Knowledge-based Economy and ICT-related Education in Estonia: Overview of the Current Situation and Challenges for the Educational System

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Tallinn 2006

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PRAXIS Center for Policy Studies is an independent, non-profit think tank that aims to improve and contribute to the policy-making process by conducting independent research, providing strategic counsel to policy makers and fostering public debate.

The research was initiated and funded by the Estonian Information Technology Foundation (2004-2005). The analysis of vocational education was funded by the Ministry of Education and Research (2005).

The Estonian Information Technology Foundation (EITF) is a non-profit organisation founded by the Estonian Republic, Tartu University, Tallinn Technical University, Eesti Telekom and the Association of Estonian Information Technology and Telecommunications Companies. EITF aims to assist in the preparation of the highly qualified IT specialists and to support information and communication technology-related development in Estonia. EITF manages the Estonian IT College, founded in 2000. EITF managed the creation of the information system of admission in higher education institutions (SAIS) and has launched two project-based initiatives: Estonian e-University and Estonian e-Vet. In addition, EITF administers the National Support Program for ICT in Higher Education Tiger University.

The authors are grateful to Tiina Annus, Jaak Anton, Meelis Aunap, Kristi Hakkaja, Anne Jürgenson, Liis Kraut, Marius Kuningas, Erik S. Reinert, Kristjan Rebane, Indrek Reimand, Margit Suurna, Toomas Sõmera, Kalle Toom and Jaak Vilo for the help in preparing the current report.

Special thanks go also to the participants of the seminar on knowledge-based economy and ICT-related higher education organised by the Estonian Information Technology Foundation and PRAXIS Center for Policy Studies, 27 November 2004, in the Estonian Information Technology College (for the list of participants, see Annex VIII).

Publishing this book is part of the project 'Establishment of the Virtual Centre of Excellence for IST RTD in Estonia' financed by the European Union Fifth Research and Technological Development Framework Programme. Neither the European Commission nor any person active on behalf of the Commission is responsible for any use which might be made of the following information.

Editor: Margit Suurna
Language editor: Ingbert Edenhofer
Layout: Kristjan Kaljund

ISBN 9985-9667-0-8 (in print)
ISBN 9985-9667-1-6 (PDF)

EXECUTIVE SUMMARY

The current analysis aims at contributing to the development of the knowledge-based economy in Estonia by enhancing education relating to information and communication technologies. The knowledge-based economy and society in Estonia are analysed in comparison with other countries; Estonian innovation and educational policies are examined in the context of an increasingly global environment, the situation of the ICT-related education and its connections with the manufacturing industry as well as the service sectors are studied considering the global developments.

The private sector in Estonia is facing very serious and conceptual problems today, which the current R&D and innovation policies are incapable of solving. Thus, an approach is needed that ensures an agreement on how the real problems of the private sector are to be dealt with within the scope of R&D and innovation policies, and how a significantly improved mechanism for the design, assessment and coordination of R&D and innovation policies are to be created. The authors' recommendations focus on the establishment of a mechanism for the consistent monitoring of the economic sectors as well as the development of technology programmes in specific sectors.

A major challenge of the ICT sector is a need to move higher in the value-added chain which inevitably assumes more complicated, in other words, knowledge-based manufacturing or other business activities. Engineers and other highly educated specialists with interdisciplinary competences are needed first and foremost. The state should make use of the opportunities offered by public procurements: public procurements, orders, competitions, etc, could be organised for the development of relevant technologies and/or for elaborating skills and training systems.

The recommendations relating to higher education provided in the fields of ICT focus on the establishment and observance of uniform scientific standards and the consistent and broad-based creation of the posterity through degree studies, in particular Doctoral studies (including bringing visiting lecturers to Estonia and involving lecturers from the private sector). Today's curricula should be developed towards more specialisation and interdisciplinarity.

The greatest shortcoming of the education provided today in the fields of ICT consists in the weakness of the practical training system. Today, practical training constitutes an additional risk for companies, while it also fails to of much use to students. A system is proposed where that risk would be hedged from the point of view of both students and companies.

Other specific recommendations for ICT vocational education are focusing on encouraging cooperation between schools and with the private sector, preparation and evaluation of teaching staff should become systematic and the study programmes should include more modules focused on the development of the social skills of the students and the share of courses taught in English should increase. An issue of critical importance is the improvement of the integration of ICT with other fields.

The research was commissioned by the Estonian Information Technology Foundation and the Ministry of Education and Research.

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INTRODUCTION

This analysis aims at contributing to the development of the knowledge-based economy in Estonia. The analysis concentrates specifically on the field of study of vocational and higher education relating to information and communication technologies[1] and on the opportunities of the enhancement thereof.

The following issues are analysed in more detail: What strategic options face the Estonian innovation and educational policies in the increasingly global environment, considering the opportunities of Estonia as a small country (Chapter 1)?

Which indicators best describe a knowledge-based economy and society and what is the current position of Estonia when compared to other countries (Chapter 2)?

What is the situation in Estonian manufacturing industries in the light of these indicators, in particular as regards ICT processing industries and the software industry (Chapter 3)?

To what degree is the educational system capable of preparing relevant specialists and what are the current primary competences? To what degree are universities and research establishments capable of generating new knowledge and satisfying the R&D needs of companies, incl. the capability of adjusting to changing conditions (Chapters 4 and 5)?

Within the scope of the research project, suggestions for developing the ICT-related education system are put forward (Chapter 6), which could become an input for the part of the single programming document discussing the education system. The latter serves as a basis for the distribution of the structural funds of the European Union (EU). These suggestions were discussed at the joint seminar of the Estonian Information Technology Foundation and PRAXIS Center for Policy Studies concerning knowledge-based economy and ICT-related higher education, which was held at the Estonian IT College on 27 November 2004 (the list of participants in the seminar is available in Annex 8).

In brief, the analysis seeks to answer the following question: Which active education policy measures derive (or should derive) from the Knowledge-based Estonia strategy and other related strategies? In discussing the various functions of the education system, its connection with the needs of the processing industries and the service sector constitutes the central criterion. Thus, the analysis could be treated as a follow-up to the research titled *The Estonian Economy Competitiveness and Future Outlooks*,[2] which analyses the sources of Estonian economic growth and relates these to the objectives of the *Knowledge-*

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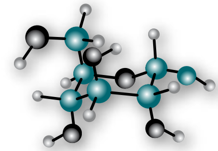
1 From now on (if not indicated otherwise) the following are included under information and communication technologies (ICT): Manufacture of office and electrical machinery; manufacture of radio, television and communication equipment; manufacture of optical instruments etc as well as advisory services on hard- and software; purvey of hard- and software; data processing and database services and other services connected with computers and telecommunication. Doing so, we include the use of ICT in different fields of economy.

2 Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, http://www.praxis.ee/data/The_Estonian_Economy_Competitiveness_and_Future_Outlooks.pdf.

based Estonia, analysing the aspects to be enhanced in the ICT-related higher education and bases for such enhancement.

The research was commissioned by the Estonian Information Technology Foundation and the Ministry of Education and Research and it has been carried out by PRAXIS Center for Policy Studies.



