage, since products of foreign origin seem to outperform local ICT goods. Still, it might be worthwhile to apply closer look to the dynamics of trade deficit in ICT cluster, just to lessen the extent of subjectivity of such an approach.

Net exports in ICT sector (mln of EEK)

T a b l e 3.

	1996	1997	1998	1999	2000
ICT goods					
Imports	4731	7438	9751	9622	18558
Exports	2115	4412	6970	6919	18042
Balance	-2615	-3025	-2782	-2702	-516
ICT services					
Imports	179	328	390	731	520
Exports	206	266	309	596	717
Balance	28	-62	-81	-135	197
Total ICT goods and services					
Imports	4909	7766	10141	10353	19079
Exports	2322	4678	7279	7515	18759
Balance	-2588	-3088	-2863	-2837	-319
Total Estonian goods and services					
Imports	41229	57633	66267	62471	85027
Exports	35186	50213	58590	57988	81409
Balance	-6043	-7420	-7676	-4483	-3619

Source: compiled based on Statistical Office of Estonia

Since 1997 aggregate net exports have shown steady growth. As services sector play quite a marginal role in compound exports, most of the growth can be assigned to goods sector. While in previous years the share of deficit of ICT goods and services in total current account deficit ranged from 37-63%, year 2000 has witnessed a substantial improvement as the share decreased to approximately 9%. It was partly due to positive net exports in services sector, where positive balance amounted for 27,4% of the whole ICT services exports, but also to relatively low deficit in ICT goods trade. The deficit dropped to 2,85% of ICT goods exports, while in previous years it accounted for as large as 124% to 39%. At this point it is necessary to emphasize that overall rise in exports has had very limited support from strengthened value of dollar, as Estonian kroon is pegged to German mark and Euro-zone countries have remained to be major trading partners for Estonia. However, we should also note here that Elcoteq, the most influent enterprise in Estonian ICT cluster, is entirely behind the export figures of ICT goods as the enterprise accounts for as large share in IT goods exports as 83%[13]. However, due to the fact that the entire performance of ICT goods export is affected

[13] According to authors' estimations made upon available data and observations

by a single company, one should also be careful in evaluating the cluster's competitiveness based on pure export statistics.

The share of Estonian ICT sector constituted significant 23% of Estonian total exports in 2000, up from 12% previous year. In comparison with European Union average of approximately 6,3%[14] it is substantially larger figure, indicating strong propensity of Estonian economy towards ICT trade. In a way, high share of ICT production in total exports outlines relatively large foreign demand towards these products, reaffirming potentially good starting point for acquiring a sustained competitive position in the ICT cluster. If Estonia captures successfully all the possibilities to transform rapid increases in exporting activity into qualitative growth, the outlooks for higher value added exports remain promising for the future. In terms of imports the share of ICT products and services in year 2000 was 22,4%, up from 16,5% from previous year - thus the dynamics of import replicates exports quite well indicating increasing economic interaction in the field of ICT related products and services. Relatively large import and export shares refer to a large subcontracting sector in ICT, as imported goods are partly used for re-exports. Elcoteq, being the most significant driver of Estonian ICT cluster, is the very evidence for that. Elcoteq's activity is entirely based on subcontracting to large international corporations such as Ericsson and Nokia. However, as mentioned above, revenues generated by Elcoteq constitute majority of the whole ICT sector's turnover.

In line with higher exports average export prices increased in 2000 by 7,8%. Import prices increased during the same period by 6,1% (Bank of Estonia). These developments convey a positive sentiment, as they indicate that value added to export goods has grown and the potential on national economy is better utilized.

Estonian ICT exports per capita in 2000 are valued at 834 EUR[15], whereas EU average is about 397 EURs (EITO 2001). Two and a half-fold difference in these levels indicate to small scales of Estonian inner market and necessity to find market outlets behind domestic boundaries. However, one must not confuse these measures with productivity, since export indicators lack the ability to assess the level of production efficiency. This way, productivity of EU citizens on average is 450% higher than that of an Estonian counterpart (17047 EUR[16] - GDP per capita in Europe, 3802 EUR in Estonia in 2000).

In order to get better insight Table 4 has fragmented services sector into further sub-activities – communication services and computer and information services. Relatively stronger performance is apparent for computer and information services, where exports are nearly twice as large as imports. Communication services have also regained positive balance, though not as vigorously as computer and information services. These developments can be associated with the fact that import of services is essential during cluster's initial development phase, when local providers are not able to respond adequately to supply either due to lower capacity, quality or inadequate competence. Evidently, at present stage it is relatively expensive to import services from the West, as the local market has already gained the capacity to service the demand. The identity of services is somewhat different from goods, since predominantly services do not call for availability of abundant natural resources and they are also relatively immobile. Main resource in ICT services sector is intellectual capital that is formed on the basis of experience and relevant knowledge diffusion. In a way, there is a primarily knowledge-based competition between domestic and foreign ICT related services sector, where domestic providers have gradually made advances in line with accumulated know-how and experience.

As services account for a relatively modest share in ICT sector on a whole, the prevailing developments are determined by ICT goods domain. Referring to table 5 the trade structure of different goods looks inherently inconsistent. While the export of office machinery and computers has fallen drastically, manufacture of radio, television and communication

[14] Based on EITO 2001 ICT trade statistics in Europe (year 1999, growth rate 11% for 2000)
[15] 120 EURs excluding Elcoteq
[16] http://www.economagic.com/em-cgi/data.exe/ecb/t5-01-01+1

equipment and apparatus has sustained competitiveness alongside with positive trade balance in year 2000.

Net exports in ICT services. *(mln of EEK)*

T a b l e 4.

	1996	1997	1998	1999	2000
ICT services					
Communication services					
Import	95	206	246	532	321
Export	159	166	196	379	357
Balance	64	-40	-50	-154	36
Computer and information services					
Import	83	122	144	199	199
Export	47	101	113	218	360
Balance	-36	-22	-32	19	161

Source: Bank of Estonia

This upsurge has proven to be decisive from net exports point of view, as remarkable positive balance in the subgroup has compensated largely for trade deficits in other divisions. Thus, one may observe good basis for competitive advantage in terms of radio, television, communication equipment and apparatus manufacturing, whilst in other categories it is not that evident. Obviously main growth figures emanated from communication equipment production, where Elcoteq alone accounted for about 83% of the total ICT goods exports. Regarding to the manufacturing of cable and electric wire as well as manufacture of medical, precision and optical instruments, watches and clocks net exports remain to be negative despite of constant export growth.

