THE ESTONIAN ICT MANUFACTURING AND SOFTWARE INDUSTRY:

Current State and Future Outlook

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FOREWORD

The existence and development of ICT manufacturing and software industries is of great importance in the long-run for any country as these industries directly or indirectly contribute to the production and export of internationally competitive products and services. At the same time they maintain or increase people's real income. The export of goods and services, together with an increase in real incomes, is the only way forward to sustainable economic development.[1] Today exports mostly consist of manufactured goods and the role of medium and high-tech manufacturing industries is increasing at the expense of low-tech industrial goods. The five fastest-growing products in world trade during 1980–1997 were high-tech information and communication technologies.[2] Thus, if small economies are to take an active part in the world economy, especially important for them due to their open nature, it is vital that they upgrade their economic systems through more technology-intensive industries. Generic technology industries (the ICT industry is an example) also provide spillovers to other sectors of the economy, thus playing a crucial role in upgrading. This report looks at the Estonian ICT manufacturing industry from this perspective.

Although software industries currently represent less than 10% of the total ICT market in the OECD area,[3] they are growing fast and face many challenges.[4] Compared to ICT manufacturing industries where efficiencies of scale and sales are on a global level, the local clustering of the software industries with other local sectors is more evident. We will therefore take a closer look at the Estonian software industry as well.

To understand the socio-economic impact of ICT in the acceding and candidate countries,[5] the Institute for Prospective Technological Studies (IPTS) has launched a number of studies as part of a project on Foresight on Information Society Technologies in an Enlarged Europe (FISTE).[6] This paper is one in a series of national contributions[7] which aim to provide data on the size of ICT manufacturing and software industries and their development trends in the acceding and candidate countries, and on the largest companies in both industries. It also provides an insight into the challenges these countries and companies must face, if the Lisbon objectives are to be achieved.

This paper uses the methodology provided by IPTS and offers a statistical view and a listing of leading companies with some anecdotal evidence about each. The paper is strongly based on existing studies on the topic. In addition, databases of the Statistical Office of Estonia and the Centre of Registers (a State agency that keeps the Central Commercial Register and works under the Ministry of Justice) were used. However, the methodological issues raised when exploring such questions are numerous, starting with the scarcity of current data, the absence of commonly agreed frameworks and the resulting difficulties with comparing data between countries. The report, nevertheless, tries to document these complex issues by analysing and contrasting available data from various sources, including interviews or press releases. International sources have been used in a traditional way, but further information at micro-level provides a close-up of the dynamics of a rapidly evolving economic sector. This gives

[1] *Industrial Development Report 2002/2003. Competing through Innovation and Learning*, United Nations Industrial Development Organization (UNIDO), http://www.unido.org/, 2002.

[2] *Ibid*, p. 15.

[3] *OECD Information Technology Outlook. ICTs and the Information Economy*, OECD, Paris: OECD Publications, 2002, p. 13.

[4] See, for example, Commentary: Business Software Needs a Revolution, *BusinessWeek Online*, http://www.businessweek.com/magazine/content/03_25/b3838630.htm, 2003.

[5] Bulgaria, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, Turkey.

[6] http://fiste.jrc.es/

[7] See also Corina Pascu, *Insights into the ICT Manufacturing and Software Industry in Romania*, EUR 21011 EN, Spain: Joint Research Centre (DG JRC), IPTS, ftp://ftp.jrc.es/pub/EURdoc/eur21011en.pdf, 2004.

originality to the contribution, which offers a genuine insight into the ICT manufacturing and software industry in Estonia, its current status and future outlook.

This paper will focus on the largest ICT manufacturing and software companies in 2002. Issues such as R&D intensiveness in Estonian ICT firms, links between companies and universities, etc., have been thoroughly analysed elsewhere and are not the central issue here.

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EXECUTIVE SUMMARY

The existence and development of ICT manufacturing and software industries is of great importance in the long run for any country as these industries directly or indirectly contribute to the production and export of internationally competitive products and services. At the same time they maintain or increase people's real income. This paper provides data on the size of the ICT manufacturing and software industries in Estonia, their development trends and largest companies. It also provides insight into the challenges Estonia and its ICT companies will face, if the Lisbon objectives are to be achieved.

The Estonian ICT market is dominated by telecommunication network services, which have 58% of the market (or 426 million EUR in 2003). The value of the IT market (excluding telecommunications) is estimated to be 216 million EUR (29% of the total market value – 740 million EUR). Per capita IT spending is 150 EUR which is higher than the CEE[8] average, but lower than the Western European average (735 EUR per capita). Hardware expenditure dominates IT spending.

Over the last decade, the Estonian economy has been modernized by foreign direct investment mainly from Sweden and Finland. Radio, TV, and communication equipment manufacturing has received 3% of total investments (2000). Among the TOP50 foreign investors in Estonia, there were two ICT manufacturing companies.

In 2001, Estonian ICT manufacturing production was 234 million EUR. It was dominated by the manufacture of radio, television and communication equipment (38% of total Estonian ICT manufacturing), followed by manufacture of electrical machinery and equipment (33%).

Estonian commodity exports are largely made up of electrical machinery, equipment and components. In 2002, the Estonian ICT manufacturing industry's total exports accounted for 21% of all Estonian commodity exports and amounted to 764 million EUR. The most export-intensive branch is manufacture of radio, television and communication equipment and apparatus (91% of industrial sales in 2001). Office machinery and computer manufacturing is the smallest segment of the Estonian ICT manufacturing industry and mainly supplies a small, local market.

The added value of the Estonian ICT manufacturing industry is 80 million EUR (7.9% of total manufacturing industry). Labour productivity in the ICT manufacturing branches that export the most is low - lower than the average indicator for the manufacturing industries.

The Estonian ICT manufacturing sector is dominated by five companies, mainly owned by investors from Finland, though cable manufacture belongs to Estonian capital.

Compared to the Estonian ICT manufacturing industry, which is largely consolidated, heavily export-intensive and based on foreign capital, the Estonian software industry sector is fragmented. Its development has been strongly influenced by the needs of the local market, especially banking, telecommunications and the governmental structure. The contribution of computer services to the value-added produced in Estonia is 47 million EUR (2001).

Among Estonia's TOP500 largest companies, there are 28 ICT companies (5.6% of the total for 2002). The 4 largest of these are telecommunications companies, followed by one ICT manufacturing company. There are 5 ICT manufacturing companies in total, although the line between computer manufacturing companies and retail/wholesale companies remains blurred. Overall, there are 7-10 ICT wholesale and retail companies in the list, and 8 software companies.

[8] CEE defined as consisting of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia

Empirical evidence (exports-imports, ownership, FDI, value-added, etc.) shows that the Estonian ICT manufacturing sector is actually part of the larger Nordic ICT manufacturing cluster**.** The main branches of the Estonian ICT manufacturing industry are exactly the same as those of Finland and Sweden. ICT manufacturing network flagships generally consist of Finnish and Swedish companies, which have subsidiaries, affiliates and joint ventures in Estonia. Empirical evidence does not support the widely held view that Estonian ICT manufacturing has been gradually moving from low value-added manufacturing towards higher value-added production**.**

Although participation in global production networks has potential for knowledge transfer, it is not automatic and requires a significant level of absorption on the part of local suppliers, who have to master a complex process in order to internalize disseminated knowledge. Currently most of the Estonian ICT manufacturing industry acts as a "lower-tier" supplier, its main competitive advantages being low cost ("price breaker"), speed, and flexibility of delivery. At the moment, existing ICT manufacturing companies are expanding and new ones are being established, as a result of Estonia's relatively low cost labour. However, real wages have risen much quicker than the overall productivity of Estonian economy and Estonian living standards are expected to converge with those of EU, leading to the loss of this advantage. As technologies and products mature, the stronger the cost-competition will be. Several flagships that currently have ICT manufacturing in Estonia are also expanding their manufacturing activities in China and other low-cost regions. As these parent companies face stronger and stronger cost-based competition, it is most probable that they will be forced to look outside Estonia for cheaper production areas in the long run.

Ambient Intelligence (*AmI*), expected to be a reality by 2010, envisages an Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. Basically, this vision argues for the extreme clustering of ICT manufacturing and software industries with other industries and service sectors. As Estonian companies have made an impressive success of the application of new technologies in some fields (banking, government) and in the development of intelligent user-friendly interfaces (for example, in the fields of mobile telecommunications, and e-health applications), they could also be successful in the realisation of the *"AmI Space"*.

Over the last decade, all industries in Estonia, particularly agricultural and resource-based industries (food and wood processing especially), have been very successful in modernizing companies and making them competitive, mainly via technology transfer from abroad. A further boost to productivity could come from clustering of the software industry and, to some extent, the ICT manufacturing industry with other branches of industry, although the currently low level of R&D investments by Estonian enterprises is a possible threat.

Incentives to innovate in the ICT industry will most probably arise in the service sector, as a result of continuous modernization in the public sector and innovations in the services field. Although these service innovations are relatively easy to implement, they are also difficult to export, as their competitive advantages are very much based on local specificities. Thus, only some of the already established companies that are plugged into global research, development and production networks will have success in exporting their service innovations to other countries.

Over the period of 2001-2003, there have been some improvements in the Estonian ICT Sector Innovation System related to the capital market. Steps have been taken to establish a public venture capital fund in Estonia using the Finnish Sitra as a model, though there is still extreme fragmentation of already small public R&D funding. Additionally, public ICT R&D funding does not actively favour university-enterprise partnerships for applied R&D. However, a recent support programme which finances centres initiated and operated jointly by companies and R&D institutions, seems to be addressing the issue. Mismatches between the skills developed and the needs of industry and commerce still exist.

PART I: CURRENT STATE

1. Introduction

Estonia is one of the smallest EU acceding countries and the smallest Baltic country with a population of only 1.4 million. It is often introduced as one of the most positive and successful examples of the transition process[9] and an emerging innovation-based economy.[10]

Table 1: Basic statistical data[11]

Population (000 – 2003)	Size (km2)	Employment rate (2002)	Unemployment rate (2002)	% of employment in manufacturing (2003 Q1)	GDP per capita (2002, in PPS, EU-15=100)
1,364	45,227	55.6	10.3	23.4	40.2
FDI (M € – 2002)	R&D expenditure as % of GDP (2001)	Total ICT production value (M € - 2001)	Total ICT Spending (M € - 2003)	Total IT Spending (M € - 2003)	IT spending/ GDP in % (2003)
307	0.78	233.9	740	216	3.1

The re-establishment of Estonia's political and economic independence from the Soviet Union took place in August 1991. The transition from a planned economy to a market economy was characterized by radical and rapid steps leading to relatively rapid macro-economic stabilization as compared with other transition economies. Estonia has also undergone strong liberalization of trade and foreign investment, and the Estonian State's direct involvement in economic life has decreased remarkably. For example, while state aid[12] in the acceding countries is, on average, 1.3% of GDP (2000), in Estonia it is 0.5%.[13]

In order to allow technology transfer, the improvement of managerial skills and more effective market competition, large-scale privatization was undertaken in Estonia and by 1995 most companies were privatized. Privatization of infrastructural enterprises, or attempts to privatize them, followed. Indeed, privatization has so far been one of the main factors influencing the inflow of foreign investment to Estonia.[14] Foreign-owned enterprises in most fields of activity have greater capital intensiveness and higher labour productivity; they pay higher wages and export more than domestic enterprises.[15]

Most foreign direct investment (FDI) originates from the neighbouring Nordic countries – in 2003, Sweden and Finland ranked top, with 42.8% and 27.0% of direct investment stock

[9] See, for example, *EBRD Transition Report 2000*, European Bank for Reconstruction and Development, London: Hyway Printing Group, 2000, pp. 14-15.