1. STRATEGIES AND STRATEGIC CHOICES

1.1. *Success Estonia 2014*, *Knowledge-based Estonia* and Innovation Policy

There are allegedly more than 70 different strategies or strategic documents in Estonia today. An attempt has been made to address the issue of superabundance of strategies by the common governance strategy *Success Estonia 2014,*[3] which is supposed to constitute a process for making strategic choices and an Estonian mechanism for achieving the goals established by the *Lisbon Strategy*[4] (and partly also the goals set out in *Knowledge-based Estonia*[5]).

However, the different strategies (incl. *Success Estonia 2014*) substantially seek to combine quite different sectoral strategies (which are of rather different levels) to a great extent and that combination lacks a substantial synthesis and – what is even more important – it lacks links to the actual problems in the Estonian economy. State financing of the Estonian innovation system is, to a great extent, targeted at the promotion of commercialisation and other economic uses of research and knowledge concentrated in universities and other research and development institutions i.e. at researchers and at bringing research into the enterprise sector.[6] However, several recent researches have revealed that the most acute problems of the competitiveness and innovation system of the Estonian economy lie in the enterprise sector.[7] Today, innovation is obviously too expensive and risky for Estonian companies, thus logically entailing the resource-intensive production system. The current situation cannot be cured immediately due to the lack of skills, experience, financial base, etc.

Yet practically no state measures, targeted at developing the innovation system, address the problems referred to above. Hence, the solutions targeted at researchers can in no way motivate companies to engage in more risky and innovative projects. The Estonian R&D and innovation policies, a substantial part of which have been formulated in the light of the *Knowledge-based Estonia* and *Success Estonia 2014* and which should form the base for the implementation of both of these strategies, are characterised by both the lack of priorities and the market-based competition.[8] The only priority that can be found in various

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3 For more details, see *Success Estonia 2014. Government's strategy document: Action Plan for implementation of Lisbon Strategy*.

4 See relevant website of the European Commission at http://europa.eu.int/comm/lisbon_strategy/index_en.html.

5 *Estonian Research and Development Strategy 2002-2006. Knowledge-based Estonia*, http://www.hm.ee.

6 Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71.

7 See also Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, http://www.praxis.ee/data/The_Estonian_Economy_Competitiveness_and_Future_Outlooks.pdf.

8 For more details, see Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71.

policy measures is tourism.[9] The Republic of Estonia has given up the main underlying reason for R&D and innovation policies: setting priorities. The market-based competition, in the allocation of funds, is favouring strong players in the market, yet fails to tell anything about whether their activities are such as to benefit the Estonian economy in the long run. In principle, all the measures of R&D and innovation policies are (or will soon be) financed out of the structural funds of the EU. The idea of structural funds is simple: to enable less developed countries to set priorities in accordance with their respective situations and needs.[10] However, Estonia has started out in a totally reverse direction as to its R&D and innovation policies. Therefore, the objectives, established both in *Knowledge-based Estonia* and *Success Estonia 2014*, have become basically unattainable. Similarly, the objectives of the *Lisbon Strategy* have been rendered unfeasible.

At the same time the technology-intensive exports of Estonian companies have been declining for several years, which means that the Estonian economy fails to generate the value added necessary to cover the current account deficit.[11] Yet, this does not mean that Estonian companies are not doing well. On the other hand, the competitive advantage based on cheap resources is disappearing – the more technology-intensive the Estonian companies, the more complicated their situation today, as they lack the means, skills and experience necessary for withstanding severe international competition. **At present, the Estonian economy literally is not sustainable** (discussed in more detail in Chapter 3).

Pursuant to the *Lisbon Strategy*, by the year 2010 Europe must become the most competitive region in the world, which is simultaneously characterised by strong social cohesion.[12] In other words, the *Lisbon Strategy* aims at a strong economy in a strong social country.[13] ICT represents one of the most important means to attain these goals – it is estimated that ICT accounts for approximately 50% of the economic growth achieved recently.[14]

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9 All the documents are available on the website of the Foundation Enterprise Estonia at http://www.eas.ee and they have been published in the State Gazette. The following measures are considered here: "Start-Up Assistance of the New Undertakings", Regulation No 75 13.04.2004 of the Minister of Economic Affairs and Communications; "Assistance for the development of business infrastructure", Regulation No 72 13.04.2004 of the Minister of Economic Affairs and Communications; "Spinno programme", Regulation No 122 3.05.2004 of the Minister of Economic Affairs and Communications; "R&D Financing programme", Regulation No 73 13.05.2004 of the Minister of Economic Affairs and Communications; "Consulting Assistance", Regulation No 74 13.05.2004 of the Minister of Economic Affairs and Communications; "Export Plan Programme", Regulation No 145 7.06.2004 of the Minister of Economic Affairs and Communications; "Training Aid", Regulation No 154 15.06.2004 of the Minister of Economic Affairs and Communications; "Tourism Product Development and Marketing" and "Enhancing Estonia's Reputation as a Tourist Destination", Regulation No 126 7.05.2004 of the Minister of Economic Affairs and Communications; "Regional Competitiveness Improvement Programme", Regulation No 36 11.06.2004 of the Minister of Internal Affairs; "Innovation Awareness Programme", Regulation No 229 30.12.2004 of the Minister of Economic Affairs and Communications; "Competence Centre Programme" is available on the website of the Foundation Enterprise Estonia. The establishment of a Risk Capital Fund is being discussed, see Zernicke 2003.

10 See, e.g., Council Regulation No 1260/1999, http://www.legaltext.ee/et/andmebaas/tekst.asp?dok=T30423&keel=et.

11 Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, http://www.praxis.ee/data/The_Estonian_Economy_Competitiveness_and_Future_Outlooks.pdf; Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71; The International Monetary Fund (IMF) also calls attention to the remarkably large foreign debt of Estonia, see IMF, *Country Report No. 04/357: Republic of Estonia: Selected Issues*, 2004, http://www.imf.org/external/pubs/cat/longres.cfm?sk=17835.0.

12 Maria João Rodrigues, "Strategy of the Europe at the Turn of the Century", *Knowledge-Based State and Economy*, Tallinn: The State Chancellery of the Republic of Estonia, 2004, 16-36.

13 See, e.g., Ján Figel, *Concluding Remarks on Industry Policy*, Industry Policy Day Conference, May 2004, European Commission.

14 See, e.g., OECD, *The OECD Information Technology Outlook 2004*, Paris: OECD, 2005; *Facing the Challenge, The Lisbon Strategy for Growth and Employment*, Report from the High Level Group chaired by Wim Kok, 2004, http://europa.eu.int/comm/lisbon_strategy/pdf/2004-1866-EN-complet.pdf; PricewaterhouseCoopers, *Rethinking the European ICT Agenda. Ten ICT-breakthroughs for reaching Lisbon goals*, 2004.

The implementation of the Lisbon Strategy faces two important challenges: firstly, the competition provided by countries with cheaper labour through the global economy; and secondly, the asymmetrical integration of the new member states (discussed in more detail in Chapter 2). The new, enlarged Europe has to deal with extremely complicated choices: on the one hand, the new member states exert remarkable pressure on the so-called old member states with their cheap labour, and on the other hand, both the new and the old member states compete with the relatively cheap and extremely productive labour in Asia. In this context, the Lisbon Strategy means that Europe has agreed on not lowering wages or other labour costs, but rather on improving productivity i.e. relying on innovation. This approach is based on the presupposition that such a tactic would be beneficial for all – for companies, employees and – through larger tax proceeds – for the public sector.