Export and import of ICT goods by divisions (mln of EEK*)*

T a b l e 5.

	1996	*1997*	*1998*	*1999*	*2000*
Manufacture of office machinery and equipment					
Imports	1654	2336	1543	1373	1576
Exports	845	505	329	197	186
Balance	*-809*	*-1831*	*-1214*	*-1176*	*-1391*
Manufacture of insulated wire and cable					
Imports	205	337	402	449	906
Exports	63	179	282	406	741
Balance	*-143*	*-158*	*-120*	*-43*	*-164*
Manufacture of radio, television and communication equipment and apparatus					
Imports	1947	3626	6577	6509	14522
Exports	853	3204	5599	5635	16077
Balance	*-1094*	*-422*	*-978*	*-874*	*1555*
Manufacture of medical, precision and optical instruments, watches and clocks					
Imports	924	1138	1230	1290	1554
Exports	355	524	760	681	1038
Balance	*-570*	*-614*	*-470*	*-609*	*-516*

Source: compiled based on Statistical Office of Estonia

Main export countries for ICT goods are Sweden and Finland, which together account for 84% of total ICT goods export. On country-to-country basis exports to Sweden exceed imports twofold, whereas net exports to Sweden amount approximately 96 MEUR (Statistical Office of Estonia). Figure 6 presents indicative breakdown of Estonian ICT sector in different

product categories and balance of trade internationally. Most competitive products are related to telecommunications equipment, apparatus, radio and television manufacturing. Medical, precision and optical instruments are also internationally relatively competitive, with primer orientation on Finnish market. In terms of other products ICT goods are most competitive on the territory of former Soviet Union, however net exports to advanced industrial countries are insignificant. As to nearer future prospective, the highest economic potential seems to be embedded in manufacture of radio, television and communication equipment and apparatus, manufacture of insulated wire and cable. Manufacture of medical, precision and optical instruments need still decisive input for establishing internationally sustainable competitive advantage in longer term. In terms of office machinery and computers the prospective for augmented international competitiveness is highly doubtful. Manufacturers of these products should primarily concentrate their efforts on sustaining competition against foreign products on local market; orientation on exporting to advanced economies is at the present moment rather challenging within this particular division.

Export and import of ICT goods by country (mln of EEK), year 2000

T a b l e 6.

	Exports	*Imports*	*Balance*
Manufacture of office machinery and equipment			
Latvia	92,2	10,3	81,9
Lithuania	37,2	6,1	31,0
Mauritius	8,7	0,0	8,7
Russia	11,3	7,5	3,8
Manufacture of insulated wire and cable			
UK	76,1	18,5	57,6
Latvia	41,4	2,5	38,9
Lithuania	36,3	1,6	34,7
Manufacture of radio, television and communication equipment and apparatus			
Sweden	2860,5	1279,1	1581,4
Hungary	95,0	17,0	78,0
Latvia	46,4	20,5	25,9
Russia	21,9	7,2	14,8
Manufacture of medical, precision and optical instruments, watches and clocks			
Finland	358,4	252,5	105,9
Russia	107,9	18,6	89,3
Ukraine	23,2	1,6	21,7
Lithuania	22,6	13,2	9,4

Source: compiled based on Statistical Office of Estonia, Bank of Estonia

Appearance of Mauritius as the third largest net export partner for office machinery and equipment might refer to short term off-shore transactions, though finding further evidence or relevance is out of the scope of the present report.

Typically, fast evolving transition economies need initial input in the form of capital goods and expertise from abroad, as domestic economic system has limited amount of necessary resources to sustain international competition. These developments are evident also for Estonia, where the necessity for adequate capital goods has derived rather large bulk of imports during first years of free market economy. Gradually, output produced by these capital goods is partly converted into exports and large gap between exports and imports diminishes or turns into surplus.

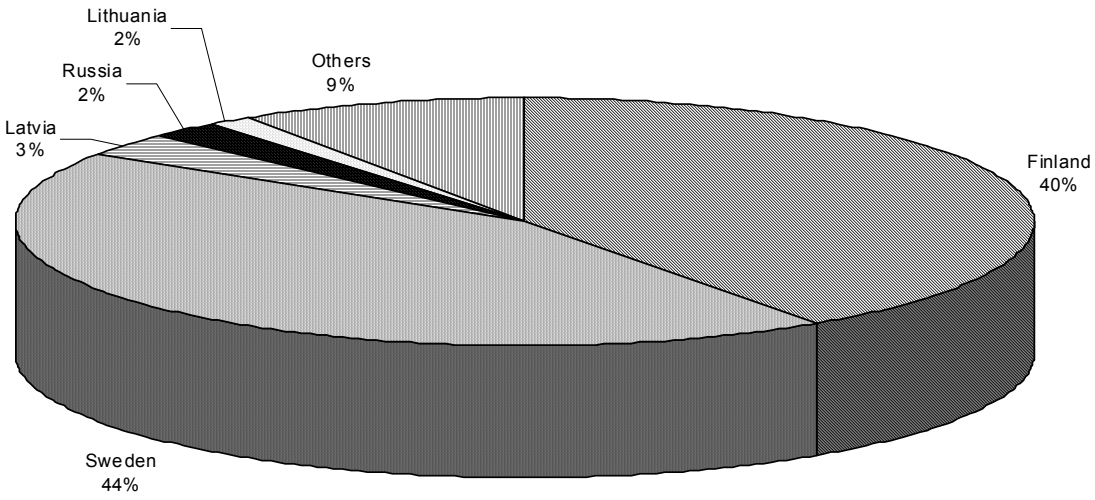

Figure 5. ICT product exports by country

4.2. Enterprise level aspects

This section approaches competitiveness issues more focused way, as primarily enterprise level aspects are under observation.

In analysing competitiveness the character of product palette offered by companies was under observation. It is adequate to assume that for a small or medium sized firm company-specific diversified products are the main mean and possibility for sustaining global competitive pressures. Diversification provides a good basis for larger value-added as additional characteristics contribute to the uniqueness and higher intrinsic value of the product. Thus, the extent of own production in total sales indicates genuine aspects of competitive advantage. Generally, Estonian IT companies are not inclined to create new products - most of offered products are actually imported brands. Amongst the latter ones financial software and network devices have largest share.