[10] See, for example, Slavo Radoševic, *Assessing Innovation Capacities of the Central and East European Countries in the Enlarged European Innovation System*, http://www.iwh-halle.de/projects/productivity-gap/prelim_results/WP3_Radosevic_01.pdf, 2002.

[11] Source: *IMF Country Report No. 03/331, Republic of Estonia: Selected Issues and Statistical Appendix*, IMF, www.imf.org, 2003; Eurostat data, http://europa.eu.int/comm/eurostat/, 2004; Statistical Office of Estonia; *European Information Technology Observatory*, European Information Technology Observatory (EITO) and European Economic Interest Grouping (EEIG), 2004.

[12] State aid, as defined under Article 87 of the Treaty on European Union, consists of any aid granted by a State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods.

[13] *State Aid Scoreboard, Special Edition on the Candidate Countries, COM(2002) 638 final*, Commission of the European Communities, http://europa.eu.int/eur-lex/en/com/cnc/2002/com2002_0638en01.pdf, 2002.

[14] Gábor Hunya, *International Competitiveness Impacts of FDI in CEEC, Background Paper for Special Session III on FDI and the Restructuring of Transition and Emerging Economies*, UN Economic Commission for Europe, 2000.

[15] Evis Sinani and Klaus Meyer, *Identifying Spillovers of Technology Transfer from FDI: the Case of Estonia*, Copenhagen Business School, 2001, pp. 13-14.

respectively.[16] FDI strongly favours the financial sector (29.8% of all FDI), followed by manufacturing (18.1%) and transport, storage, communication (17.4%).[17] This reveals the manufacturing industry's relative weakness and the relative strength of the finance and transportation sectors. In the manufacturing sectors, food and beverages occupy first place, followed by wood, publishing and printing, then textiles and clothing. By 2000, 2.9% of FDI into manufacturing had gone into radio, TV and communication equipment and 0% to office machinery and computers manufacturing. There were two ICT manufacturing companies among the TOP50 foreign investors in Estonia (2000).[18]

Estonia, like other Central and Eastern European transition economies, has competitive advantages mainly in the labour intensive (e.g. textile) and resource intensive (e.g. timber) industries, whereas the capital and technology intensive industries (for example, chemicals, machinery and equipment) are relatively uncompetitive.[19] The Estonian economy has, however, been successful in *catching-up*[20] with developed countries via the application of technologies, work organization and know-how imported from the more advanced countries, although several challenges still lie ahead. These are related to the commitment to bring about the economic, social and environmental renewal proposed in the EU's Lisbon Strategy, which will involve using innovation as the motor for economic change, and developing a *learning economy*. In fact, the current trends in Estonian economic development are *diverging* from the goals of Lisbon strategy. The technological structure of Estonia's manufacturing industry has evolved since the mid 1990s towards less complexity. The share of added value created by medium and high technology industries is decreasing: "*This in turn highlights that, despite an enviable record of economic growth, Estonia's industrial structure in 1996 was in better shape than in 2000".*[21] Although all industries in Estonia, particularly agricultural and resource-based industries (wood producers especially), have been very successful in modernizing companies and making them effective, almost none of this change has grown out of local value-chains. In other words, added value and productivity gains made by Estonian companies will not stay in Estonia and they will not create additional specialization. Instead they will profit the value-chains of the original technology producers. More often than not, these value-chains are Scandinavian.[22]

Table 2: Basic statistical time series[23]

	1998	1999	2000	2001	2002
Nominal GDP (Mil EUR)	4700	4878	5585	6257	6904
Real GDP (% change)	4.6	-0.6	7.3	6.5	6.0
Total FDI (Mil EUR)	516	284	425	603	307
Trade balance (Mil EUR)	-1005	-773	-840	-881	-1165
Trade balance / GDP	-21.4	-15.8	-15.0	-14.1	-16.9
Current account / GDP	-9.2	-4.7	-5.8	-6.0	-12.3
Unemployment (% of labour force)	9.9	12.3	13.7	12.6	10.3

[16] Bank of Estonia, *Direct investment stock by countries*, http://www.eestipank.info/, 2004.

[17] Bank of Estonia, Direct investment stock by fields of activity, http://www.eestipank.info/, 2004.

[18] OECD Reviews of Foreign Direct Investment. Estonia, OECD, 2001, pp. 19-20, 24-28.

[19] Peter Havlik, *Restructuring of CEE Manufacturing Industry*, Vienna Institute for International Economic Studies, 2002.

[20] See Moses Abramovitz, Catching Up, Forging Ahead, and Falling Behind, Journal of Economic History, vol. 46, no. 2, 1986, pp. 385-406.

[21] Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli (Estonian Research and Development Council in co-operation with PRAXIS), Competitiveness and Future Outlooks of the Estonian Economy, Tallinn: Research and Development Council, 2003, p. 27.

[22] Rainer Kattel and Riivo Anton, The Estonian Genome Project and Economic Development, *TRAMES*, vol. 8, pp, 106-128, 2004.

[23] Source: IMF Country Report No. 03/331, Republic of Estonia: Selected Issues and Statistical Appendix, IMF, www.imf.org, 2003.

2. The Estonian ICT Market

Various international reports on Information Society development have given Estonia credit for a good ICT infrastructure and a decent online environment.[24] Indeed, Estonia has succeeded in building up modern telecommunications infrastructures, computerizing the secondary education sector, making progress with the regulatory environment and setting up several large-scale programmes initiated by the government, NGOs and private sector.[25]

IT expenditure in Estonia is relatively high: 3.1% of GDP compared to 2.3% on average in CEE[26] (excluding telecommunications). However, in absolute terms the Estonian ICT market is very small, smaller than the Latvian and Lithuanian markets. It is estimated to be 740 million EUR, a 1.9% share of the total CEE market, the total value of which is estimated to be 39 billion EUR (2003).[27]

The Estonian ICT market is dominated by telecommunication network services which have 58% (or 426 million EUR) of the market (2003). Mobile telephony has a larger share (197 million EUR) than fixed voice telephone services (151 million EUR) and fixed data services (59 million EUR).[28] This is also illustrated by the fact that the TOP4 Estonian ICT companies by turnover are telecom operators: three mobile operators and a former incumbent fixed line operator (Table 14, Annex I).

The value of the IT market (excluding telecommunications) is estimated to be 216 million EUR (29% of the total market value). Although IT spending (150 EUR per capita) is much lower than IT spending in Western Europe (735 EUR per capita), it is still higher than the CEE average (111 EUR).[29] This provides empirical evidence of the uniqueness of Estonia: while in general there is a correlation between IT investments and levels of GDP, Estonia deviates from the norm in these indicators and others.[30]

As is typical of an economy that is in the catching-up phase, hardware expenditure dominates IT spending (computer hardware - 94 million EUR; datacom and network equipment - 90 million EUR[31]). However, with the upgrading of telecommunication networks and penetration of ICT equipment close to saturation levels, the Estonian IT market is slowly maturing and it can be expected that a larger share of spending will be devoted to software and services.

[24] For example, the United Nations Development Report 2002 places Estonia on the 30th place in the domain of general technological achievement. McConnell International report from 2001 places Estonia ahead of not only the most CEEC but also many highly industrialized Western European countries. The Global Information Technology Report 2001-2002 by Harvard University has given the ICT development in Estonia the 23rd ranking among 75 countries surveyed. For most recent benchmarking, see eEurope+ Final Progress Report, European Commission, http://www.emcis2004.hu, 2004.

[25] See Andre Krull, ICT Infrastructure and E-readiness Assessment Report: ESTONIA. A Report Financed by the InfoDev Program. PRAXIS Center for Policy Studies, www.praxis.ee, 2003; Tarmo Kalvet. Analysis of the Estonian ICT Sector Innovation System. ICT, Innovations and Innovation policy: The Case of Estonia, Tartu: SA Archimedes, http://www.esis.ee/eVikings/evaluation/eVikings_WP_Tarmo_Kalvet.pdf, 2002.

[26] CEE defined as consisting of Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.

[27] *European Information Technology Observatory*, European Information Technology Observatory (EITO) and European Economic Interest Grouping (EEIG), 2004, p. 84.

[28] Ibid, p. 290.

[29] Ibid, p. 73.

[30] Tarmo Kalvet, Estonia's Adaptation to ICT Based Society, pp. 18-30, in: Mari Kalkun and Tarmo Kalvet (Eds), Digital Divide in Estonia and How To Bridge It. E-book. PRAXIS, www.praxis.ee, 2002.

[31] European Information Technology Observatory, European Information Technology Observatory (EITO) and European Economic Interest Grouping (EEIG), 2004, p. 290.

3. The Estonian ICT Manufacturing Industry

During Soviet times, radio-electronic and semi-conductor industries were well developed in Estonia. However, in the early 1990s the whole industry collapsed.

Over the period 1992-2001, Estonian ICT manufacturing industry production grew by 30% *per annum* on average and is currently 234 million EUR (Table 3).[32] The share of ICT manufacturing industry output in manufacturing output as a whole also grew from 3.8% of total manufacturing in 1995 to 5.1% in 1998 and 6.1% in 2001.

Table 3: Estonian production and exports in ICT manufacturing, prices in 2001[33]

	Manufacture of radio, television and communication equipment and apparatus (NACE 32)	Manufacture of electrical machinery and apparatus (NACE 31)	Manufacture of medical, precision and optical instruments (NACE 33)	Manufacture of office machinery and computers (NACE 30)	Total
Value (million EUR)	**88.2**	**77.0**	52.7	16.0	233.9
% of total ICT manufacturing	**37.7**	**32.9**	22.5	6.9	100.0
Exports (% of production)	**90.5**	52.5	**81.2**	1.2	

The three leading ICT manufacturing branches are heavily export-intensive, their main markets being Finland and Sweden. The most export-intensive branch is manufacture of radio, television and communication equipment and apparatus (91% of industrial sales in 2001). An obviously smaller segment of the Estonian ICT industry (7% of production in 2001) is office machinery and computer manufacturing. This sector mainly supplies a small local market. The production of local computers is estimated to be 25,000 (2001).

The manufacture of radio, television and communication equipment makes up 38% of total Estonian ICT manufacturing in 2001, followed by the manufacture of electrical machinery and equipment (33%), although there have been major fluctuations over the last few years (Table 4).

Total Estonian commodity exports are heavily dominated by electrical machinery, equipment and components. In 2002, total Estonian ICT manufacturing industry exports [34] accounted for 21% of all Estonian commodity exports and amounted to 764 million EUR, having reached figures higher than 1 billion EUR in 2000 and 2001. However, such high figures are balanced by imports on a similar scale (18% of total imports, 910 million EUR in 2002) and are explained by the subcontracting nature of the Estonian ICT manufacturing industry and imports for inward processing.[35] It has also been linked to transfer pricing to take advantage of the Estonian tax system.[36]

[32] All data from Statistical Office of Estonia if not indicated otherwise.

[33] Source: Statistical Office of Estonia.

[34] According to Chapter 85 of the Harmonized System of international trade they include "Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles".

[35] In the case of exports the value of commodity is the selling value; in the case of imports, the value of commodity is the purchase value.

[36] Transfer pricing indicates to a practice of multinational companies of selling components from a high tax country to a subsidiary in a low tax one at an artificially low price. In Estonia, from 1 January 2000, corporate income tax level is 0%. Dividends and other profit distributions, fringe benefits, gifts and expenses not related to business are subject to tax at the grossed-up rate of 26/74 of the amount of taxable payment.