The development and success of capitalism have always built upon the concurrence of economic and political interests, which has made it possible to increase the general weal (improve the living standard) through the promotion of the private interests (profits) of companies. Namely, different market participants have different advantages and it would be remarkably easier to utilise these advantages if the risks, which are inevitable in a market, have been hedged in one way or another. The state, through its public policy, has been and continues to be the strongest institution capable of hedging such risks. Starting from patents, protection of markets, central banking and infrastructure investments, up to the financing of R&D and the consumer protection, the socialisation of risks on the part of the public sector has contributed to the reconciliation of private interests and the public interest. Over the last five hundred years, public policy has basically aimed at enhancing the general weal on the basis of the **advantages and needs of the particular country and society**. In reality, this means acknowledging the qualitative differentiation of economic activities, i.e. sectoral economic policy. Therefore, the aim of the economic policy has been relatively easy to define: the aim is to improve the distribution of work, i.e. to increase clustering, as this makes it easier to utilise the implementation of national economic and other advantages while contributing to as wide-ranging an improvement of welfare as possible. Thus, there have been quite different approaches to the accomplishment of the said objective during history, as besides fields of activity also public policies differ by countries and periods, because they are based on the needs of particular countries and societies.

However, as economy is becoming increasingly global, economic and political interests need not concur any more. The transition of labour-intensive industries to developing countries, as observed in recent years, entails the disappearance, or material alteration, of jobs held by the middle classes of developed countries, as well. The interests of companies are not related to geographical regions any longer, but rather to the sectors in question, irrespective of the geographical locations. Hence, economic clusters cannot be unambiguously defined in geographic terms any more. That trend has arisen from the circumstance observed by Joseph A. Schumpeter, namely that while economic growth builds upon the development of technology, economy is not enhanced by technology as such, but rather by the companies that seek for, find and utilise new solutions and opportunities (innovation).[15] While, broadly speaking, the interests of companies are global, the primary interest and task of the public policy is always centred around the particular society. Hence, while globalisation represents a huge opportunity for companies, it constitutes at least a huge challenge for the public policy, as in the environment of global economy the objective of the economic policy (clusters) is not unambiguously definable any more, because clusters themselves are variable by nature.

15 Joseph A. Schumpeter, "The Economy as a Whole. Seventh Chapter of the Theory of Economic Development", *Industry and Innovation*, 1/2, 2002, 93-145.

1.2. Globalisation and Small Countries[16]

The economic theory and policy have practically always been based upon the renowned principle stated by Adam Smith, according to which there is a positive link between welfare and the size of a market.[17] Thus, the EU should be good news for Estonian companies. Yet, the globalisation is now reversing the formed economic logic to a great extent. In 1995, a cover of *The Economist* probably summarised the economic nature of globalisation the most strikingly: *The Death of Distance*. On 15 November 2003, the editorial article of the *New York Times* warned about the "Wal-Martization" of the USA, referring to the policy of Wal-Mart, as one of the largest chains of supermarkets, to use extremely cheap labour to keep prices down.[18] Two weeks later, on 1 December 2003, the *BusinessWeek* discussed the same issue in *"Waking up from the American Dream"*.[19] Both *BusinessWeek* and the *New York Times* observed a quick decrease in the wages of middle class Americans, which implies the creation of peripheries even in highly developed countries. The same debate and awakening is probably still in store for the enlarging EU, although the first warning signals have been heard both from Germany, where approximately one fourth of the jobs in the telecommunications sector might be lost in the coming years,[20] and from Belgium.[21] That trend does not signify just the transition of cheap jobs to countries with a lower living standard, but also the transition of R&D activities on the whole. Countries in Central and Eastern Europe are also becoming important destinations.

In view of the proximity of communications and target markets, geography, as the decisive factor in the creation of economic clusters, is basically losing its hitherto vital role: clustering is not occurring on the basis of geography (geographic proximity, a certain common political and social framework and culture) any more, but increasingly rather within industries, while utilising broader regional – and, increasingly, global – opportunities. Developing countries like Estonia, in particular, should be cautious, as the rapid development of certain sectors (e.g. biotechnology or nanotechnology) need not have any substantial impact on the welfare of people living in Estonia, because that high-tech sector may have become a small part of the Scandinavian (e.g. biotechnology) cluster, value added generated by which is removed from Estonia.[22]

Then again, these principal changes entail remarkable opportunities namely for countries like Estonia. A reference of the BusinessWeek magazine to rising competence centres in various spheres across the world illustrates this. Despite their small population numbers, Israel (6.1 million), Singapore (4.1 million) and several relatively small countries like Taiwan (23 million) and South Korea (49 million) are represented. The latter countries are, irrespective of their smallness, the bearers of a remarkable number of innovations in the ICT sphere (see e.g. patenting in the US) (Figure 1-1).

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16 For more details, see Rainer Kattel, "Introduction: Knowledge-Based State and Economy", *Knowledge-Based State and Economy*, Tallinn: The State Chancellery of the Republic of Estonia, 2004, 6-15.

17 For the point of view of a small state, see Austin Robison, ed., *Economic Consequences of the Size of Nations*, London: Macmillan, 1963.

18 http://www.businessweek.com/@@A50u5oUQ9Q4xyREA/magazine/content/03_48/b3860067_mz021.htm.

19 "Waking up from the American Dream", *BusinessWeek*, 1 December 2003.

20 See, e.g., *Der Spiegel*, http://www.spiegel.de/wirtschaft/0,1518,292371,00.html and chapter 2 below.

21 *How to Make Belgium a Hotspot for Innovation. Results of a Survey among Managers of Enterprises in Belgium*, FEB and Arthur D Little, 2004, http://www.feb.be.

22 See Rainer Kattel and Riivo Anton, "Estonian Genome Project and Economic Development", *Trames*, 8, 1/2, 2004, 106-128.

Figure 1-1. The world's rising innovation hot spots[23]

In 2003, U.S. inventors secured 88,000 U.S. patents. The U.S. spent 2.7% of GDP on R&D and graduated 400,000 scientists and engineers. But developing nations are making rapid progress.

	India	China	Russia	Israel	Singapore	Taiwan	South Korea
Strengths	Embedded software, drugs, business software, chip design	Mechanical engineering, computer graphics, handwriting recognition	Aerospace, software, laser optics, energy, algorithms, chemistry	Optical and wireless communications, chips, software, sensors	Broadband, grid computing, biotech, handheld devices, computer peripherals	Chips, PCs, multimedia devices, network equipment	Digital displays, memory chips, computer games, wireless telecom, broadband
U.S. Patents 1993	30	60	62	306	39	62	764
U.S. Patents 2003	354	366	268	1,188	438	5,300	3,952
R&D Spending	1% of GDP	1.2% of GDP	1.2% of GDP	4.7% of GDP	2.2% of GDP	2.3% of GDP	2.9% of GDP
Science & Engineering Grads	316 thousand	337 thousand	216 thousand	14 thousand	5.6 thousand	49 thousand	97 thousand

While some dozen years ago, the transition of certain pharmaceutical industry processes to Estonia would basically have required an expenditure equal to the GDP in its entirety, it would not be impossible today, as that part of the pharmaceutical industry need not be too large and certain tasks are moving from the industry to the biotechnology sector, aiming at finding cheaper, yet qualified labour. The same applies to other sectors, e.g. instrument-making, etc.