Low incentive to create new products is to a large extent arising from lack of human capital in product development domain, putting in its turn constraints on releasing innovative and internationally renown and competitive products.

Most active creation of own products is performed in electronics sector, where telecom equipment and testers, industrial controllers, transformers, supply blocks, fibre optical devices etc represent the list of produced goods, though evidence for diversification is insubstantial. Several software programs, GIS (geo-informatics systems), information systems, Internet portals and IT related services were also mentioned as Estonian IT companies' in-house created products, but there is no internationally renown brands on the market. In terms of new technological orientations large potential is associated with location-based services, language technology as well as electronics design, which capture relatively high intrinsic value, but also have support from relevant research structures.

Good advances are seen in telecom sector, where competitive efforts are pushing prices down and urging telecom enterprises to innovate. As a result, m-parking, location based services, banking services etc have successfully penetrated into people's everyday usage, illustrating the effect of simple incremental innovation onto companies' economic performance.

The results of interviews with ICT companies revealed that competition is sustained in the first place by high quality and diversified products, though uniqueness and relatively low price are also important features. In quantitative terms high quality was weighted by 76 points out of

226 available (34%), whilst diversification gained 52 (23%), low price and uniqueness both 39 points (17%). Tendency on orientating on higher quality and diversification is rather comforting, as grounding upon vanishing advantages such as low price might bring upon further setbacks in the whole corporate structure of IT landscape. Therefore, competition has gradually shifted from cost-leadership model to quality leadership, meaning that the domain of foreign competitors is being replaced by domestic companies. It is also confirmed by the fact that local IT companies predominantly expect competitive pressure to be derived by local competitors. Though, one should not underestimate new emerging low-cost technology providers from Russia, the region of St. Petersburg and relatively large software producers from Latvia. It is highly probable that competitive pressures will arise primarily from these regions already in the nearest future.

Good skills in finding strategic partners and clients is crucial for successful performance of the sector in mid to long term. In terms of Estonian ICT companies there are most common channels for finding partners and clients are Internet (40%), personal relations and acquaintance (20%), fairs and expositions (20%). Other channels were less relevant. There were of course different approaches, depending upon companies profile. Therefore, for instance, WWW was the main channel for finding customers for multimedia and content providers (75%), whereas in terms of software production personal relations were the ones of highest weight.

Internationalisation level is a relevant indicator for assessing competitive advantages on the global market. There are several stages for internationalisation – subcontracting, early exports, mature exports, sales representatives, sales office, agency, foreign direct investment into production plant. The further is the internationalisation level the highest risk is associated with, though also better opportunities for using returns to scale effects and portfolio diversification are gained.

Subcontracting experience was observed in terms of approximately 3/5 of IT enterprises; the share of enterprises pursuing export activity was about the same. Average exports constituted though only 37% of total turnover. At the same time more than 70% of IT enterprises import materials, intermediate or finished goods, constituting about 45% from their turnover. Thus it is the basic reason for negative net exports. The share of those imported materials and components that are subject to further value adding activities – input to export goods - is obviously too low. It is therefore adequate to conclude that a large share of imports such as office machinery, servers, telecom equipment etc. is also used for capital investments.

Subcontracting and early exporting activity is very typical to Estonian IT sector, indicating the fact that penetration to international markets has been relatively passive and conservative. Sales representation was founded by only 9% of the companies, production plants and foreign agencies by 4%.

Investments into foreign IT companies were evident for 5% of the respondents. Considering the nature of information technology and its relatively low dependency on location, cross border investments and expansion could be more intensive. Still, it is highly probable that companies will continue to pursue somewhat more active expansion strategies, especially in context of the closest neighbouring countries like Latvia and Lithuania, whereas competing against Scandinavian companies is still challenging. Often the limitations are also derived from low capacity associated with limited number of human potential in the ICT field.

4.3. Productivity

Productivity is essential measure in evaluating nation’s competitiveness, as it reflects an underlying wealth generating ability of a particular economy, but is also an indicator for quality of life in general. Rising productivity contributes to increasing national income in the form of potentially higher labour compensation rate. Still, as higher labour expenses are covered by additional production, nation’s competitive edge is well sustained.

Productivity is usually defined as a ratio of volume measure of output to a volume measure of input use. This is the basic understanding with more comprehensive approach including also the dimension of value into the concept. Indeed, the value of output generates genuine wealth, whilst higher value can be achieved with ever decreasing volume. Therefore, in the present analysis we focus primarily on assessing productivity in IT sector based upon output value measures and general value based growth rates.

OECD Productivity Manual (2000) indicates basically four non-parametric input based productivity measures. In terms of the present evaluation two of these measures are found to be most appropriate i.e. labour and labour-capital based indicators. It is possible to assess productivity also on the basis of output type, either using gross output or value-added based approaches. The latter one represents our prime interest, as according to the Manual in comparison with growth output based productivity measure value added productivity is less dependent on any change in the ratio between intermediate inputs and labour, or degree of vertical integration. For instance, it is the case of outsourcing, when labour is replaced by intermediate inputs. Also, value-added approach does not leave out any direct effects of technical change, be they embodied or disembodied.

Another reason for using value-added concept is justified by its ability to convey the extent of additionally created value. Whilst gross output indicates the level of production, it does not reflect inherently how much of that value is contributed by the nation. Furthermore, value-added can be in a way referred as a gross profit margin, which is rather objective basis for conducting further comparative analysis both between different sectors, clusters or even economies.

As Estonian Statistical Office does not pursue IT sector-specific data collection procedure yet, the methodology for evaluating IT sector's competitiveness has proceeded from alternative basis. A sample of IT companies was examined, based on the data extracted from Estonian Business Registry database (covering in fact up to 90% of IT sector by turnover), while their value added and productivity measures were calculated on the basis of the relevant profit statements. In the present case productivity is defined as amount of produced value added in kroons per kroon spent on labour, but also value added in kroons per kroon spent on labour and investment. Investment is measured by yearly depreciation as most appropriate proxy for used amount of capital. The rationale behind these measures is to express productivity in terms of the monetary gains received from every invested kroon. An advantage of such measure is embedded in the fact that real changes in value of money do not affect the ratio substantially, besides it enables to filter out the tendency of smaller companies to reduce artificially corporate tax rates[17] as value added is calculated by subtracting the cost of materials, supplies, fuels, purchased electricity from total revenues and by adding net change in finished goods and work in process inventories. Thus, the measure does not include other unproductive costs that are actually reducing profit margins.