Table 4: Time series of production value of Estonian ICT manufacturing, mil EUR, current prices[37]

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Manufacture of radio, television and communication equipment and apparatus	4.1	5.0	3.6	6.1	19.2	28.7	32.6	40.3	75.2	88.2
Manufacture of electrical machinery and apparatus	19.2	12.8	19.6	26.9	31.6	37.5	37.5	46.5	65.6	77.0
Manufacture of medical, precision and optical instruments	5.8	7.5	9.0	10.3	13.0	26.0	46.8	47.0	66.4	52.7
Manufacture of office machinery and computers	0.1	0.7	2.9	8.4	8.4	13.8	24.1	16.4	15.6	16.0
Total	**29.1**	**26.0**	**35.1**	**51.6**	**72.3**	**106.0**	**141.1**	**150.2**	**222.8**	**233.9**

As supported by empirical evidence (exports-imports, ownership, FDI, value-added, etc.), the Estonian ICT manufacturing sector is actually part of the larger Nordic ICT manufacturing cluster. The main branches of the Estonian ICT manufacturing industry are exactly the same as those of Finland and Sweden. Finland is the fourth largest radio communications and mobile phone producer in Western Europe and Sweden is fifth after the United Kingdom, France and Germany. In Finland, the added value of the electronics industry was 6.5% of GDP in 2000 and Finnish electronics output increased by 32% in 2000, by 13% in 1999, 29%; in 1998, and 29% in 1997).[38] This major flourishing of ICT manufacturing in a neighbouring country has certainly provided spillovers, allowing Estonia to enter global production networks. Global production networks - a major organizational innovation - combine rapid dispersion of the value chain across firm and national boundaries, with a parallel process of integration of hierarchical layers of network participants.[39] ICT manufacturing network flagships generally consist of Finnish and Swedish companies, which have subsidiaries, affiliates and joint ventures in Estonia.

When looking at the value-added structure of the Estonian economy, however, it becomes clear that the role of ICT manufacturing in comparison with other branches of manufacturing is relatively small (Table 5). A similar conclusion is reached in the analysis of the Estonian exports structure. Although Sweden and Finland dominate Estonian international trade in absolute figures (especially exports of electrical machinery, equipment and components), Germany, Netherlands and Russia, for example, become more important when the value-added structure of exports is considered. Similarly, exports of food and wood products have a larger impact than ICT manufacturing on the Estonian economy.[40]

In 2002 there were 9,400 people employed in the manufacture of electrical machinery and apparatus (down from 10,600 in 2000, 10,700 in 2001, and 20,000 in 1989), although this figure seems to be overestimated.[41] Employment has remained fairly stable since 1994 although production volumes have increased over time (Table 4), showing the capital-intensiveness of the industry.

[37] Source: Statistical Office of Estonia

[38] *Yearbook of World Electronics Data 2003, Volume 1 - West Europe*, Reed Electronics Research, 2002, pp. 19, 90, 91.

[39] Dieter Ernst and Linsu Kim, Global Production Networks, Knowledge Diffusion, and Local Capability Formation, *Research Policy*, Vol. 31, Issues 8-9, pp. 1417-1429, 2002.

[40] Ülo Kaasik, *Eesti eksporditoodete lisandväärtus (Value-added of Estonian Export Commodities),* Tallinn: Eesti Pank, 2003.

[41] Will be elaboration in section 6.

Table 5: The added value of some economic activities, basic prices, 2001[42]

Economic activity	Added value	
	million EUR	% of total manufacturing
manufacture of electrical machinery and apparatus	36	3.5
manufacture of radio, television and communication equipment and apparatus	32	3.1
manufacture of medical, precision and optical instruments	10	1.0
manufacture of office machinery and computers	2	0.3
manufacture of food products and beverages	193	18.9
manufacture of wood and of products of wood and cork	137	13.4

The sub-contracting nature of the Estonian ICT manufacturing industry is also confirmed by the fact that labour productivity in the ICT manufacturing branches that export most is low, even lower then the average for the manufacturing industries. The difference is especially striking when ICT manufacturing labour productivity is compared with that of wood and food products manufacturing (Table 6).

Table 6: Productivity indicators, 2003, 3rd quarter[43]

	Labour productivity, EUR	Hour productivity, EUR	Productivity of labour costs, EUR
Economic activities total	9523	23.84	0.36
Manufacturing	9459	23.78	0.37
- manufacture of wood and wood products	12399	29.02	0.48
- manufacture of food products and beverages	11632	28.50	0.46
- manufacture of textiles	5560	15.59	0.31
- manufacture of office machinery and computers	29272	72.99	0.77
- manufacture of electrical machinery and apparatus	10226	25.31	0.30
- manufacture of medical, precision and optical instruments	7669	18.79	0.29
- manufacture of radio, television and communication equipment and apparatus	5369	13.55	0.23

Or, although production volumes have increased since 1997 about 2.2 times (Table 3), the added value in absolute terms has increased only 1.8 times and the share in total manufacturing has remained more or less the same (Table 7). **Thus, there is no empirical evidence for the widely held view that Estonian ICT manufacturing has been gradually moving from low value-added manufacturing towards higher value-added production.** It could even be argued that the production value of lower vlaue-added ICT manufacturing areas has increased much more rapidly (Table 4 and Table 6).

Table 7: Added value of ICT manufacturing, basic prices, respective year[44]

	1994	1995	1996	1997	1998	1999	2000	2001
Added value in electrical machinery, apparatus and appliances (mil EUR)	14.3	21.3	29.2	43.3	48.3	52.7	75.1	79.6
Added value (% of total manufacturing)	4.6	5.5	6.0	7.4	7.2	7.4	8.5	7.9
Change in added value-		0.9	0.5	1.4	-0.2	0.2	1.1	-0.6

[42] Source: Statistical Office of Estonia, *National Accounts of Estonia*, 2002.

[43] Source: Statistical Office of Estonia.

[44] Source: Statistical Office of Estonia, *National Accounts of Estonia,* 1994-2001.

4. The Estonian Software Industry

Compared to the Estonian ICT manufacturing industry, which is largely consolidated, heavily export-intensive and based on foreign capital, the Estonian software industry[45] is very different. The number of companies in the sector is very high, production volumes and exports are low and specialization is still not established. Although Estonia enjoys the presence of firms representing major Western software companies, such as Oracle, Microsoft, etc., these mainly limit themselves to selling and servicing software, and, to some extent, to localization.

The impact of Estonian traditional industries on the emergence of a local ICT sector, however, is marginal because traditional industries in Estonia are supplier-intensive. The technologies used are developed elsewhere with minimum participation of local companies.[46]
The development of the Estonian software industry has been largely influenced by developments in governmental structures. Legislation has created a favourable environment, and governmental structures have also been active in procuring innovative solutions from local companies. Some examples are the on-line services of the Taxation Board, the X-road initiative to modernize national databases, and the ID-card initiative, etc. The State has contributed a stable 1% of its total budget to financing ICT expenditure.[47] As local companies have mainly been contracted to provide customised solutions, positive spillovers have emerged. The efforts of governmental institutions to build up an Information Society in Estonia have been coupled with those of NGOs.

The banking sector has played at least as big a role as governmental structures. A modern banking system was already established in Estonia by 1993 and Internet banking services were introduced by 1996.[48] However, a strong software industry that could develop and service large-scale banking information systems was missing and Estonian banks had to build up their own in-house capacity. As a result, the banks have been the "informal" leaders in the software industry - the software divisions of Hansabank and Estonian Union Bank have more personnel than the biggest Estonian software companies. For example, approximately 250 of Hansabank's 2,245 employees are IT specialists and Ühispank, the second largest bank, employs 139 IT specialists.[49]

The conclusion that the telecommunications sector, and banking and governmental structures are the key drivers for Estonian ICT cluster[50] is also supported by a similar empirical study on 42 US industries. This study concludes that wholesale trade, the finance sector, and business services are the sectors with the largest IT investment and positive externalities.[51] Indeed, the reestablishment of governmental structures, the emergence of a private sector banking system and rapid development in wholesale and retail trade have all contributed to the emergence of the Estonian software industry.

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[45] Defined hereby as NACE 7220 - Software consultancy and supply.

[46] This argument is developed further in Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli (Estonian Research and Development Council in co-operation with PRAXIS), Competitiveness and Future Outlooks of the Estonian Economy, Tallinn: Research and Development Council, 2003, section 2.3.

[47] For more information on public sector IT projects, see *IT in Public Administration of Estonia 2002*, Estonian Informatics Center, http://www.ria.ee/english/2002/, 2003; *IT in Public Administration of Estonia 2000*, Estonian Informatics Center, http://www.ria.ee/english/2000/, 2001. See also Andre Krull, *ICT Infrastructure and E-readiness Assessment Report: ESTONIA. A Report Financed by the InfoDev Program*, PRAXIS Center for Policy Studies, www.praxis.ee, 2003, chapter 6; Mari Kalkun and Tarmo Kalvet (Eds), *Digital Divide in Estonia and How To Bridge It*. E-book. PRAXIS, www.praxis.ee, 2002.

[48] On the history of Internet banking in Estonia and analysis of success factors, see Katri Kerem, *Internet Banking in Estonia, A Report Financed by the InfoDev Program*. PRAXIS Center for Policy Studies, www.praxis.ee, 2003.

[49] Data on employment: *Äripäev*, March 10, 2003; data on Hansapank's employment from *Hansapank Annual Report 2003*, http://www.hansagroup.com/aa2003/Hansabank2003_eng.pdf, p. 25.

[50] On clustering in the Estonian ICT sector, see Tarmo Kalvet, Tarmo Pihl and Marek Tiits, *Analysis of the Estonian ICT Sector Innovation System. Executive Summary*, Tartu: SA Archimedes, http://www.esis.ee/eVikings/, 2002.

[51] Sung-Bae Mun and Ishaq M. Nadiri, *Information Technology Externalities: Empirical Evidence From 42 U.S. Industries*, NBER Working Paper No. 9272, http://www.nber.org/papers/w9272, 2002.

5. A Company-based Insight into the Estonian ICT Supply Side

Estonia registered 522 ICT manufacturing and software companies in 2001 (Table 8),[52] though the number of active enterprises[53] was actually 296.

Table 8: Number of companies in the ICT manufacturing and software sectors in Estonia, 2001[54]

		Active companies			Activity	NACE
No	%	No	%			
1	0.2	1	0.3	in	Manufacture of office machinery	3001
12	2.3	6	2.0	in	Manufacture of computers and other information processing equipment	3002
4	0.8	3	1.0	in	Manufacture of insulated wire and cable	3130
37	7.1	29	9.8	in	Manufacture of electronic valves and tubes and other electronic components	3210
3	0.6	1	0.3	in	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	3220
16	3.1	9	3.0	in	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	3230
33	6.3	23	7.8	in	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	3320
15	2.9	8	2.7	in	Manufacture of industrial process control equipment	3330
380	72.8	203	68.6	in	Software consultancy and supply	7220
13	2.5	8	2.7	in	Data processing	7230
8	1.5	5	1.7	in	Database activities	7240
522	**100.0**	**296**	**100.0**	in	**TOTAL**	

According to the Register, the total number of Estonian ICT manufacturing companies registered is 121 (23% of the total number) and they employ 4,785 people (2001). They represent 2.2% of the total number of manufacturing enterprises.[55] However, when we add four large companies, active in the field but for some reason not registered under these respective categories, and look only at active enterprises, the number of companies is actually 84 and they employ 6,358 people (2001).

However, the Estonian Statistical Office gives a number that is 41 companies higher (Table 9). As the Office reveals only aggregate data, further clarification is very much needed in future.

[52] According to the Central Commercial Register of Estonian enterprises hold by the Centre of Registers, Ministry of Justice.

[53] Defined henceforth as companies reporting of one or more employees in 2001.