In principle, the global economy and the accession to the EU involve substantial development opportunities for Estonia, as well as for other countries in Central and Eastern Europe. It should be noted, however, that besides a liberal economic policy there should be more reasons for the industry staying here, if such a development is to be sustainable. The current trends indicate an opposite development: the industry is becoming extremely mobile and while clustering is now based on sectors rather than geographic proximity, the mobility is increasing. Hence, the opportunities for creating linkages to the pharmaceutical industry's value chain or something similar in the ICT industries in Estonia in the near future, are quite realistic. Then again, the related risks are at least as realistic.

The most drastic example in this context probably concerns the development of former East Germany, which thanks to the substantial cash flow from West Germany could be regarded as the most positive example of an increasingly global economy, in view of the harmonisation of the labour market and social policies besides the liberalisation of markets. On the other hand, the integration of the two Germanys, the cost of which has amounted to EUR 1250 billion by now, has basically entailed some catastrophic results: the current situation is principally characterised by the creation of high-tech oases in a few cities,

23 *BusinessWeek*, 11 October 2004.

which, however, are surrounded by extremely rapid regression and vast unemployment.[24] Such a disproportionate national development is increasingly typical of several developing countries, as well as Central and Eastern European countries.

The occurrence of similar phenomena also in welfare states is a noteworthy new trend, which basically confirms the fact that the clustering of industries is no longer primarily related to geographic locations. In this light, policies aiming at a continuous modernisation of industries are of increasing importance and, owing to the logic referred to above, need to be sector-specific. In other words, from the point of view of economic policy, it is not the size of a market that counts, but rather the existence and sizes of value chains in a country, i.e. not the number of specialisations, but the amount of the value added created locally. It is because of that very reason why knowledge and skills have become essential in practically all industries: they are the only factors that make it possible to withstand competition in the creation of value added. Thus, continuous and vigorous modernisation of the existing economy, not the high-tech or resource-based race, ensures success for small developing countries.

1.3. Paradigm-based Educational Policy and R&D, and Sector-Specific Economic Policy

Economic development is not smooth or linear, but dynamic and salutory. The alternation of product generations, triggered by new knowledge and values, which, in turn, requires changes in the broader institutional environment, causes the cyclic nature of socio-economic development, with the cycles referred to as technological-economic paradigms[25] (Figure 1-2). Paradigms arise as a result of massive investments in certain radically new scientific inventions and commercialisation thereof, as well as the extensive use of the corresponding technologies characterised by growing productivity.[26]

Owing to the history of economy, it has been asserted that such paradigms last for approximately half a century, initially explosively developing in a narrow technological sphere, until the technology in question provides several different opportunities for use and has become so inexpensive as to enable practically all industries to abruptly increase productivity.[27] The current techno-economic paradigm that started in 1971 with the development of the Intel chip is thus still under way. The next two decades will most probably see (1) a massive growth and breakthrough of ICT-based technologies and solutions: ICT will become as natural as plastics, rubber, electricity, petrol, mass production and factories; (2) owing to the massive spread and breakthrough of ICT, searches for new technological solutions that would render new solutions and productivity growth possible, i.e. large investments in bio- and nanotechnologies.

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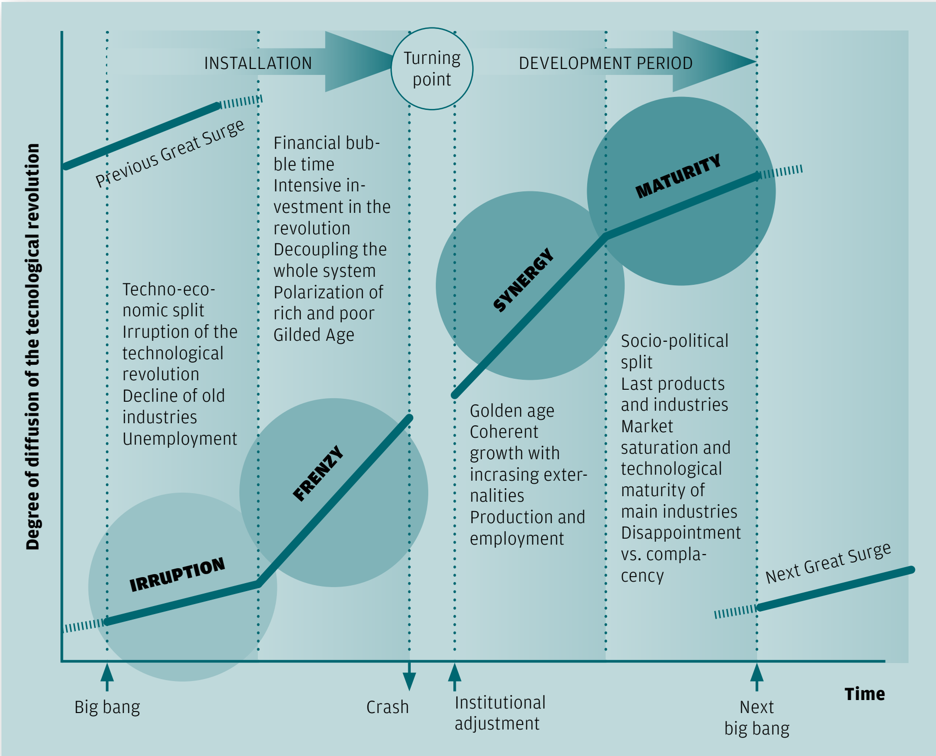
24 For more details, see Erik S. Reinert and Rainer Kattel, *The Qualitative Shift in European Integration: Towards Permanent Wage Pressures and a 'Latin-Americanization' of Europe?*, PRAXIS Working Paper no 17/2004, http://www.praxis.ee/data/WP_17_20042.pdf; and also e.g. *Der Spiegel*, http://www.spiegel.de/politik/deutschland/0,1518,294097,00.html.

25 Nikolai Kondratjev was the first author who proved it, see "Die langen Wellen der Konjunktur", *Archiv für Sozialwissenschaft und Sozialpolitik*, 56, 3, 1926, 573-609 and "The long Waves in Economic Life", *Readings in Business Cycle Theory*, Philadelphia: Blakiston, 1944, 20-42; see also Christopher Freeman and Francisco Louçã, *As Time Goes by – From the Industrial Revolutions to the Information Revolution*, Oxford: Oxford University Press, 2001; Carlota Perez, *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*, Cheltenham: Edward Elgar Publishers, 2002.

26 For a short overview, see the video recording of the presentation made by Carlota Perez on 27 September 2002 in Tallinn at a seminar organised by PRAXIS in the Ministry of Economic Affairs and Communications, http://www.praxis.ee/innovation/workshop.

27 *Ibid*.

Figure 1-2. Development of techno-economic paradigms, and economic crises[28]



On the other hand, the rapid spread of knowledge and technologies (especially as regards the developed world) implies that the productivity, arising from a particular technology, cannot improve endlessly. Productivity will decrease in inverse proportion to the spread of technology, as competition tightens and the technology exhausts its potential. In such a situation, a new technology and the paradigm based thereon can offer a new improvement in productivity. Thus, R&D and innovation policies should always be based on the particular technology and its state of development.[29]

To sum it up, the competitiveness of the economy of a (small) country is based on the following: (a) increasing share of medium- and high-tech companies in the value added produced, especially in exports, and (b) the nature and quality of the knowledge and technological base of the same companies. The key question is: are we operating within the right paradigm or are we trying to use cheap labour for breakthrough within the scope of an old paradigm i.e. are we implementing and developing technologies that no longer enable substantial improvements in productivity?