For domestic ICT companies, in 1999 average value added per kroon spent on labour expenses was approximately 3,4 Estonian kroons. In 1998 the measure was 3,7 EEK per labour expense unit. In other words, every kroon invested in labour generated about 3,5 kroons of value added, or in financial terms one can consider gross return on labour to be 350%. Median values 2,7 for 1999 and 2,5 for 2000 were however somewhat lower, though more objective, as enormously large deviations are filtered out. Highest average value added emanated from telecom sector – approximately 7 kroons per labour expense unit, lowest 2,5 in electronics manufacturing sector, industrial automation.

Labour productivity alone does not fully reflect overall efficiency; it is also imperative to observe how effectively is labour combined with existing stock of capital. Thus, value added in kroons per kroon spent on labour and investments is derived. Based on the sample one can assert average value added of 2,7 kroons per unit of expenses in 1998 with slight decrease in 1999 to 2,6 kroons. Median values are relevantly 2,2 and 2 kroons of value added per unit of labour and capital expenses. Highest value added of 3,5 kroons is in hardware-software sale

[17] From year 2000 corporate profits are not subject of taxation in Estonia. However, before year 2000 corporate profits were tax-eligible.

and computer maintenance, lowest again in electronics sector, average of 2 kroons. However, one should be relatively cautious in interpreting these results – high value added in sales sector might indicate low investment level, whilst at the same time branches investing presently heavily might generate high value added in the future. Therefore, it is worthwhile to assess present state on the background of future developments, where f.i. telecom sector has large potential, as initial large capital investments are now beginning to produce higher value added. High capitalization of telecom sector and heavy investments into infrastructure are also evident by the capital-labour ratio, which is largest for telecom across different ICT sub-sectors, approaching 1,5. All other sub-sectors yield substantially lower ratios, where labour expenses are predominant. Lowest capitalization is in electronics sector, somewhere between 0,1 – 0,2. Average capital-labour ratio in ICT sector is about 0,3, confirming the fact that ICT sector is fundamentally grounded on human capital.

As the above analysis is based on sample, it is useful to limit comparisons of productivity levels to the sample. In order to apply extended analysis between productivities of different economic sectors, we have used "Financial Statistics of Enterprises Yearbook 1999" issued by Estonian Statistical Office, which has larger coverage, though ICT is not indicated there as a uniform sector. Therefore, one needs some intuition in assessing the performance of the sector based upon the general data. The basic methodology in calculating labour productivity is analogous to that applied above. According to table 7 most productive sector is Post and Telecommunication, which partly constitutes also ICT sector defined by present report. As expected, Forestry and Logging as traditional Estonian industry and Transit as highly increasing and consolidated economic sectors both sustain high productivity.

Productivity in different fields of economic activity in Estonia

T a b l e 7

Sector	*VA per kroon spent on labour in 2000*	*VA per kroon spent on labour in 1997*
Post and telecommunication	3,25	2,89
Transport, storage and communication	2,37	2,14
Forestry, logging and related activities	2,04	1,74
Electricity, gas and water supply	1,89	1,73
Manufacturing	1,61	1,6
Wholesale and retail trade	1,59	1,53
Real estate, renting and business activities	1,56	1,65
Fishing	1,54	1,24
Hotels and restaurants	1,52	1,73
Computer and related activities	1,51	1,9
Mining	1,47	1,51
Construction	1,43	1,43
Agriculture, hunting and related service activities	1,31	1,26
Education	1,28	1,48

Source: calculated based on Estonian Business Registry

However, computer and related activities have rather low productivity ranking in comparison to other, more traditional economic sectors. In 1997 the relevant figure for computer and related activities was 1,9 or in other words every kroon invested into labour bore 190% interest. Presently value added has decreased to 1,51 kroons per kroon invested into labour. The tendency indicates fast rise in labour expenses evidently due to higher competition amongst enterprises for qualified personnel and due to larger foreign demand for computer related products and services. Post and telecom sector is in relatively better situation compared to 1997, since its productivity has led labour expense growth. Further fast rise of wage in ICT sector might undermine the present position both nationally as well as internationally, as salaries absorb relatively large share of gross profits and leave fewer resources for investments.

As seen above, telecom has a distinct lead in productivity. However, due to monopolistic power of Estonian Telephone until year 2001 value added generated by the sector had a tendency to overestimate productivity level under competitive constraints. The growth of value added in telecom is gradually stabilising, with larger productivity shifting to services and software sectors. It is estimated that in 2001 telecom growth will be approximately 10%, while services sector is expected to expand by 24% and software 18,6% (EITO Yearbook 2000).

5. Estonian ICT cluster in international comparison

Economic openness and relative transparency of Estonian economic system derives also adequate economic responsiveness to major developments on international markets. Therefore, being part of a global competitive scene it is imperative to consider linkages and competitive sustainability of Estonian ICT cluster on a somewhat more general basis, extending observation also to an international context.

Estonian ICT market is rather small compared to other West and East European countries. Due to limited number of IT users as well as relatively low purchasing power the demand for ICT products stays consequentially low. In relative terms, Estonian market size per capita is 373 Euros (based on EITO 2000 and population statistics), approximately equal to that of Czech's and Slovenia's, however being more than 5 times less compared to technology forerunner Sweden (see Figure 6).

In OECD comparison, Estonian ICT export specialisation as measured by RCSA index[18] is approximately 1,84. It is on average 84% more than the relative figure for an ICT cluster in an OECD country would indicate. It could be related to Estonian limited domestic market. Small domestic market supports incentives for finding market outlets in other regions via channelling rather high share of ICT products to exports – 21% of GDP, including however also low value added re-export of Elcoteq's electronic equipment that alone accounts for approximately one fourth of the figure. For a comparison, European average ICT exports is somewhere around 2% of aggregate GDP.