[54] Source: Centre of Registers, Ministry of Justice, Central Commercial Register, May 2003.

[55] Number of enterprises from the Statistical Office of Estonia. Calculations of the author.

Table 9: ICT manufacturing companies in Estonia according to the Estonian Statistical Office, 2001[56]

Activity and NACE code	No of companies	Net sales (Mil EUR)	industrial production (Mil EUR)	industrial production from net sales (%)	difference from the Register
Manufacture of office machinery and computers (NACE 30)	**16**	**31.9**	**16.0**	**50.3**	
Manufacture of office machinery (NACE 3001)	2				+1
Manufacture of computers and other information processing equipment (NACE 3002)	14				+2
Manufacture of electrical machinery and apparatus (NACE 31)	**63**	**109.9**	**77.0**	**70.1**	
Manufacture of insulated wire and cable (NACE 3130)	5				-1
Manufacture of radio, television and communication equipment and apparatus (NACE 32)	**94**	**89.6**	**88.2**	**98.4**	
Manufacture of electronic valves and tubes and other electronic components (NACE 3210)	47	41.1	40.3	98.0	+10
Manufacture of television and radio transmitters and apparatus... (NACE 3220)	4				-1
Manufacture of television and radio receivers, sound or video recording ... (NACE 3230)	43				+27
Manufacture of medical, precision and optical instruments (NACE 33)	**90**	**56.8**	**52.7**	**92.7**	
Manufacture of instruments and appliances for measuring, checking... (NACE 3320)	34	7.9	7.0	89.4	+1
Manufacture of industrial process control equipment (NACE 3330)	13				+2
ICT manufacturing: NACE 30-33	**263**	**288.2**	**233.9**	**81.2**	
ICT manufacturing (NACE 30, 31.3, 32, 33.2, 33.3)	**162**				+41

According to the Register again, there are some 216 active software and database companies (73% of the total in 2001) in Estonia that employ a total of 1,641 people (1,186 in 2000 and 855 in 1999) showing the extreme fragmentation of the sector. In reality, the sector employs many more people, as will be shown in Section 7. However, as the companies are also active in the retail of ICT, maintenance activities, etc., in addition to software development, the exact figures remain unclear.

Among the Estonia's TOP500 largest companies (Table 14, Annex I), there are 28 ICT companies (5.6% of the total in 2002). The four largest of these are telecommunications companies (in total there are five telecommunication companies in the list), followed by one ICT manufacturing company. The total number of ICT manufacturing companies in the TOP500 is five, although the line between computer manufacturing companies and retail/wholesale companies remains blurred (see also the column 'Industrial production from net sales', Table 9). Overall, there are 10 ICT wholesale and retail companies in the list, although, as mentioned, three of these are also involved in computer manufacturing (see also Table 9). There are also 8 software companies and, again, these are heavily involved in other ICT-related activities.

If the market share of Estonian ICT companies that belong to the TOP500 by turnover (Table 14, Annex I) is compared with the estimates of the Estonian total ICT market,[57] it can be seen

[56] Source: Statistical Office of Estonia, September 3, 2003. More detailed data not available due to publishing restrictions.

that the market is most consolidated among telecommunication operators, followed by retail of ICT equipment and software products/IT services. According to EITO, the market value has increased by 9.9% between 2001 and 2002, but the aggregated turnover of ICT companies belonging to TOP500 has remained unchanged: although their position has strenghtened in telecommunications, they have lost ground in software products/IT services.[58]

The ranking of Estonian ICT companies, based on sales, sales growth, profits, annual profit growth, profit margin and return on assets (Table 15, Annex II), compiled by the daily business newspaper "Äripäev" also confirms that the market is undergoing constant change. For example, the list includes 47 companies, of which only 13 have stayed in the TOP30 in both 2001 and 2002.

[57] European Information Technology Observatory, European Information Technology Observatory (EITO) and European Economic Interest Grouping (EEIG), 2004, p. 290.

[58] Please note, that these are estimations: EITO values are estimations and subject to errors (especially values on Estonian telecommunications market) and the distribution of companies between different categories is very subjective.

6. Estonian ICT Manufacturing Sector Companies

The Estonian ICT manufacturing sector[59] employs 6,300[60] to 9,400 people[61] and consists of 84 to 121 companies (with one or more employees, registered in the Centre of Registers in 2001). The sector is fairly consolidated – there are five dominant companies that generate most of the turnover and exports, and employ more than 4,000 people (Table 10). All these companies are described in detail in sections 6.1 - 6.5.

Among the leaders is Elcoteq Tallinn AS, the 17th largest foreign investor with a total investment of 17.5 million EUR as of 2000. JOT Eesti OÜ, with a total investment of 7 million EUR took 43rd place among the largest foreign investors as of 2000.[62] However, most other enterprises are small and medium-sized with fewer than 50 employees. In Section 6.6, some other larger players are presented.

A comparison of these companies shows major differences in workforce/turnover ratio. Average monthly salary was, for example, in Elcoteq Tallinn AS 757 EUR for whitecollars (344 employees) and 258 EUR for blue-collars (2,291 employees), while the average salary in the manufacturing industry in Estonia was 330 EUR (2001). The average salary in AS Tarkon was also lower then the Estonian average – 292 EUR. However, JOT Eesti OÜ had an average salary of 862 EUR in 2001. The latter also spends 12% of turnover on R&D.[63]

Table 10: Estonian TOP5 ICT manufacturing companies present in the Estonian TOP500 companies by turnover, 2001[64]

	NAME	Share-holders	County	NACE	Status	Turnover (2001) Mil EUR	Turnover (2000) Mil EUR	Work-force (2001)
1	Elcoteq Tallinn AS	FIN	Tallinn	3210	PubLC	39.2	37.6	2635
2	JOT Eesti OÜ	FIN	Tallinn	3330	PriLC	17.3	37.1	186
3	Keila Kaabel AS	FIN+local	Keila	3130	PubLC	17.2	15.4	57
4	Harju Elekter AS	local	Keila	3120	PubLC	12.5	13.1	673
5	Tarkon AS	SWE	Tartu		PubLC	10.4	11.4	600
					TOTAL	**96.5**	**114.7**	**4151**

Elcoteq Tallinn AS

Elcoteq Tallinn AS is a subsidiary of Elcoteq Networks Corporation, the biggest electronics manufacturing services company in Europe, with headquarters in Finland. Its main business areas are production of terminal products and communications network equipment. Elcoteq's customer list includes Nokia, Ericsson, ADC, Allgon, ABB, Danfoss, Kone, Vaisala, Viterra, and Andrew Corporation. Elcoteq's largest plants are situated in Hungary, Beijing and Tallinn in Estonia.

Elcoteq Tallinn AS mainly manufactures electronic subassemblies such as electronic parts and accessories for mobile phones, but also provides engineering and after sales services. The company is by far the biggest player on Estonian ICT landscape - it accounted for 83% of total

[59] Includes the following NACE categories: 30, 31.1-31.6, 32.1-32.3, 33.1-33.5.

[60] Centre of Registers, Ministry of Justice, Central Commercial Register, May 2003.

[61] Statistical Office of Estonia.

[62] OECD Reviews of Foreign Direct Investment. Estonia, OECD, 2001, p. 28.

[63] Annual Reports 2001 of Elcoteq Tallinn AS, JOT Eesti OÜ and Tarkon AS. Average salary from Statistical Office of Estonia.

[64] Source: Centre of Registers, Ministry of Justice, Central Commercial Register, May 2003, Public information

Estonian ICT exports in 2001.[65] It was also the biggest Finnish company in Estonia and the biggest exporter in 2002, contributing 15% to Estonia's total exports.

As most of the production is subcontracting work, Elcoteq Tallinn's sales and performance has been substantially reliant on large scale subcontracting orders. At the beginning of 2000 Elcoteq witnessed remarkable export growth and employed as many as 3,600 people. However, global slowdown on telecom markets in 2001 seriously affected Elcoteq's business, which resulted in downsizing both in Estonia (in August 2001 the number of employees dropped to 2,000) and Hungary, and the postponement of the building of a new plant in Tallinn. From December 2002, the market situation improved - the number of employees is now around 2,000 in Estonia and the Tallinn plant is now operational.

There have also been discussions in the media about the possibility of Elcoteq's headquarters being moved from Finland to Estonia, mainly due to differences in corporate income taxation schemes. However, analysts do not expect this to happen and are currently questioning how long Estonia will remain an attractive place for volume manufacturing as compared with China, especially in the light of increasing salaries. Elcoteq Networks Corporation acquired two manufacturing plants in China at the end of 2002, which substantially increase the proportion of total net sales derived from the Asia-Pacific region and employment there.[66]

JOT Eesti OÜ

JOT Eesti OÜ (JOT Estonia) was established in 1997 by JOT Automation Group, Finland. It is currently part of the Elektrobit Group after the merger of JOT Automation and Elektrobit on 31May, 2002.

The Elektrobit Group is a versatile engineering company, whose customer groups include telecommunications manufacturers and operators, electronics contract manufacturers, component and subassembly manufacturers, automotive electronics manufacturers, industrial automation manufacturers and the defence and space industry. The telecommunications industry makes up the company's main customer group, accounting for about 80% of net sales.

JOT Eesti OÜ is involved in industrial automation production, which is entirely channelled to export. In 2000, JOT Estonia's export revenues and turnover amounted to 37 million EUR. JOT Estonia employed 186 people altogether in 2001.

AS Keila Kaabel

The core business of AS Keila Kaabel, founded in 1992, is the production and wholesale of power, telecommunication and special cables for Baltic countries.

Draka Holding N.V., one of the world's largest cable concerns, is the major owner (66%) of the company. It is part of Draka NK Cables (Nokia Cables until 1997), which employs over 750 people, has its headquarters in Finland and subsidiaries in Estonia, Russia, Singapore, Sweden, etc. Shares are also held by AS Harju Elekter (34%).[67]

AS Keila Kaabel's turnover amounted to 21 million EUR in 2002. The company employed 67 people altogether in 2002.

AS Harju Elekter

AS Harju Elekter (Harju Electricity Ltd.), the leading electrical equipment producer in the Baltic countries, has its core business in the production of electrical equipment (equipment for power distribution network) and subcontracted production of cable harnesses and connection

[65] Estimation by Tarmo Pihl based on Statistical Office of Estonia and publicly available materials. See also Tarmo Pihl, *Estonian ICT cluster: Present State and Future Outlooks*, www.esis.ee/eVikings, 2002, p. 4.

[66] See also Elcoteq Annual Report 2002, www.elcoteq.fi, 2003, pp. 13 and 35.

[67] See also 6.4.

cables for the automobile and electronic industry. It is the only Estonian ICT manufacturing company quoted on Tallinn stock market, HEX Tallinn.

The company had 351 employees in 2002 (673 in 2001[68]) and it belongs mainly to Estonian shareholders. The company's net sales in 2002 amounted to 17.3 million EUR, of which the export share was 44.5%.

AS Tarkon

AS Tarkon's predecessor - telephone factory, Edisson-Kompagnie - was established in August 1907 and, during World War I, it produced over 13,000 telephones. During Soviet times, the company, operating under the name of Tartu Control Equipment Factory, focused on producing black boxes or flight recorders for both civil and military aircraft. Reorganized as a state company - RAS TARKON - in 1992, it was then privatized in 1996 when it was sold to a Swedish company, Hallberg Sekrom AB.

Currently the main activities of the company include manufacturing of fine mechanical components and diverse assembly works including cables, telecommunication systems electronics, the car industry and apparatus building.

The company has 600 employees. Turnover for 2000 exceeded 11 million EUR and 7 million EUR came from exports to Scandinavia, the largest partners being Elcoteq and Ericsson.