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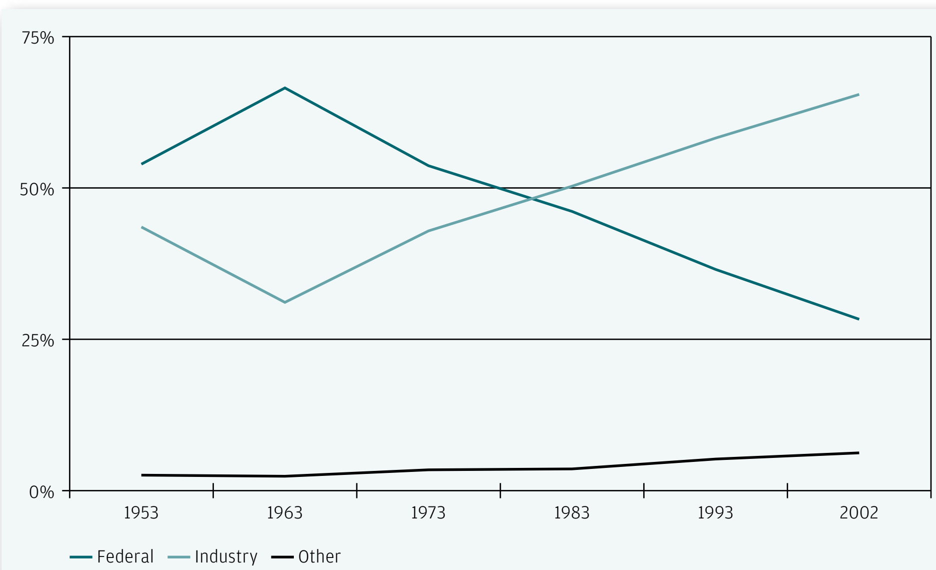
28 Carlota Perez, *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*, Cheltenham: Edward Elgar Publishers, 2002.

29 Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, http://www.praxis.ee/data/The_Estonian_Economy_Competitiveness_and_Future_Outlooks.pdf.

The impact of the technology that leads a paradigm on other industrial sectors, is quite diverse, i.e. sector-specific. **Hence, it can be relatively easily understood why economic policy and particularly innovation policy targeted at the enterprise sector must be sector-specific.** It appears at first sight that also the educational policy must follow the same sector-specific logic. This is not true: **research and educational policies must be paradigm-centred in order to prepare people who would be able to manage in the economic, social and technological environment resulting from the paradigm, and to develop irrespective of the sectors they operate in.**

Over the last 200 years, the United States of America has been the most successful country in developing the economy, namely within the framework of different paradigms. The common denominator of the *Report on Manufacturers*[30] by Alexander Hamilton, and the large investments in future technologies placed by today's administration of the USA, consists in the continuous modernisation of the economic structure and environment in line with the development of technologies.[31] This is illustrated by the circumstance that, upon the creation and in the initial phase of a new paradigm, the role of public investments in R&D is much bigger than that of private investments, while decreasing materially by the time, that thanks to development, the private sector is able to earn substantial profits and continue the investments (Figure 1-3).[32]

Figure 1-3. Share of U.S. R&D funds, by source, 1953–2002[33]



30 Alexander Hamilton, *Report on Manufactures*, 1791, http://history.sandiego.edu/gen/text/civ/1791manufactures.html.

31 It should be kept in mind that, in addition, different states invest in future technologies and business development from their own resources, too.

32 For information about the profitability of public sector investments in research and development, see, e.g., Ammon J. Salter and Ben R. Martin, "The Economic Benefits of Publicly Funded Basic Research: A Critical Review", *Research Policy*, 30, 3, 2001, 509-532.

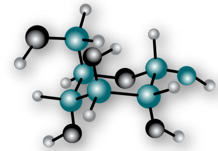
33 Source: National Science Foundation, *Science & Engineering Indicators* – 2004, 2004, http://www.nsf.gov/sbe/srs/seind04/c4/fig04-04.htm.

Hence, there must be a complex approach to the current situation in Estonia: the development of the research and educational system in line with the requirements and needs of the ICT paradigm; rendering economic and innovation policies sector-based and priority-centred.

The development of the ICT sector as one of the most eminent indicators of Estonia's progress so far has been constantly criticised since at least the year 2003. Note that ICT is one of the most important technologies referred to in the *Lisbon Strategy*. It is obvious that Estonia needs essential changes in R&D and innovation policies and more specifically in the ICT sphere. While the European Research Area,[34] the Sixth and Seventh Framework Programmes of the EU,[35] *Single Programming Document*, etc, constitute the opportunities and means to change the current situation, the questions which are currently avoided in Estonian R&D and innovation policies but which inevitably need to be answered are: **What should be developed and on which bases? What should priorities be based on?** In the ICT sphere, two similar specific questions should be answered: Which research and education should be supported? Which industries should be supported? This document seeks to answer the questions concerning the ICT sphere.

34 *Towards a European Research Area*, Communication from the Commission, 2000, ftp://ftp.cordis.lu/pub/documents_r5/natdir0000001/s_1372005_20010125_143514_C001190en.pdf.

35 See http://www.cordis.lu/en/home.html.



2. INTERNATIONAL STATISTICAL COMPARISON: INDUSTRY, EDUCATION, R&D AND INNOVATION

This chapter aims at mapping the position of Estonia in relation to (1) similar countries in transition, and (2) countries characterised by strong ICT development. Even though the choice of reference countries (Ireland, the Netherlands, South Korea, Slovenia, Finland, Hungary) is to some extent arbitrary, all of them are relatively small states that have been remarkably successful in ICT production and/or implementation, which is reflected in the high scores of those countries in international rankings.[36] Thus, it is quite logical to compare Estonia with these countries, all the more so because several of them are Estonia's direct competitors or partners.

This chapter discusses the development of manufacturing industries in 1990–2000 and their current position both in terms of labour costs and productivity on the one hand, and the current situation with human capital in technical fields on the other hand. That comparison creates a background system, based on which Estonia's current potential, in technology spheres, can be assessed both as regards industry and human capital, and which should make it possible to point out the major problems. That, in turn, facilitates assessing the current situation of research and education in the Estonian ICT in more detail in the next chapter.

2.1. Development of Manufacturing Industries in 1990–2000[37]

In order to determine the quality of the economic development in the reference countries, regarding changes in the structure of manufacturing industries measured on the basis of the volume of knowledge and skills, two widely used measures can be used as the basis: the change of the relative share of medium- and high-tech industries in exports and in value added.[38] As regards the third dimension, the value added of processing industries per inhabitant is discussed, which indicates the impact of structural changes in the economy on the real welfare of the population.

In 1990–2000, two countries in transition – Estonia and Hungary – have developed at a significantly lower pace when compared to other reference countries (Figure 2-1).