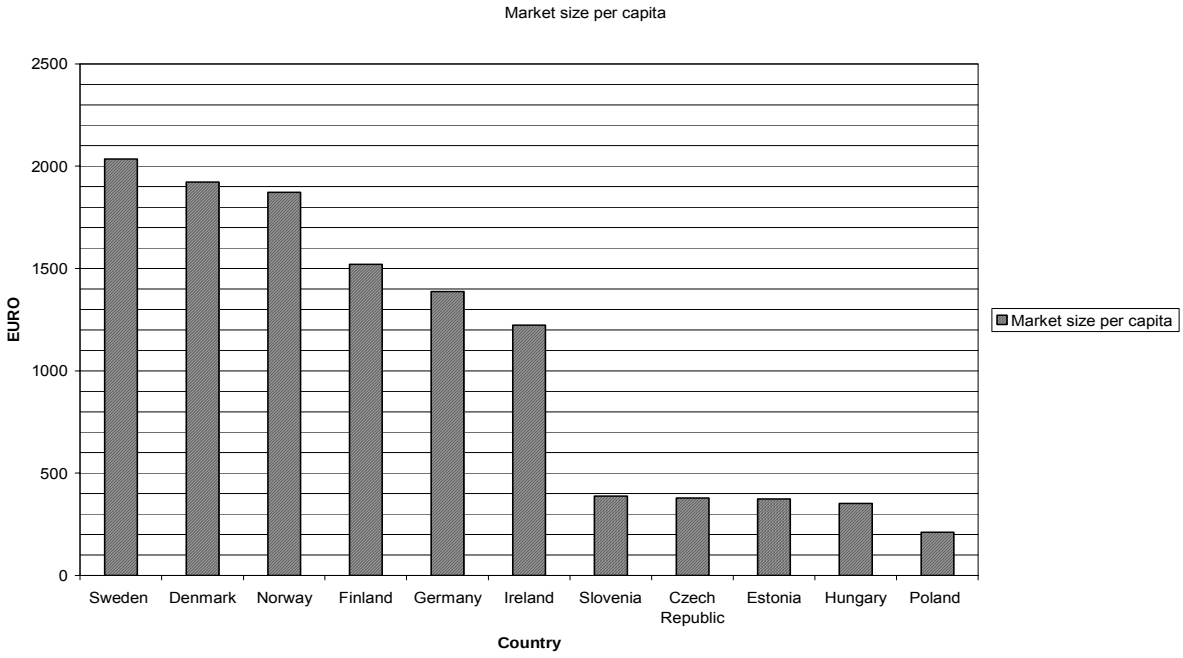

Figure 6. Market size per capita, year 2000. Source: EITO 2000, EU Population Statistics

[18] RCA (Revealed Comparative Advantage) index is calculated as follows

$$RSA = \frac{X_{ij} / \sum_{i=1}^{n} X_{ij}}{\sum_{j=1}^{n} X_{ij} / \sum_{i=1}^{n} \sum_{j=1}^{n} X_{ij}},$$ where *Xij* is the exports of the cluster *i* from the country *j*, and ∑*Hij* is the total exports form the country. The nominator denotes the share of OECD cluster *i* of total OECD exports.

Structurally, Estonian ICT cluster incorporates some similarities with Finnish cluster, partly conditional on regional and economical proximity, partly due to analogous orientations and priorities. However, in Estonian case the development of ICT cluster is still very much in an embryonic phase. It is reasonable to assume, that due to regional cohesion Estonian ICT cluster converges more and more with Scandinavian ones, in particular with Finnish and Swedish one. At the same time one has to bear in mind that this convergence can be successful only in case Estonia manages to excel in absorbing innovative solutions generated by Scandinavian companies and offer adequate knowledge base to compete at the same level with the Nordic neighbours.

Table in annex I reveals tight relationships with Scandinavian ICT cluster, as most of Estonian ICT export is channelled to Scandinavia. Important trade partner is also Latvia, which is export market for a number of ICT goods.

Key industries for Finnish technology cluster are ICT equipment, network operation and network services as well as digital content provision. Production is largest in manufacturing field, 66% of total goods and services. Services constitute the other 34%, prevailed by telecom services. There is well established interaction between telecom sector, IT services and software producers as well as digital content providers, conforming thus to elementary conditions for establishing highly competitive ICT cluster. In case of Estonia these interactions are not so evident, except for telecom equipment and services, and banking.

In 1998, in Finland value added per employee employed by the ICT cluster was 99960 EURs. The relevant weighted average figure for Estonian counterpart is approximately 17000 EURs, thus about 6 times lower. Still, on comparative labour costs basis value added produced by Finnish worker constituted 3,2 FIMs for a one FIM spent on labour, approximately the same figure yielded by Estonian telecom sector, which has dominating part in Estonian ICT cluster. However, computer services domain yields rarely 1,5 kroons per kroon spent on labour.

In terms of key industries, Finnish cluster is more balanced, as services constitute above 1/3 of total revenues. Estonian ICT cluster is substantially more biased towards low value added production, which share is as large as 96%, leaving the rest 4% to services section. This fact indicates that tertian sector is still missing in terms of ICT cluster, making it more dependent on global developments. Services are often attached to local market, therefore these represent the more stable part in worldwide economic relations.

In Sweden electronics industry accounts for 36% of total revenues, while IT related service companies produce 64% of revenues. It clearly indicates that the share of services is prevailing in Sweden, on the contrast to Estonia. Value added per ICT cluster employee is 71643 EURs, thus a bit lower than in Finland, but still four times higher than in Estonia. Exports of Swedish ICT cluster gave 112 billion SEK, of that 73% was related to communications equipment (Swedish…). As to Estonia, telecom equipment gave 85% of total exports.

The list of supporting industries is rather short for Estonian ICT cluster. Main support industry is parts and components manufacturing, also contract manufacturing, while the role of education and R&D is rather inconsistent. In terms of associated services reliance on venture capital is rather low, the case is also for consultancy.

Related industries, such as banking, consumer electronics and public services, have important interaction with Estonian ICT cluster analogously to the Finnish one. However, such domains as entertainment, advertising, traditional media etc. have presently very limited effect on the development of the cluster, whereas in Finland these fields have quite important role to play.

Figure Y outlines export growth potential for different EU countries based upon their net export statistics and competitiveness performance. Vertical axis is denoted with value added per wage unit for a countries' ICT sector, horizontal axis reflects net export per capita. Intuitively, one can admit that countries with larger value added per wage unit have greater

potential to increase their ICT related exports, as they possess higher capability of generating larger income and thus have good prospective in attracting ICT industry players more efficiently. Certainly, the level of wages is by far not the only criteria for investment and location decisions, but considering rather similar economic structure of western European countries, relative labour costs play important role. On the basis of these findings it can be expected for instance that Austria's negative net export will gradually decrease, since the present competitiveness index is the largest. One the other hand, for Belgium it is relatively difficult to overcome the negative gap as relative productivity as defined by the presented value added figure is lower than in other countries.