[68] The company has been focusing its activities: in 2002 a subsidiary was formed on the basis of Cable Harnesses Factory and the shares of subsidiary were sold to PKC Group (FIN).

7. Some other ICT manufacturing companies

Table 11: Other Estonian ICT manufacturing companies[69]

NAME	Share-holders	COUNTY	NACE	Status	Turnover (2001) Mil EUR[70]	Work-force (2001)
AS ASWEGA	local	Tallinn	3320	PubLC	2.7	235
	AS ASWEGA (ASWEGA Ltd), former Tallinn Measurement Instrumentation Corporation "Tööstusaparaat" ("Промприбор") privatized in 1994, produces and installs electromagnetic heat meters and flow meters, designs and produces calibration rigs (stations) for liquid meters and adapters for meter data reading. Mainly exports to Russia.					
Tondi Elektroonika AS	local	Tallinn	3310	PubLC	2.6	170
	Tondi Elektroonika AS (Tondi Electronics Ltd.), former Tallinn Electrotechnical Plant, is the largest manufacturer of hearing aids in Eastern Europe.					
Wecan Cables Eesti OÜ	FIN	Sindi		PriLC		130
	Wecan Cables Eesti OÜ, cable assembly company, was established as a subsidiary of Wecan Electronics Oy (Finland) in 1997, currently part of Scanfil plc (Finland) due to the merger between Wecan Electronics Oyj and Scanfil Oy in 2002. Scanfil plc has production plants in Finland, China, Estonia and Hungary. Out of the 1,300 people in the group 130 work in Estonia.					
Stoneridge Electronics AS	USA	Tallinn	3210	PubLC	9.3	100
	Stoneridge Electronics AS, active in the fields of instruments, man-machine interface products, electronic control units, sensors is a subsidiary of Stoneridge Inc. The group has a total of 5,500 employees and is a designer and manufacturer of electrical and electronic components, modules and systems for the automotive, medium- and heavy-duty truck, agricultural and off-highway vehicle markets.					
RD Electronic AS	local	Narva	3210	PubLC	1.2	98
	RD Electronic AS is a producer of electronics and printed circuit boards.					
Incap Electronics Estonia OÜ	FIN	Kuressaare	3210	PriLC	2.9	73
	Incap Electronics Estonia OÜ, subsidiary of Incap Electronics, activities include printed circuit boards assembly and testing and final assembly.					
Fabec Elektroonika OÜ	SWE	Tallinn	3210	PriLC	1.0	65
	Fabec Elektroonika OÜ is subcontractor in fields of thermo-regulators, power supply units, remote control devices, bus information panels, detectors, battery assemblies.					
AS ML Arvutid	local	Tallinn	3002	PubLC		38
	AS ML Arvutid (former MicroLink Arvutid AS was a subsidiary of the largest Baltic IT company with the total number of employees around 650 people) is active in wholesale, retail and production of computers. It has a market share of 30-35% in Estonia.					
AS Ordi	local	Tartu	3002	PubLC		70
	AS Ordi has been involved in wholesale, retail and production of computers since 1992. It has a market share of 20% in Estonia.					
TOTAL						**979**

[69] Source: Center of Registers, Ministry of Justice, Central Commercial Register, May 2003 and public sources.

[70] For some companies only part of turnover follows from ICT manufacturing as they are in addition dealing with ICT wholesale, retail, and maintenance (see also Table ***). In these cases these figures are not given as they are not comparable for current purposes.

8. Estonian Software Consultancy and Supply Companies

There are 380 companies officially registered as software supply and consultancy companies in Estonia (NACE 7220 - 2001), although the number of active companies is actually 216, which employ 1,641 people (2001).71 Some experts estimate that the actual number is even smaller – 150.72 Companies that produce software for Western clients and/or large local enterprises and/or large-scale public projects, are the most successful. Some larger players are presented in Table 12.

Table 12: Estonian TOP5 software companies by turnover and employment, 2001[73]

NAME	Share-holders	COUNTY	NACE	Status	Turnover (2001) Mil EUR[74]	Work-force
Cybernetica AS	Estonian State	Tallinn	7220, 7260	PubLC	2,1	92
	Cybernetica AS, established in 1997 as a spin-off of the Institute of Cybernetics of Tallinn Technical University, is an information security (communications security products, digital signature technology), information systems (development of mission-critical systems) and navigation systems (visual navigation, signalling and telematics systems and their components) development company. Its main clients are public organizations, banks, telecom companies, and ports. It has been an active participant in EU R&D programmes.					
Abobase Systems AS	local	Tallinn		PubLC		59
	Abobase Systems AS, established in 1990, was, according to the newspaper "Äripäev", the best IT company in Estonia in 2001. The company is an Estonian representative of a lot of world leading IT corporations in Estonia. Next to hardware retail and support services it is heavily involved in information systems development.					
MicroLink Süsteemid AS	local	Tallinn		PubLC		90
	MicroLink Süsteemid AS, a subsidiary of the largest Baltic IT company, with a total of around 650 employees, is the largest of the five business units and contributed 42% of MicroLink Group sales in the financial year 2001/02. The company has started to focus on systems development (based on Oracle, Microsoft, Progress), rather than purely product sales. Its main clients in Estonia were media agencies and public sector institutions in 2002.					
Helmes AS	local	Tallinn		PubLC		60
	Helmes AS, established in 1991, provides services to corporate and government organizations. The company specialized in Microsoft .NET based software development, XML, EDI.					
Cell Network AS	SWE	Tallinn		PubLC		76
	Cell Network AS, a subsidiary of the Swedish company Cell Network AB, is involved in the development of system and application software and sales of computers and relevant peripherals.					
TOTAL						**285**

[71] Central Commercial Register of Estonian enterprises hold by the Centre of Registers, Ministry of Justice.

[72] Marja Nissinen, *The Baltics as a Business Location for Information Technology and Electronics Industries*, VTT Research Notes 2169, http://www.inf.vtt.fi/pdf/tiedotteet/2002/T2169.pdf, 2002, p. 46.

[73] Source: Center of Registers, Ministry of Justice, Central Commercial Register, May 2003 and public sources.

[74] Out of these companies only one of them, Cybernetica AS, has been registered under NACE 7220. As the turnover of most of the other companies includes in addition to software development also retail of ICT, maintenance activities, etc., these figures are not given as they are not comparable for current purposes.

9. Conclusions: Overview of the Current Situation

On the basis of this overall national analysis, the following conclusions about the Estonian ICT manufacturing and software industries can be drawn:

The Estonian ICT market is dominated by telecommunication network services which have 58% (or 426 million EUR) of the market (2003). The value of the IT market (excluding telecommunications) is estimated to be 216 million EUR (29% of the total market value) with per capita IT spending being 150 EUR - higher than the CEE average, but lower than the Western European average (735 EUR per capita). Hardware expenditure dominates IT spending.

Over the last decade, the Estonian economy has been modernized by foreign direct investment mainly from Sweden and Finland. Radio, TV, and communication equipment manufacturing has received 3% of total investments (2000) and among the TOP50 foreign investors in Estonia, there were two ICT manufacturing companies.

Estonian ICT manufacturing production was 234 million EUR in 2001 and was dominated by the manufacture of radio, television and communication equipment (38% of total Estonian ICT manufacturing, 2001), followed by manufacture of electrical machinery and equipment (33%).

Estonian total exports of commodities are heavily dominated by electrical machinery, equipment and components. In 2002, total exports of the Estonian ICT manufacturing industry accounted for 21% of all Estonian exports of commodities and amounted to 764 million EUR. The most export-intensive branch is "manufacture of radio, television and communication equipment and apparatus" (91% of industrial sales in 2001). Office machinery and computer manufacturing, however, is the smaller segment of the Estonian ICT manufacturing industry and mainly supplies a small, local market.

The added value of the Estonian ICT manufacturing industry is 80 million EUR (7.9% of the total for the manufacturing industry), the labour productivity in the ICT manufacturing branches that export most being low, lower then the average for the manufacturing industries.

The Estonian ICT manufacturing sector is dominated by five companies, mainly owned by investors from Finland, though cable manufacture belongs to Estonian capital.

In comparison with the Estonian ICT manufacturing industry, which is largely consolidated, heavily export-intensive and based on foreign capital, the Estonian software industry sector is fragmented. Its development has been strongly influenced by the needs of the local market, especially banking, telecommunications and the governmental structure. The contribution of computer services (NACE 72) to the added value produced in Estonia is 47 million EUR.

Among the Estonia's TOP500 largest companies, there are 28 ICT companies (5.6% of the total in 2002). The four largest of these are telecommunications companies, followed by one ICT manufacturing company. The total number of ICT manufacturing companies is five, although the line between computer manufacturing companies and retail/wholesale companies remains blurred. Overall, there are 7-10 ICT wholesale and retail companies in the list, and 8 software companies.

Empirical evidence (exports-imports, ownership, FDI, value-added, etc.) shows that the Estonian ICT manufacturing sector is actually part of the larger Nordic ICT manufacturing cluster. The main branches of the Estonian ICT manufacturing industry are exactly the same as those of Finland and Sweden. ICT manufacturing network flagships generally consist of Finnish and Swedish companies, which have subsidiaries, affiliates and joint ventures in Estonia. **There is no empirical evidence for the widely held view that Estonian ICT manufacturing has been gradually moving from low value-added manufacturing towards higher value-added production.**

PART II: FUTURE OUTLOOK

1. Major Factors Influencing the Estonian ICT Manufacturing and Software Industry

As argued by Dieter Ernst, small firms in small countries are at a disadvantage. He mentioned four types of size-related disadvantages:

i. The small domestic market places tight restrictions on the ability to function as a buffer against heavy fluctuations in international demand.
ii. It limits the development of sophisticated "lead users" that could stimulate innovation.
iii. It also limits the scope for technological spillovers.
iv. The limited national knowledge and capital base restricts the choice of industries in which such small nations might successfully specialize.[75]

In combination with the understanding of transition processes and technological trajectories, it provides a viable framework for understanding possible development scenarios for the Estonian ICT manufacturing and software industry. This chapter briefly outlines some main trends.

Cost-based Competition and Globalization

At the moment we are witnessing both the establishment of new ICT manufacturing companies as well as the expansion of existing ones in Estonia (Table 13).

Table 13: Examples of new or enlarged production capabilities of ICT manufacturing companies in Estonia, first quarter 2004[76]

NAME	Share-holders	County	Description	Expansion or new manufacturer?
Efore AS	FIN	Pärnu	power conversion solutions, electronics design, manufacturing services	new company, expected employment 60
Elcoteq Tallinn AS	FIN	Tallinn	electronics manufacturing services in the communications technology field	production at Elcoteq's Espoo (FIN) plant to be moved to Estonia
Incap Electronics Estonia OÜ	FIN	Kures-saare	design and building of electronic, mechanical and electromechanical components and subassemblies	threefold expansion of production facilities
LGP Allgon	SWE	Tallinn	manufacturer of electronic components	new company, expected employment 180
Paitec Elektroonika OÜ	FIN	Pärnu	printed circuit board and device assembly	expansion, employment +200

The rationale of these companies is characterised by the following statements: "Competitiveness in manufacturing is maintained and improved by concentrating our manufacturing in countries with low production costs, such as China and Estonia. We will constantly procure our components internationally from the most cost-effective sources".[77] Or, "With the aim of

[75] Dieter Ernst, What Permits Small Firms to Compete in High-Tech Industries? Inter-Organizational Knowledge Creation in the Taiwanese Computer Industry, DRUID Working Paper 1998-3, http://www.business.auc.dk/druid/wp/pdf_files/98-3.pdf, 1998.