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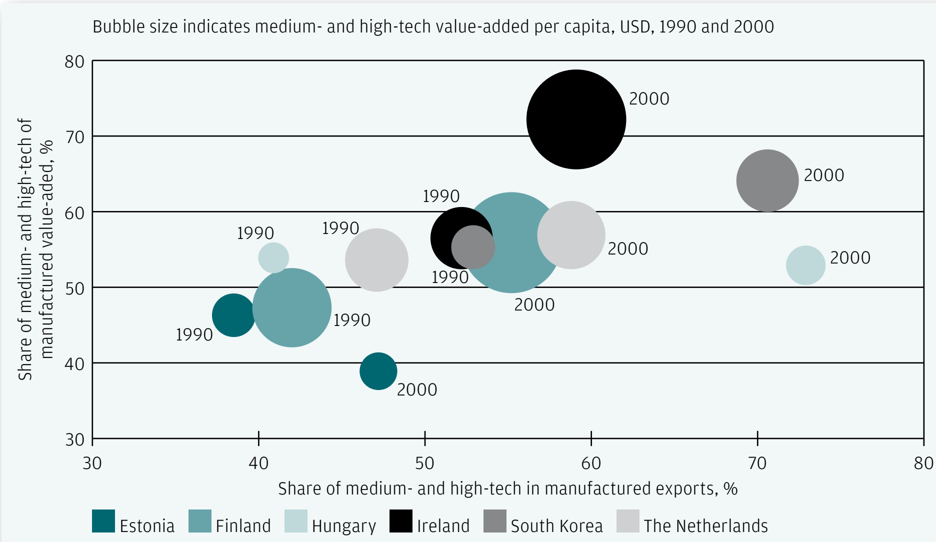
36 For a critical discussion of competitiveness indices, still, see Sanjaya Lall, "Competitiveness Indices and Developing Countries: An Economic Evaluation of the Global Competitiveness Report", *World Development*, 29/9, 2001, 1501-1525.

37 The following includes neither the impact of foreign direct investments on development nor the problems concerned with the current account. For more information about these issues, see Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, http://www.praxis.ee/data/The_Estonian_Economy_Competitiveness_and_Future_Outlooks.pdf; Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71.

38 UNIDO has used this method already for years, see *Industrial Development Report 2004. Industrialization, Environment and the Millennium Development Goals in Sub-Saharan Africa. The New Frontier in the Fight against Poverty*, United Nations Industrial Development Organization (UNIDO), 2004, http://www.unido.org; *Industrial Development Report 2002/2003. Competing through Innovation and Learning*, UNIDO, http://www.unido.org.

Figure 2-1. Technology-intensity of industry and exports, and value added per inhabitant in some countries[39,40]



Hungary has managed to remarkably increase the share of its medium- and high-tech processing industries in exports, but this has not had any substantial effect on the national structure of processing industries, which, in turn, is reflected in the circumstance that the value added of processing industries per inhabitant has not increased much in 10 years. As for Estonia, a similar trend can be observed, i.e. even though the share of medium- and high-tech processing industries in exports has increased since 1996, the share of these industries has declined in the generation of value added. Hence, in 2000 the economy of Estonia was in a state much worse than was the case in 1996. The same is reflected in the circumstance that the value added, per inhabitant, generated in Estonia was higher in 1990 than it was in 2000.[41]

At the beginning of the 1990s, Finland was in a position comparable to that of Estonia in structure terms, yet much wealthier, but by the year 2000 Finland had improved the structure of its economy, thus increasing its wealth even more. Ireland, the Netherlands and South Korea had relatively similar positions in 1990, even if value added, generated in South Korea, was much smaller. The development of Ireland has been quite impressive, which is also expressed in the notable increase in wealth.

With the exception of South Korea, all of the countries compared herein are members of the EU, which means that they compete with each other both as regards exports and foreign investments. Then again, the global economy also places South Korea essentially on the same level.

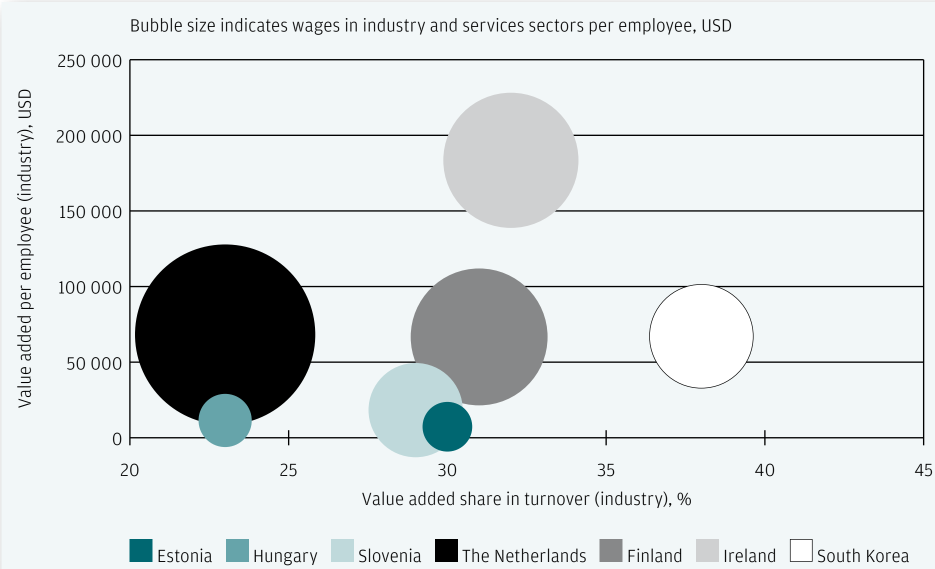
The following is an analysis of the reference countries' competition in wages and productivity, i.e. a comparison of staff costs per employee and the added value created (Figure 2-2).

39 Statistical information about Slovenia was not available; Estonian export data cover the years 1996-2000.

40 Source: *Industrial Development Report 2004. Industrialization, Environment and the Millennium Development Goals in Sub-Saharan Africa. The New Frontier in the Fight against Poverty*, United Nations Industrial Development Organization (UNIDO), 2004, http://www.unido.org; authors' calculations.

41 For more details, see Marek Tiits, Rainer Kattel, Tarmo Kalvet, Rein Kaarli, *The Estonian Economy Competitiveness and Future Outlooks*, Tallinn: Research and Development Council, 2003, http://www.praxis.ee/data/The_Estonian_Economy_Competitiveness_and_Future_Outlooks.pdf.

Figure 2-2. Wage competition in reference countries, 2001[42]



In principle, it is quite the same as to which country one operates in: there are efficient and profitable companies in all of these countries, as is also indicated by the share of value added in the turnover. However, staff costs are definitely the highest in the Netherlands, whereas staff costs are remarkably lower in South Korea (even in comparison with Finland) with the productivity level being the same as in the Netherlands. With comparable staff costs, Ireland's productivity is much higher. In the countries in transition low staff costs are accompanied by low productivity. Although low productivity *per se* need not automatically have an adverse effect on development, the figure above demonstrates that countries in transition have not succeeded in making the structure of their economies more knowledge-intensive over the past ten years. The figure indicates relatively clearly that companies in the so-called old Europe have basically three alternatives to withstand competition: reduce local wage costs; take production to Eastern Europe or Asia; or considerably improve local productivity.[43] Both competition within Europe and the competition of Europe as a region with Asia are extremely severe.