In terms of Estonia, outlook remains rather promising due to relatively high value added margin in comparison to the present wage level. At the same time, it is imperative to notice that very probably wages will keep increasing in the future, therefore, in order to maintain good competitiveness position it is necessary to boost productivity in line with increases in average wage level.

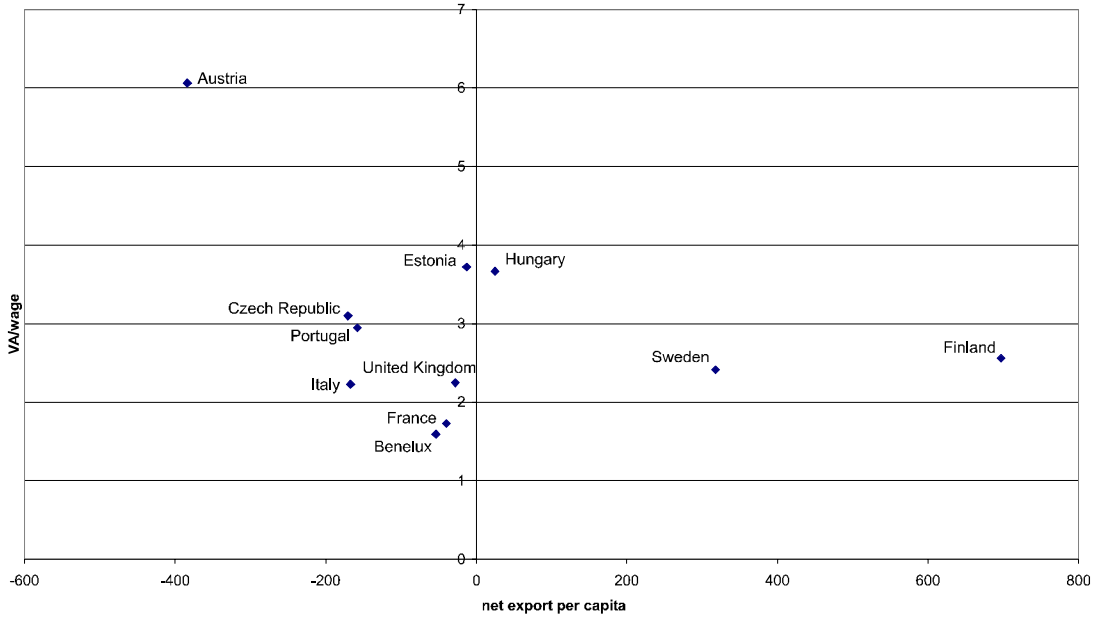

Figure 7. Export growth potential

6. Clustering in Estonian ICT sector - main findings

The present study revealed the following concluding results. The basis for close interrelation between Porter's diamond determinants is potentially existing, but not realised at the present moment. All the broad attributes of Porter's diamond are still evolving, however their interaction has been a way too occasional to form a distinguished and internationally competitive ICT cluster. The main findings are summarised on the figure 8.

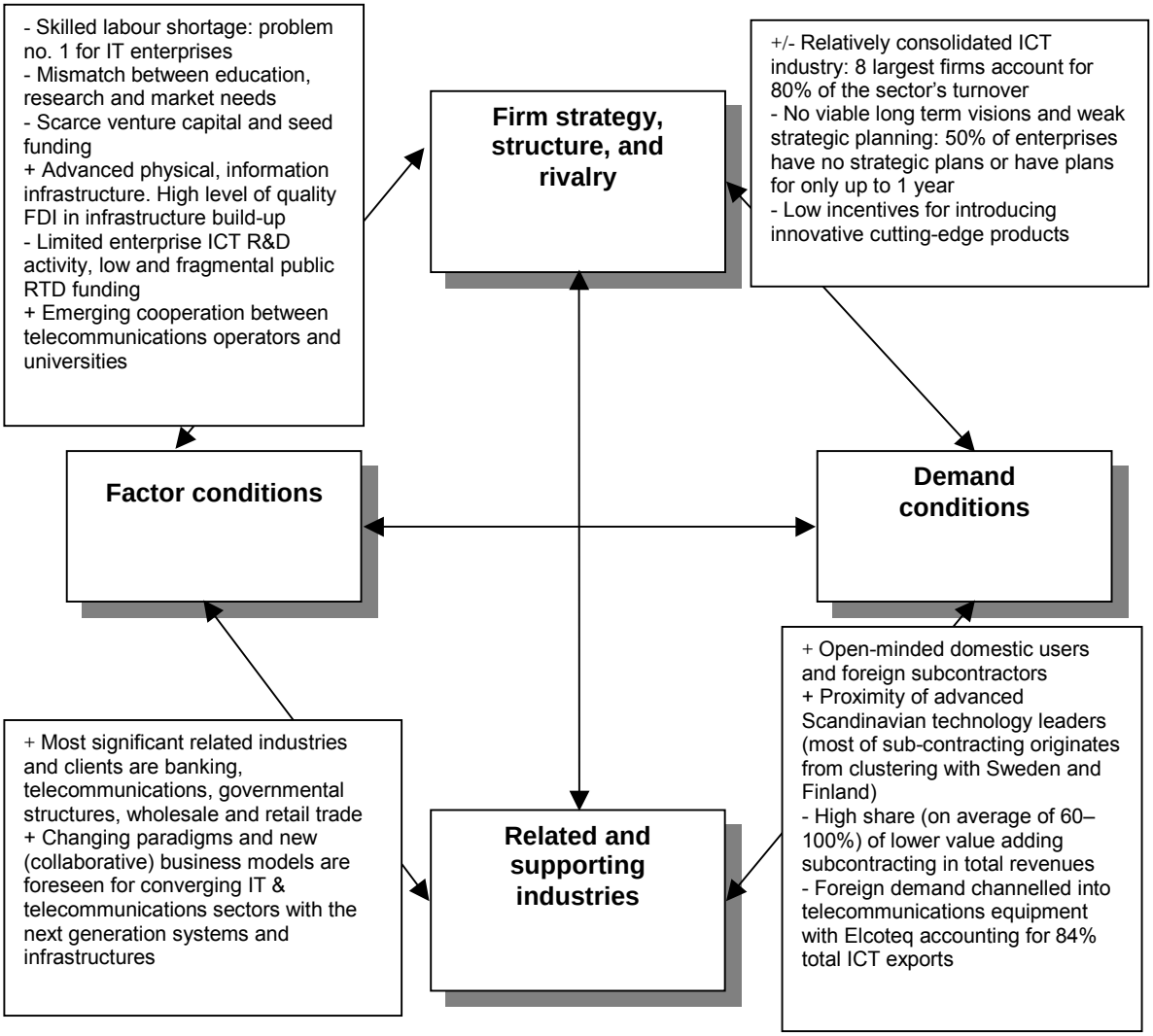

Figure 8. Estonian ICT cluster – competitive advantages and disadvantages

Factor conditions in Estonian ICT industry comprise of skilled labour, advanced physical, administrative and information infrastructure, functioning capital market and medium quality scientific as well as research infrastructure. There are deficiencies in almost all named categories, which necessitate dedicated efforts in overcoming these on the level of highest decision power.