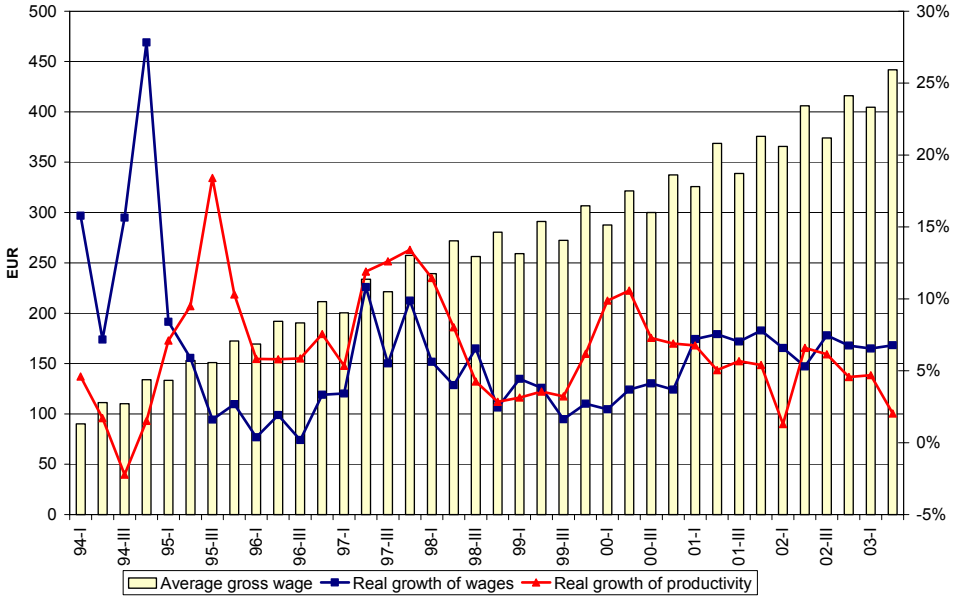
[76] Source: press releases, company web-sites and other public sources.

[77] Efore OYJ, Annual Report 2003, http://www.efore.fi/, 2004, p. 5.

lowering manufacturing costs, more electronics manufacture and assembly was done in Estonia."[78]

Indeed, relatively low-cost labour is one of the attractive features of Estonia. Average annual gross earnings in industry was 27,581 EUR in Finland (2000), 30,643 EUR in Sweden and 3,647 EUR in Estonia, 8 times lower.[79] However, real wages have risen much quicker than the overall productivity of Estonian economy (Figure 1), leading to the loss of this advantage.

Figure 1: Dynamics of wages and productivity in Estonia, 1994 - 2003 II quarter[80]



Second, as technologies and products mature, the stronger the cost-competition and the more attractive less developed countries for volume production will be. As summarised by Carlota Perez: "*Technologies tend to make more intensive use of labour in their initial phases and to use relatively costly personnel with high levels of knowledge and qualifications. When they approach maturity, however, they are using highly standardized, mechanized and automated processes. When technologies mature, there are forces which push them out more and more towards the periphery, where, presumably, there are complementary forces that pull them in order to set development processes in motion"*[81] (changing entry conditions over time are graphically illustrated in Figure 2).

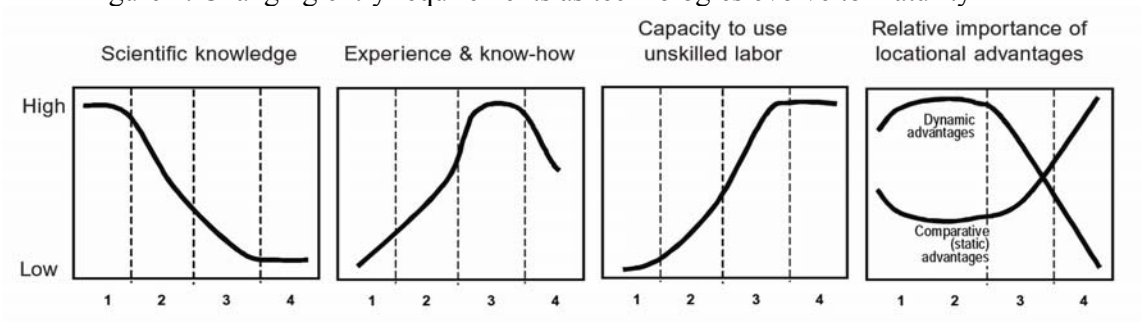
[78] Incap Corporation, Annual Report 2003, http://www.incap.fi/englanti/acrobat/2004/InCap_vsk_Engl.pdf, 2004, p. 20.

[79] Eurostat, *Statistics in Focus, Annual Gross Earnings Results from Member States, Acceding and Candidate Countries, and Switzerland*, 2003, p. 4.

[80] Real wage is deflated by GDP deflator. Source: Statistical Office of Estonia, calculations by PRAXIS Center for Policy Studies.

[81] Carlota Perez, Technological change and opportunities for development as a moving target, *Cepal Review*, No. 75, pp. 111-112, 2001.

Figure 2: Changing entry requirements as technologies evolve to maturity[82]



Although participation in global production networks has potential for knowledge transfer, it is not automatic and requires a significant level of absorption on the part of local suppliers and a complex internalization process for disseminated knowledge. But, once a network supplier successfully upgrades its capabilities, this creates an incentive for flagships to transfer more sophisticated knowledge, including engineering, product and process development. This is certainly a major challenge as currently most of the ICT manufacturing industry in Estonia acts as a "lower-tier" supplier, the main competitive advantages being low cost ("price breaker"), speed, and flexibility of delivery.

Several flagships that currently have ICT manufacturing in Estonia are also expanding their manufacturing activities in China and other low-cost regions. Indeed, in the situation where "Production workers (in China) typically cost 5% of their U.S. or European counterparts"[83] Estonia, whose living standards are expected to converge with those of the EU, will be facing totally different challenges. The key factor that will decide the attractiveness of Estonia as an ICT manufacturing location will be, rather, the availability of a critical mass of skilled labour for the production of *higher value- added goods*. Thus, the quality of the Estonian ICT sector innovation system will determine the future. In practice this will mean trying to take advantage of the spillovers from neighbouring countries in order to stay in Phase 2 and 3 (Figure 2) where higher levels of scientific knowledge and qualifications are made use of, and are remunerated accordingly. Such accumulation of technological and social capabilities is, however, the ultimate goal of all developing economies and much depends on the public policies of the countries concerned, and the entrepreneurs.

Current tendencies indicate that in the short-run Estonia seems to be attracting sub-contracted ICT manufacturing from Nordic countries, as do the other European transition economies. While outsourcing accounted for 21% of total assembly and box-build activity in Europe in 2000, it is forecasted to account for over 40% by 2007. Western Europe is expected to lose further ground as companies migrate manufacturing to low cost countries, with China and Eastern Europe as the main beneficiaries.[84] However, in the long-run – as parent companies face stronger and stronger cost-based competition – they will be forced to look for cheaper production areas. Estonia cannot be a low-cost production area in the long run, especially in the light of the EU enlargement and the rise of the welfare state. However, even if these companies relocate their Estonian production, the loss will be largely statistical (for example, according to simple export statistics, Estonian is considered to be a high-tech country due to ICT manufacturing exports). No real economic crisis is therefore expected.

[82] Carlota Perez, Technological change and opportunities for development as a moving target, 2001, *Cepal Review*, No. 75, p. 112.

[83] Boston Consulting Group, *Made in China: Why Industrial Goods Are Going Next,* http://www.bcg.com/, 2003, p.3.

[84] *Yearbook of World Electronics Data 2003, Volume 1 - West Europe*, Reed Electronics Research, 2002, p. 8.

New Emerging Paradigms: Ambient Intelligence

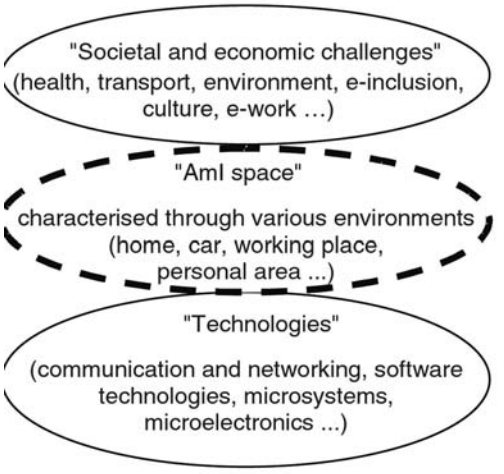
Marc Weiser, a computer scientist at the Palo Alto Research Center (Xerox Parc), coined the term 'ubiquitous computing' in 1988:

> *Since we started this work at PARC in 1988 a few places have begun work on this possible next-generation computing environment in which each person is continually interacting with hundreds of nearby wirelessly interconnected computers. The goal is to achieve the most effective kind of technology, that which is essentially invisible to the user. To bring computers to this point while retaining their power will require radically new kinds of computers of all sizes and shapes to be available to each person. I call this future world "Ubiquitous Computing".*[85]

The concept of *Ambient Intelligence* (*AmI*), central to EU strategies in the ICT field, is very much based on this and provides a vision of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions.[86] The realisation of such a vision is expected to be a reality as early as 2010, when people will be surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.[87]

Basically, this vision argues for the extreme clustering of ICT manufacturing and software industries with other industries and service sectors. Societal and economic challenges are being solved through technologies via „*AmI Space*" (Figure 3). This stems from the convergence of three key technologies, i.e. ubiquitous computing, ubiquitous communication, and intelligent user-friendly interfaces.

Figure 3. The AmI Space: 3-layer model[88]



Thus, the emergence of AmI is a new paradigm within ICT and represents Phases 1 and 2 in Figure 2. Knowledge that establishes a base for economic success is not accumulated in the

[85] Marc Weiser, Some Computer Science Issues in Ubiquitous Computing, Communications of the ACM, vol. 36, no. 7, pp. 74-84, 1993, p. 75.

[86] See, for example: IST Advisory Group (ISTAG), Ambient Intelligence: From Vision to Reality, http://www.cordis.lu/ist/istag.htm, 2003; ISTAG Strategic Orientations and Priorities for IST in FP6, http://www.cordis.lu/ist/istag.htm, 2002; ISTAG Software Technologies, Embedded Systems and Distributed Systems, http://www.cordis.lu/ist/istag.htm, 2002.

[87] For illustrative examples, see ISTAG, Scenarios for Ambient Intelligence in 2010, Seville: IPTS, 2001.

[88] Source: ISTAG, *Strategic Orientations and Priorities for IST in FP6*, http://www.cordis.lu/ist/istag.htm, 2002, p. 17.

developed countries. Rather, in the early phases of technological trajectories, knowledge is spread and the prior experience required is not very great. It is a coordinated approach to technological, economic and societal challenges that determines success.

Just as Estonian companies have made as impressive success of the application of new technologies in some fields (e.g. banking, government) and in the development of intelligent user-friendly interfaces (for example, in the fields of mobile telecommunications, e-health applications), they could be equally successful in realizing the „*AmI Space*". The present turnover of these successful companies is small, but growth can be expected. Success will largely depend on their skill in entering global research, development and production networks. The total number of such companies that can achieve success on an international scale with their niche products and services still remains small, probably less than 10 over the next five years.