In light of the foregoing, Estonia needs to substantially increase the knowledge-intensive part of its industry, for which qualified labour is an essential condition precedent. Hence, the chances of countries in Central and Eastern Europe to reverse the negative development trend of the 1990s and to move towards a more knowledge-intensive industry and economy are, to a great extent, dependent on the quality of human capital in those countries, in particular as regards technological fields. Other macroeconomic conditions are relatively similar.

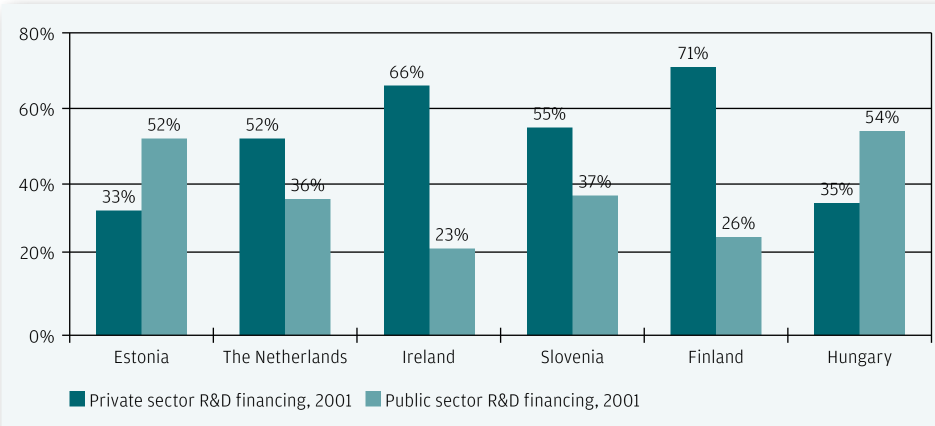
42 Source: *UNIDO Country Statistics*, http://www.unido.org/Regions.cfm?area=GLO; authors' calculations.

43 For more details, see Erik S. Reinert and Rainer Kattel, *The Qualitative Shift in European Integration: Towards Permanent Wage Pressures and a 'Latin-Americanization' of Europe?*, PRAXIS Working Paper no 17/2004, 2004, http://www.praxis.ee/data/WP_17_20042.pdf; David B. Audretsh, *Entrepreneurship Policy & the Strategic Management of Places*, 2004, http://www.hhh.umn.edu/centers/slp/clusters_entrepreneurship/audretsch_entrepreneurship_policy.pdf.

2.2. Human Capital[44]

One of the most significant differences between R&D systems consists in the fact that the structure of R&D financing in Central and Eastern European countries is quite different from that of developed countries, with the R&D expenditure in the private and public sectors being the most noteworthy example (Figure 2-3).

Figure 2-3. R&D expenditure in private and public sectors, 2001[45]



Of the Central and Eastern European countries compared, Slovenia is the only one possessing an R&D financing structure similar to that of developed countries. With Estonia and Hungary, a continuation of the trends pointed out in the figures above can be observed. The restructuring of the industry has not been towards knowledge-intensity, but the other way round, especially in Estonia: knowledge-intensity is diminishing. Hence the scarce R&D expenditure in the private sector. The institutional environment created by the public sector has enabled the private sector to develop without having had the need to place substantial investments in the development of knowledge and technologies.

As for Estonia, this is, among other things, reflected in the number of researchers and engineers per thousand inhabitants in the private sector, which is the lowest in the reference countries (Figure 2-4). On the other hand, there are relatively many researchers and engineers in the higher education sector. This is probably why the Estonian R&D and innovation policies are, to a great extent, targeted at bringing people and activities in R&D establishments into the enterprise sector.[46]

In Estonia and Slovenia the number of employees in the R&D sphere decreased in 1996–2001 (Figure 2-5). Many of these employees have most probably engaged in fields other than those in which they had specialised.

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44 The authors are grateful to Marius Kuningas for collecting international statistics.

45 Source: European Commission. *Towards European Research Area – Science, Technology and Innovation Key Figures 2003-2004*. Brussels, 2003, http://europa.eu.int/comm/research/era/pdf/indicators/ind_kf0304.pdf.

46 For more information, see chapter 1.

Figure 2-4. Researchers and engineers by sectors, based on the full-time equivalent per 1,000 inhabitants, 2001[47,48]

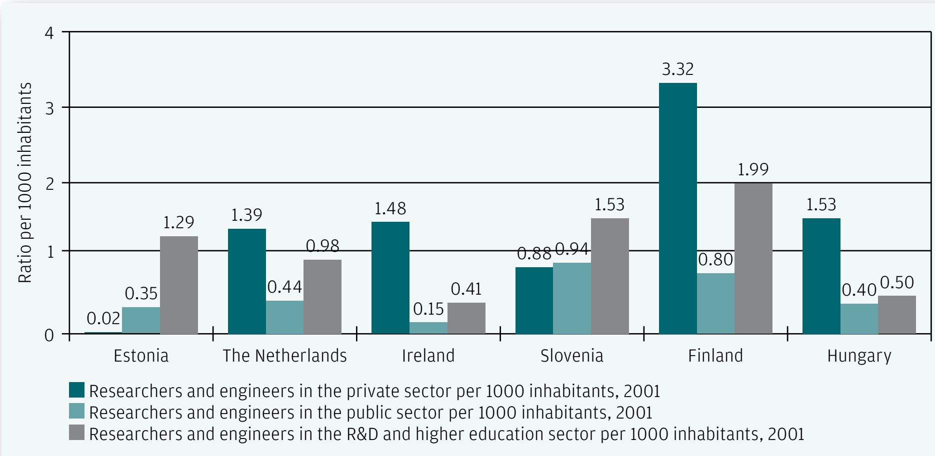
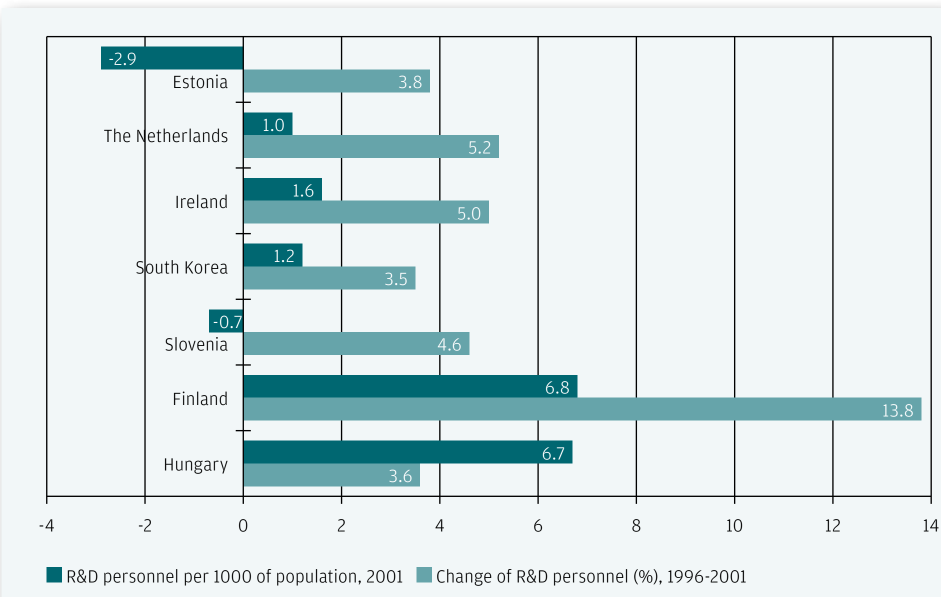


Figure 2-5. R&D employees per 1,000 inhabitants (2001) and change in percentage (1996-2001)[49]



47 The higher education sector includes universities, technical colleges, and other higher education institutions and research institutes under their governance. The public sector includes all state owned institutions which provide society with public services (excl. higher education) as well as non-profit institutions which are financed and controlled by the state.