Skilled labour has an underlying role in the development of the ICT sector. However, there is serious skilled labour shortage on the market. On one hand, this situation is caused due to the discrepancies between market tailored skills need and the education provided by universities and other higher education institutions. On the other hand, many young scholars are attracted by lucrative opportunities in making a professional career in private sector for substantially higher compensation rates. A number of undergraduates are engaged in working, putting thus smaller accent on the quality of their studies in university. The shortage of skilled labour has therefore twofold effect: firstly, a number of intellectually promising

individuals disrupt their studies at university and leave for relatively low value adding and intellectually unchallenging work in a small or medium sized IT companies due to alluring earning opportunities. Secondly, low competition in the domain of IT specialists does not facilitate personal development and skills enhancement, lowers motivation to generate new innovative solutions and distinguish thus from other competitors.

Research and scientific projects conducted under the facilities of universities are predominantly derived by the interests of scientists with either low market relevance or insufficiently performed marketing push. Older generation of scientists is often biased towards basic research and is not fully aware of practical market driven requirements. On the other hand, innovations from private sector are occasional, since there is a lack of R&D staff as well as overload of orders that keeps the innovation incentives low. Positive signs can be observed only in telecom sector, which has built strong links with universities and research groups, and pursues research activities also in-house. Another sector that has been successful in providing market tailored innovations is banking with its own development groups.

Physical, administrative as well as information infrastructure are generally well developed. In this context the proximity of advanced Scandinavian technology forerunners is significant driver. Rapid uptake of novel technologies, enhanced wireless communication infrastructure, high number of conventional telephone lines and internet hosts have created a favourable platform for building up appropriate forms of applications. Regulatory environment does not generally impede entering the ICT market, and over-regulation is not the case.

Capital market is well functioning, but not efficient enough to provide funding to start-ups and new companies. Main sources for outside funding are banks, but claims for collateral eradicate almost every possibility for a smaller company to receive necessary financing. Venture capital is scarce with only a couple of companies present, thus insufficient channel for bringing new ideas to the market.

Demand conditions are determined by open-minded domestic as well as foreign sophisticated users. Willingness to use wireless services by domestic users accompanied by the affection to use mobile phones has had a positive impact on advances in telecom sector. Internet banking solutions provided by Estonian banks have found good response amongst users. In the rest domains most of demand is derived however either by local corporate institutions or foreign enterprises, who either outsource services or subcontract production from local IT firms.

Subcontracting is actually an important activity in competing with each other, as most of orders to indigenous enterprises originate from abroad. Typically, subcontracting involves assembly of various communication equipment and software outsourcing. As a result, subcontracting revenues constitute 60-100% of turnover of telecom equipment production, industrial automation, consumer electronics and components, and about 15% of computers and office machinery sub-sector. Due to high foreign demand export of Estonian ICT industry has increased fast. On the downside, most of the rise can be assigned to a single company's activity. Elcoteq provides 83% of total Estonian ICT exports and 96% of telecommunications equipment. Thus, demand conditions that are channelled to local market via exports and subcontracting are actually distorting, as this demand is essentially limited to an activity of a single company. Subcontracting is definitely an important source of income to local companies, but lacks innovation as the work done is contractually fixed and the motivation to develop new solutions relatively low. The share of services is marginal in total Estonian ICT exports, comprising only 4%. Low share of services is an impeding factor to the cluster development as a whole, since services bound together a substantial part of accompanying activities such as computer services, multimedia production and content creation, which comprise the application part of existing hardware and software solutions. Neighbouring Scandinavian countries have by far more balanced trade portfolio, as services account for 1/3 of their ICT exports.

Most of subcontracting originates from local market as well as Finland and Sweden. Finland and Sweden are also the largest trade partners for Estonian ICT industry. 84% of ICT goods

are exported to these two countries. It gives a good reason to believe that Estonian ICT cluster is actually a sub-part of larger Scandinavian ICT cluster, where lower value added activities in the form of outsourcing and sub-contracting are performed. The effect of Scandinavia can be summed up in dual manner: on one hand, it has facilitated the uptake of novel technology and provided Estonian companies with sustainable income through subcontracting, on the other hand reinforces the lock-in effect as Estonian ICT industry is captured in low value added technology serving activity without any innovative incentives left.

From domestic industries manufacturing, telecom sector, banking, wholesale and retail and governmental structures are the important drivers of emerging Estonian ICT cluster as they demand most of the production generated by the ICT sector. Above mentioned sectors are also the **related and supporting industries** of Estonian ICT cluster. Observing the related industries provides valuable hints about the factors that have impact on the activities related to the cluster framework. Evidently, fast development of Estonian banking sector and high tech solutions elaborated by banks' own product development departments have reinforced the need for quality software and trustworthy and secure products, thus having positive effect on generating innovative solutions. This need is well reflected in the everyday work of Estonian software companies, who provide competitive software, including trust and security products. Collaborative actions undertaken with telecom operators have established strong links between these two sectors, paving the way for future m-commerce related activities. However, in this context the relations with content providers are insufficient, meaning that these relations have to develop in order a functioning m-business could appear.

Governmental structures are important users of telecom equipment and services, office machinery, computers and software, whereas government's affection towards novel technological solutions has had a positive effect on a number of public sector initiatives. Manufacturing is relatively consolidated sector generating mainly the demand for telecom equipment and related IT hardware. Due to the fact that Estonian manufacturing sector is mainly low-tech, the innovation complying to the needs of the sector is also low.