Although Estonia's small size and preponderance of SMEs can indeed be a disadvantage, if properly played, it could also be a strength. Small firm in small countries can be flexible and have the capacity to adjust to abrupt and frequently unexpected changes in demand and technology. There seem to be major opportunities in incremental product/service innovation with incredibly fast speed-to-market.[89]

However, the impact from clustering with local manufacturing industries – the best way forward to successful clustering and later exports of innovative solutions – remains limited. This is especially true, when the current low level of R&D investments in manufacturing industries is considered. The strongest explanation for low private sector R&D expenditures and the lack of willingness to cooperate with academia follows from Pavitt's sectoral taxonomy of innovations.[90] According to this approach, in supplier-dominated activities (such as agriculture, textiles, clothing), most innovations come from suppliers of equipment and materials; firms generally undertake little R&D and request few patents. In production-intensive activities (such as scale-intensive industries like cement and glass manufacturing, and machinery production), R&D is conducted in the larger firms; firms tend towards vertical integration and appropriation is linked to tacit knowledge, secrecy, and patents. Within science-based industries (e.g. electrical equipment manufacturing, fine chemicals including pharmaceuticals, and biotechnology) most technology comes from the R&D activities of the firms. The majority of Estonian manufacturing enterprises belong to low-technology supplier-dominated or production-intensive groups. The fact that the number of innovative acts in these sectors is relatively low everywhere, could explain why Estonian enterprises generally invest very little in research and development. **However, the clustering of software and, to some extent, ICT manufacturing industries with other branches of industry provides additional opportunities.**[91] Over the last decade, all industries in Estonia and in particular agricultural and resource-based industries (food and wood processing especially) have been very successful in modernizing companies and making them competitive, mainly via technology transfer from abroad. A further boost to productivity could come from clustering with local ICT industries.

At the same time, **incentives to innovate in ICT industry will most probably follow from the services sector** where ICT-use and spillovers are more intensive and result in productivity increase. In the short-run, continuous modernization of the public sector, especially through the use of EU funds, and further development of the service sectors will have major impact on the Estonian ICT sector. Although innovations in the services field are relatively easier to implement, they are also more difficult to export as competitive advantages are very much

[89] An example of the supportive environment is the fact that as of March 2003 Estonia is the only EU country (acceding, accession, or member) with an e-voting law for national elections actually in place and technological solutions are being developed. On the development of e-voting in Estonia, see Wolfgang Drechsler and Ülle Madise, e-Voting in Estonia, *Trames*, Vol. 6, No 3, pp. 234–244, 2002.

[90] Keith Pavitt, Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory, *Research Policy*, Vol. 13, pp. 343-73, 1984.

[91] See also OECD Information Technology Outlook. ICTs and the Information Economy, OECD, Paris: OECD Publications, 2002, p. 13.

based on local specificities (for example, language technologies). Thus, only a few established companies that are plugged into global research, development and production networks will have success in exporting their service innovations to other countries. Another boost to the development of innovative solutions could follow from stronger co-operation with Estonian research and development strongholds, particularly in the field of biotechnologies (bioinformatics). The impact of this, however, will be revealed only in the long term.

2. Challenges to the Estonian ICT Sector Innovation System

Since the decision adopted at the Barcelona Summit in 2002 by the heads of state and government leaders of the EU Member States to increase national investment directed at research and development to 3% of GDP by 2010, there has been much discussion in acceding states on this topic. To achieve this goal, acceding states would need to spend as much as 4 times more on R&D by 2010 as they do now…

A study by the Innovation Centre of the Archimedes Foundation in Estonia carried out a thorough analysis of Estonia's ICT sector innovation system in 2001.[92] The study focused precisely on the emergence of the Estonian ICT sector as a knowledge-based economic cluster. During the project, major desk research was carried out, as well as extensive interviewing of key stakeholders in the Estonian ICT cluster.

Michael Porter's approach to clusters is used in the project. Porter defines four broad attributes which shape the economic environment in the form of an efficient cluster-based network and contribute to the emergence of a national competitive advantage. These determinants are observed in the particular economic context of a cluster, which represents an value-added chain of activities frequently spanning different sectors.[93] In the case of the Estonian ICT cluster, the authors concluded that all the broad attributes of Porter's diamond are still evolving in Estonia, but their interaction has been too infrequent to form a distinctive and internationally competitive ICT cluster (Figure 4).

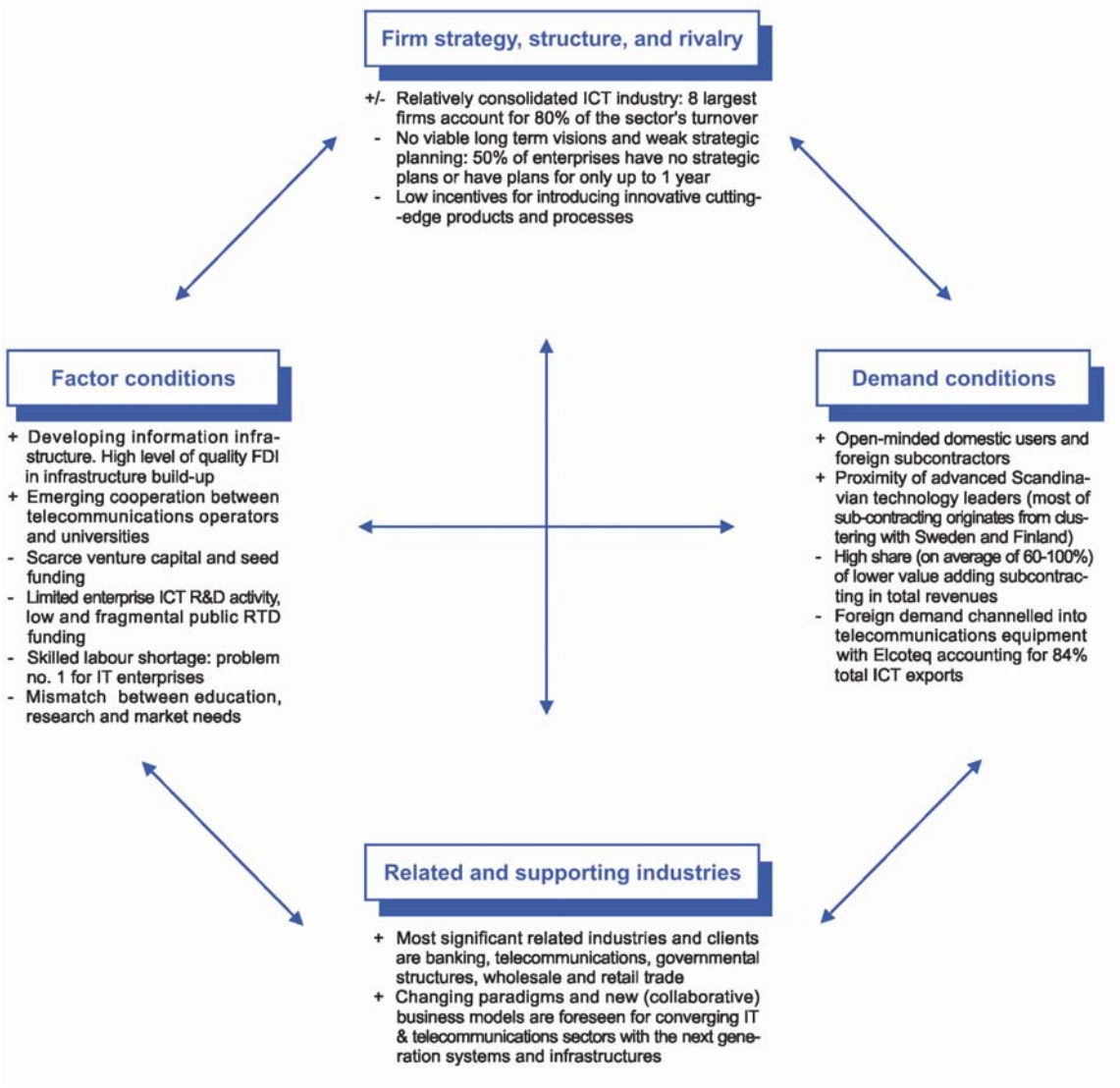
The fact that the Estonian ICT cluster is actually a sub-section of the larger Nordic ICT cluster has, on the one hand, facilitated the uptake of novel technology and provided Estonian companies with sustainable income through subcontracting. On the other hand, it reinforces the lock-in effect as the Estonian ICT industry is captured in low value-added activities with little incentive for innovation. The study was conducted in 2001 and over the last three years, clustering tendencies in the lower value-added end of the market have only strengthened.

As regards the capital market in Estonia, it was concluded in 2001 that this is functioning, although it is not efficient enough to provide funding to start-ups and new companies. This issue has been addressed by public policy and from 2004, steps will be taken to establish a public venture capital fund in Estonia, using the Finnish Sitra as a model. Of the shortcomings identified in the Estonian ICT sector innovation system in 2001, the issue of the capital market seems to have been addressed most successfully, although the exact impact of the fund depends very much on concrete implementation mechanisms.

[92] The project Estonian eVikings was financed by FP5 (IST-2000-26452). The research results have been published: Tarmo Kalvet, Tarmo Pihl and Marek Tiits, Analysis of the Estonian ICT Sector Innovation System. Executive Summary, Tartu: SA Archimedes, http://www.esis.ee/eVikings/, 2002. See also Tarmo Kalvet, Analysis of the Estonian ICT Sector Innovation System. ICT, Innovations and Innovation Policy: The Case of Estonia, www.esis.ee/eVikings, 2002; Tarmo Pihl, Estonian ICT cluster: Present State and Future Outlooks, www.esis.ee/eVikings, 2002; Marek Tiits and Tarmo Pihl, IST R&D and Innovation in Estonia, www.esis.ee/eVikings, 2002.

[93] Michael E. Porter, The Competitive Advantage of Nations: with a New Introduction. New York: Free Press, 1998.

Figure 4: Estonian ICT cluster – Porter's diamond[94]



The study also concluded that there is a mismatch between the skills developed and the needs of industry and commerce. Most of the companies (56%)[95] needed specialists for specific products or technologies in 2001, and 39% were looking for project managers and sales staff. Only 10% of interviewed companies needed research and development personnel, and 20% expected a need for additional R&D staff to emerge only in the longer term.

[94] Source: Tarmo Kalvet, Tarmo Pihl and Marek Tiits, *Analysis of the Estonian ICT Sector Innovation System. Executive Summary*, Tartu: SA Archimedes, http://www.esis.ee/eVikings/, 2002, p. 15.

[95] All data derives from the eVikings survey from May 2001 if not indicated otherwise.

Extreme fragmentation of already small amounts of public R&D funding, relatively low competition and the large number of small projects were clearly some of the main weaknesses of the R&D funding system in 2001 and continue to be so. The system in place does not encourage the launch of new high-risk and possibly high-return R&D projects. Nor is it proactive in anticipating prospective socio-economic development scenarios, and allocating the priorities accordingly. In addition, public ICT R&D funding does not actively favour university-enterprise partnerships for applied R&D, whereas in the 'Western economies', an integrated R&D and product development cycle is the common practice for the elaboration of new technological solutions. The latter, however, is being addressed by a Technological Development Centre Support Programme that finances centres initiated and operated jointly by companies and R&D institutions.

There were also major differences reported between the public funding paid to R&D personnel and the rates paid to the ICT experts in the private sector, where the latter receive salaries at least four times higher. Different levels of compensation between the ICT industry and public research labs encourage institute staff to leave their places and search for more lucrative options in the private sphere.

Incentives for innovation were relatively low for Estonian ICT companies. They do not perceive the necessity to elaborate their own cutting-edge solutions. Generally, they try to imitate and use novel products developed elsewhere as quickly as possible. Awareness of research institutions and their activity was very low among private enterprises. Only 35% of those interviewed indicated that they have some knowledge of existing research institutes. The number of companies who have used professional help from such institutes was significantly lower: just 9%. More than half of the respondents referred to the excessive academic orientation of universities and R&D institutes as the reason for modest cooperation. Most of the enterprises considered cooperation with universities unnecessary – the locally focused business strategies taken by Estonian ICT companies simply do not assume knowledge intensities comparable to those of the more developed markets.