As fundamental changes in the related and supporting industries are not foreseen in the closer future, the environment, where Estonian ICT cluster presently operates, will evidently remain stable.

Firm strategy, structure and rivalry mark the level of consolidation and pressure to innovate under competitive conditions. In general terms, Estonian ICT sector is relatively consolidated upon turnover statistics. 8 largest companies account for approximately 80% of Estonian ICT market. Out of these, telecom enterprises are well dominating. There are three rivals in telecom market, but considering the size and market of Estonia there is not much room left for other intruders. Competitions in telecom domain has resulted in a number of interesting solutions as well as fast replication of Scandinavian developments.

There are also a number of smaller IT companies, but the market share they account for is almost irrelevant from the prospective of cluster development. Even there, companies manage to find enough orders to earn sufficient income. The innovative incentives are therefore relatively low, companies do not perceive necessity to elaborate new solutions. Mostly, they try to be fast followers in the sense of innovation, and utilise the novel products made elsewhere. Firms' strategy and rivalry are rather weak aspects, as strategic plans of the companies are not fully developed and rivalry is low, as demand conditions favour at the moment the existence of so large number of ICT companies.

The direct result of effective cluster interaction is higher productivity due to commonly shared infrastructure, know-how spill-over, concentrated competition as well as innovative incentives. With a view to Estonian ICT cluster productivity as an indicator of national as well as international competitiveness is highest in post and telecom sector. Computer services hold medium position. Also, within the cluster, telecom services have highest value added generating ability. In international context Estonia's outlook is good, as competitive index of 'value added per labour expense unit' is well above majority of countries. Still, one should not overestimate the result, as it is only one possible approach out of several ones.

Based upon the results of cluster study Estonia can be classified at the moment as investment driven economy. Transition to innovation driven economy has to be undertaken, which is the most challenging part in competing against other countries. Governments role here is clear: it is necessary to foster high rate of innovation through public as well as private investments into research and development, higher education and improved capital markets. Advantages in factor conditions might disappear in case a nation fails to offer alternative benefits such as highly innovative product creation environment.

7. Conclusions

- Estonian ICT sector is relatively consolidated upon turnover statistics. 8 largest companies account for approximately 80% of Estonian ICT market. Out of these, telecom enterprises are presently a driving force.
- Estonian ICT cluster in the present context comprises of telecom equipment production, telecom services, computer services, incorporating some fields of manufacturing, wholesale and retail, banking and governmental structures. The core segment of the cluster is telecom, all the rest segments are either supporting industries or related.
- Subcontracting is important aspect in the development of local ICT industry. Subcontracting is highest in electronics sector – telecom equipment production, industrial automation, consumer electronics and components, where subcontracting revenues range between 60-100% of turnover and lowest in computers and office machinery with average of 15%.
- Export of Estonian ICT industry has increased fast, however most of the rise can be assigned to Elcoteq's activity. Elcoteq provided 83% of total Estonian ICT exports in 2000. In telecommunications domain the company accounted for as large as 96%. Therefore, all developments in Estonian ICT exports should be closely viewed in line with Elcoteq's activity.
- The share of services is marginal in total Estonian ICT exports, comprising only 4%. Neighbouring Scandinavian countries have by far more balanced trade portfolio, as services comprise up to 1/3 of ICT exports.
- Largest trade partners for ICT goods exports are Finland and Sweden. 84% of total exports serve the markets of these countries. Intuitively and grounding also on the large subcontracting share of Estonian ICT companies, one can observe Estonian ICT cluster as a part of larger Scandinavian ICT cluster.
- Productivity as an indicator of national as well as international competitiveness is on national scales highest in post and telecom sector. Computer services hold medium position. Also, within the cluster, telecom services have highest value added generating ability. In international context Estonia's outlook is good, as competitive index of 'value added per labour expense unit' is well above majority's of countries. Still, one should not overestimate the result, as it is only one possible approach out of several ones.
- Finally, all four dimensions of Porter's diamond are evolving in Estonian context. However, there is no distinct lead or progress in any of these. In view of production factors, most important factor is skills and experience. Still, though there are a number of good ICT specialists, several deficiencies are associated with IT related education and relevant market needs.

  Demand conditions are developing gradually, as most of input and output are represented by telecom sector. Other main contributors to demand are manufacturing sector, governmental structures, banking, wholesale and retail. All these sectors have good potential for further augmentation, thus rising demand is very probable. The situation in related industries is mixed, as banking, manufacturing and telecom are very consolidated sectors, at the same time wholesale and retail as well as governmental structures are extensive in their nature. The fourth element of the diamond, firms strategy and rivalry are rather weak aspects, as strategic plans of the companies are not fully developed and rivalry is low, as demand conditions favour at the moment the existence of so large number of ICT companies.

  Thus, in conclusion, from economic prospective Estonian ICT cluster is evolving, though competitive edge is not evident. However, there is some potential associated with telecom industry, electronics design, and software production. In international comparison there is a good basis for regional cohesion with Scandinavian ICT cluster, however at a price of being somewhat lower value adding performer in the production value chain.

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Main Estonian trade partners for ICT goods (1998, thousands of EEK)

	Export	Import
Manufacture of office machinery and equipment		
Latvia	92159	10292
Sweden	71495	93329
Finland	61908	307268
Lithuania	37159	6146
Singapore	15918	43684
Russian Federation	11313	7547
Mauritius	8690	0
Germany	5117	49727
Ukraine	5043	427
United States	4361	156565
Manufacture of insulated wire and cable		
Finland	92542	187321
United Kingdom	76102	18527
Latvia	41445	2536
Lithuania	36325	1635
Sweden	33712	45530
Russian Federation	987	9849
France	624	6756
Manufacture of radio, television and communication equipment and apparatus		
Sweden	2860473	1279076
Finland	2287815	2404500
Hungary	94984	16962
United States	73450	186007
Latvia	46435	20529
Korea, Republic of	40343	81280
Denmark	32931	65632
United Kingdom	31333	145190
Germany	27871	443625
Hong Kong	23335	34121
Manufacture of medical, precision and optical instruments, watches and clocks		
Finland	358446	252513
Russian Federation	107949	18625
Sweden	90100	95158
Latvia	47232	42923
Germany	31684	214362
United States	28953	95669
Ukraine	23249	1581
Lithuania	22608	13216
Canada	8163	2927
Kazakstan	7204	0

Source: Statistical Office of Estonia, Foreign Trade, 1999