50% of the sample ICT companies reported having 'strategic' business plans for only one year ahead, or having no plans at all. Normally, at least three-year planning and implementation periods should be allowed for R&D activities, which need to follow-up the actual introduction of products to the market.

3. Conclusions: Possible Future Scenarios

Although participation in global production networks has potential for knowledge transfer, it is not automatic and requires a significant level of absorption on the part of local suppliers who must master a complex process of internalization of disseminated knowledge. Currently most of the ICT manufacturing industry in Estonia acts as a "lower-tier" supplier, the main competitive advantages being low cost ("price breaker"), speed, and flexibility of delivery. At the moment new ICT manufacturing companies are being established and existing ones are being expanded, as a result of the current availability of relatively low-cost labour. However, real wages have risen much quicker than the overall productivity of the Estonian economy and Estonian living standards are expected to converge with those of the EU, leading to the loss of this advantage. As technologies and products mature, the stronger the cost-competition will be. **Several flagships that currently have ICT manufacturing in Estonia are also expanding their manufacturing activities in China and other low-cost regions. It is very probable that in the long run, as they face stronger and stronger cost-based competition, they will be forced to look for cheaper production areas outside Estonia.**

Ambient Intelligence (*AmI*) is a vision of the Information Society that puts emphasis on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions and is expected to be a reality by 2010. Basically this vision argues for the extreme clustering of ICT manufacturing and software industries with other industries and service sectors. **Just as Estonian companies have made an impressive success of the application of new technologies in some fields (banking, government) and in the development of intelligent user-friendly interfaces (for example in the fields of mobile telecommunications, e-health applications), they could be equally successful in the realisation of the „*AmI Space*".**

Over the last decades all industries in Estonia and in particular agricultural and resource-based industries (food and wood processing especially) have been very successful in modernizing companies and making them competitive, mainly via technology transfer from abroad. **A further boost to productivity could come from the clustering of software and, to some extent, of ICT manufacturing industries with other branches of industry, although the currently low level of R&D investment by Estonian enterprises is a possible threat.**

Continuous modernization of the public sector and innovations in the services field will probably act as incentives for innovation in the ICT industry. These innovations, though relatively easy to implement, are more difficult to export as their competitive advantages are very much based on local specificities. Thus, only a few established companies that are plugged into global research, development and production networks will have success in exporting their service innovations to other countries.

Over the period of 2001-2003, there have been some improvements in the Estonian ICT Sector Innovation System related to the capital market. Steps have been taken to establish a public venture capital fund in Estonia using the Finnish Sitra as a model. Still, there is extreme fragmentation of already small public R&D funding. Additionally, public ICT R&D funding does not actively favour university-enterprise partnerships for applied R&D. However, a recent support programme which finances centres initiated and operated jointly by companies and R&D institutions, seems to be addressing the issue. Mismatches between the skills developed and the needs of industry and commerce still exist.

A more detailed picture of future prospects would be facilitated by analysis of the following issues:

- FDI is the main agent for transformation of economies of new member states. How can acceding countries attract high-quality FDI that could also be invested, for example, in R&D?

- Future economic development will be strongly dependant on biotechnologies and especially ICT and biotechnology clustering. What is the position of acceding countries in this respect?
- How can these issues be addressed by public policies, bearing in mind that strong sector-specific industrial policies under the neo-liberal world order are strongly discouraged?
- Estonia is rapidly developing an Information Society, characterized by many Internet and mobile telephone users, etc. However, what are the economic benefits of this and how can economic developments be strengthened?

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ANNEX I:

ICT Companies in Estonian TOP500 by Turnover, 2000-2002

Table 14: ICT companies in Estonian TOP500 companies by turnover, 2000-2002[96]

RANK 2002	RANK 2001	RANK 2000	NAME	Turnover (2002) Mil EUR	Turnover (2001) Mil EUR	Turnover (2000) Mil EUR
4	3	2	Elion Ettevõtted AS (former Eesti Telefon AS)	148.5	177.2	160.1
5	5	4	EMT AS	140.8	128.8	103.5
32	44	69	Radiolinja Eesti AS	55.3	39.8	25.4
36	57	115	Tele2 Eesti AS	52.5	34.5	16.9
62	45	43	Elcoteq Tallinn AS	35.4	39.2	37.6
86	75	82	GNT Eesti AS (former CHS Eesti AS)	28.9	27.2	22.4
92	69	100	Siemens AS	27.4	29.0	18.6
110	90	81	Tech Data Eesti AS	23.9	23.3	23.0
118	130	137	Keila Kaabel AS	21.2	17.2	15.4
134	85	46	Ericsson Eesti AS	19.0	24.8	36.8
151	182	162	Harju Elekter AS	17.3	12.5	13.1
156		45	JOT Eesti OÜ[97]	16.8	17.3	37.1
168	176	226	Ordi AS	15.6	13.2	9.4
204	160	120	ML Arvutid AS (former MicroLink Arvutid AS)	12.6	14.6	16.5
246	216	183	Tarkon AS	10.7	10.4	11.4
254	250	273	Infotark AS	10.4	9.1	7.8
267	141	140	Nokia Eesti OÜ	9.9	16.3	15.1
312			Uninet AS[98]	8.6	6.0	1.7
326	**155**	**306**	**Abobase Systems AS**	**8.1**	**14.9**	**7.1**
330	276	258	KTK Overall AS	8.0	8.5	8.4
356	**271**	**303**	**MicroLink Süsteemid AS**	**7.4**	**8.5**	**7.1**
381	**392**	**400**	**Datel AS**	**6.9**	**5.8**	**5.3**
391	**328**	**325**	**Helmes AS**	**6.6**	**7.1**	**6.6**
404	**378**	**450**	**Cell Network AS**	**6.4**	**6.0**	**4.7**
441	**362**	**312**	**IT Grupp AS**	**5.7**	**6.4**	**6.9**
454			Klisseran AS	5.3	3.3	
463			**BCS Infra AS**[99]	**5.1**		
477	**358**		**MicroLink ServIT AS**[100]	**5.0**	**6.5**	**8.8**

[96] Source: Äripäev, *TOP100. Estonia's Leading Enterprises*, November 2003, pp. 16-22.

[97] According to turnover its position should have been 130 in 2001. For some reason not listed in the ranking.

[98] According to turnover its position should have been 242 in 2001. For some reason not listed in the ranking.

[99] Part of former Baltic Computer Systems AS

[100] According to turnover its position should have been 379 in 2000. For some reason not listed in the ranking.

ANNEX II:

TOP 30 ICT Companies in 2002 and 2001

The Estonian daily business newspaper "Äripäev" has ranked Estonian ICT companies every year since 1994 under six headings: sales, sales growth, profits, annual profit growth, profit margin and return on assets.[101]

Table 15: TOP 30 ICT companies in 2002 and 2001, ranking compiled by "Äripäev"[102]

RANK 2002	RANK 2001	NAME	County	Turnover (2002) Mil EUR	Profit (2002) Mil EUR	Turnover (2001) Mil EUR	Profit (2001) Mil EUR
1	8	PT Mikro AS	Rakvere	4.3	0.4	2.9	0.2
2		Argo Electronics AS	Narva	1.7	0.3	0.8	0.0
3		Trigger Software OÜ	Tallinn	1.5	0.3	1.1	0.3
4	84	TRL Group OÜ	Tallinn	0.4	0.1	0.2	-0.1
5	14	Telegrupp AS	Tallinn	3.2	0.5	3.2	0.1
6	75	MicroLink Data AS	Tallinn	3.7	0.2	2.9	0.0
7	28	ID Süsteemide AS	Tallinn	2.1	0.2	1.9	0.2
8		Klisseran AS	Tallinn	5.3	0.1	3.3	0.0
9	66	ML Arvutid AS (former MicroLink Arvutid AS)	Tallinn	12.6	0.3	11.9	0.1
10	24	Ferdida AS	Tallinn	0.4	0.1	0.3	0.0
11	17	Infotark AS	Tallinn	10.4	0.8	9.1	0.8
12		Ebeling Data OÜ	Tallinn	0.5	0.0	0.2	0.0
13		Reaalsüsteemide AS	Tallinn	0.5	0.1	0.4	0.1
14	37	Proekspert AS	Tallinn	0.7	0.1	0.6	0.1
15	23	Net Group OÜ	Tallinn	1.4	0.0	0.9	0.0
16	55	Profit Software AS	Tallinn	1.8	0.2	1.9	0.1
17		Aqris Software AS	Tallinn	0.6	0.1	0.6	0.1
18	63	Datel AS	Tallinn	6.9	0.1	5.8	0.0
19	5	Ordi AS	Tallinn	15.6	0.5	13.2	0.6
20		IT Arvutiteeninduse OÜ	Rapla	0.5	0.0	0.3	0.0
21	61	Aprote AS	Tartu	0.6	0.1	0.5	0.0
22	30	Sysdec AS	Tallinn	0.5	0.1	0.5	0.1
23	36	IE Tarkvara OÜ	Tallinn	0.3	0.2	0.3	0.2
24	22	PCT Arvutid AS	Tallinn	2.1	0.1	2.2	0.0
25	4	MicroLink Süsteemid AS	Tallinn	7.4	0.7	8.5	0.9
26	31	Medisoft AS	Tallinn	1.2	0.1	1.0	0.1
27	12	TietoEnator Financial Solutions AS	Tallinn	0.5	0.1	0.4	0.1
28		Business Software Partners OÜ	Tallinn	0.2	0.0	0.1	0.0
29	3	Cell Network AS	Tallinn	6.4	0.7	6.0	1.1
30	25	A-Kaabel YE AS	Tallinn	3.6	0.1	3.2	0.1

(continues on next page)

[101] Most of the ICT manufacturing companies (other than manufacture of computers) are not included.

[102] Source: Äripäev, *Arvutifirmade TOP (TOP ICT Companies)*, 4 September 2002.

(continued)

RANK 2002	RANK 2001	NAME	County	Turnover (2002) Mil EUR	Profit (2002) Mil EUR	Turnover (2001) Mil EUR	Profit (2001) Mil EUR
31	27	Lynx Nebula OÜ	Tallinn	0.5	0.0	0.4	0.0
38	2	Columbus IT Partner Eesti AS	Tallinn	1.7	0.3	1.9	0.6
39	15	DataGate OÜ	Tallinn	2.9	0.1	2.7	0.1
40	7	KTK Overall AS	Tallinn	8.0	0.6	8.5	1.3
42	6	Elvior OÜ	Tallinn	0.5	0.2	0.6	0.3
43	16	Taavi Tarkvara OÜ	Tallinn	0.3	0.0	0.3	0.1
48	1	Abobase Systems AS	Tallinn	8.1	0.5	14.9	2.2
54	18	GNT Eesti AS	Tallinn	28.9	0.1	27.1	0.3
60	11	Esknet AS	Tallinn	1.2	0.1	1.4	0.2
70	20	Voicecom OÜ	Tallinn	0.3	0.0	0.4	0.0
78	19	Tech Data Eesti AS	Tallinn	23.9	-0.3	23.3	0.5
82	9	NOVO Systems AS	Tallinn	0.7	0.0	0.6	0.4
84	21	Helmes AS	Tallinn	6.6	-0.4	7.1	0.2
86	10	TietoEnator Eesti AS	Tallinn	1.7	-0.1	1.8	0.2
	13	Reiw-Elektroonika AS	Tallinn			1.9	0.1
	26	Previo Estonia OÜ	Tallinn			2.4	0.1
	29	Infosüsteemide OÜ	Tartu			1.0	0.0