48 Source: Statistical Office of Estonia: *Research and Development*; Statistical Office of the Republic of Slovenia, http://www.stat.si; Hungarian Central Statistical Office, http://portal.ksh.hu; European Commission. *Towards European Research Area – Science, Technology and Innovation Key Figures 2003-2004*. Brussels, 2003, http://europa.eu.int/comm/research/rtdinfo/index_en.html; calculations by Marius Kuningas.

49 *Towards European Research Area – Science, Technology and Innovation Key Figures 2003-2004*, European Commission, Brussels, 2003, http://europa.eu.int/comm/research/rtdinfo/index_en.html; Korean Statistical Information System, http://kosis.nso.go.kr; calculations by Marius Kuningas.

Table 2-6. Graduates of higher education institutions in 2001 – higher education in total and graduates of science, engineering manufacturing and construction[50]

States	Graduates of higher education institutions					In science						In engineering, manufacturing and construction					
	Total	Average annual growth 1998-2001 (%)	Per 1,000 population aged 20-29	Ph-D graduates	Average annual growth rate of PhD graduates in 1998-2001 (%)	**Total**	Average annual growth rate in 1998-2001 in science (%)	Per 1,000 population aged 20-29 in science	Graduates in science,% of all graduates of higher education institutions	Ph-D graduates	Average annual growth rate of PhD graduates 1998-2001 (%)	**Total**	Average annual growth rate in 1998-2001 in engineering, manufacturing and construction (%)	Per 1,000 population aged 20-29 in engineering, manufacturing and construction	Graduates in engineering, manufacturing and construction, % of all graduates of higher education institutions	Ph-D graduates	Average annual growth rate of PhD graduates 1998-2001 (%)
EU-15	**1,963,415**	2.5	40.4	74,908	3.1	**218,755**	5.4	4.5	11.1	23,149	2.1	**286,087**	1.9	5.9	14.6	9,754	2.6
New Member States	**631,073**	19.5	55.3	7,555	1.0	**26,758**	42.3	2.3	4.2	1,472	0	**55,433**	7.3	4.9	8.8	1,196	-3.2
Estonia	**7,600**	10.0	39.9	87[51]	12.0	**456**	28.1	2.4	6.0	22	n/a	**923**	31.9	4.8	12.1	9	n/a
Ireland	**45,818**	4.0	70.3	572	6.4	**8,707**	4.7	13.4	19.8	293	3.5	**5,331**	-0.7	8.2	12.1	63	n/a
The Netherlands	**81,603**	0.6	39.8	2,533	0.2	**4,279**	-0.9	2.1	5.2	530	2.2	**8,385**	-3.1	4.1	10.3	390	-3.7
Slovenia	**11,991**	7.1	40.0	298	4.0	**437**	-1.8	1.5	3.6	76	n/a	**1,995**	2.3	6.6	16.6	57	n/a
Finland	**3,641**	-3.7	57.7	1,797	2.1	**2,728**	5.9	4.4	7.5	345	7.6	**7,376**	-2.4	11.8	20.4	321	-5.3
Hungary	**57,882**	15.0	36.1	793	-18.9	**1,379**	-16.6	0.9	2.4	142	-37.0	**5,820**	-0.9	3.6	10.1	50	n/a

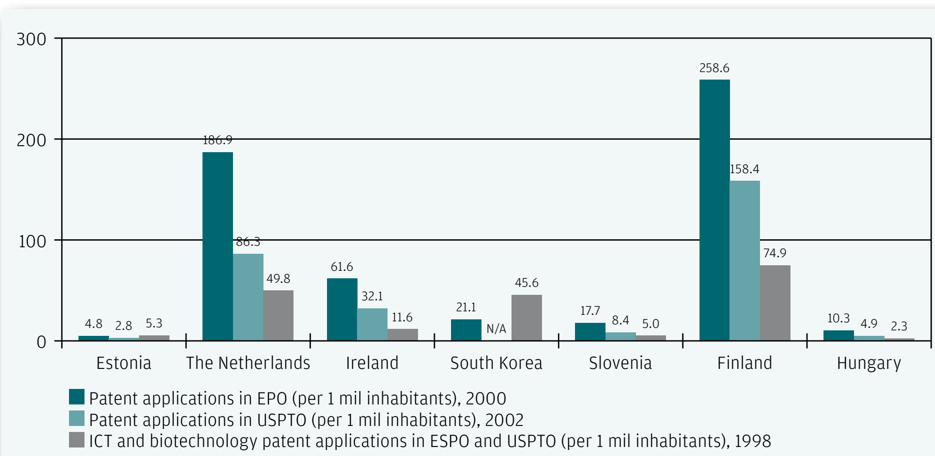
50 Sources: Eurostat, *Catching up with the EU? Comparing Highly Qualified Human Resources in the EU and the Acceding Countries. Science and Technology*, 9-9/2003, http://epp.eurostat.cec.eu.int/cache/ITY_OFFPUB/KS-NS-03-009/EN/KS-NS-03-009-EN.PDF; Statistical Office of Estonia; calculations by Marius Kuningas.

51 Eurostat gives 149 as the figure for Estonia. It also includes the number of resident students in medicine which has been excluded in the case of the other countries. Therefore, the comparable number 87 (2000) is presented for Estonia. There were 106 PhD graduates (without resident students in medicine) in 2002 and 121 in 2003. Source: Statistical Office of Estonia.

Of the reference countries, Estonia has the highest annual increase of graduates (1998–2001) as regards science, as well as among those having higher education in engineering, manufacturing and construction (Table 2–6), which, however, can be explained by the relatively low starting position. The relative share of graduates (per one thousand inhabitants aged 20–29) in the sphere of science, engineering, manufacturing and construction in Estonia is comparable to that of other new member states, but falls short of the corresponding figures of Ireland and Finland many times. When comparing the numbers of graduates of Doctorate studies, the position of the new member states is relatively weak: while in the EU-15 74,908 people were awarded the Doctor's degree, in the new member states the number was 7,555. The ratio of the graduates to the population aged 25–29 years is problematic in this regard: per 1,000 inhabitants (aged 25–29 years) 1.3 persons are awarded the Doctor's degree in the former applicant countries (only 0.88 in Estonia)[52], while the corresponding figure is 2.9 in the EU.

The contribution of R&D to the development of entrepreneurship is probably most evident when observing the dynamics of patent applications (Figure 2-7). As far as general patent applications are concerned, Estonia has the weakest position, yet the number of patent applications per one million inhabitants concerning ICT and biotechnology originating from Estonia and filed with the European Patent Office and the United States Patent and Trademark Office exceed the same numbers of both Hungary and Slovenia.

Figure 2-7. Patent applications per one million inhabitants[53]

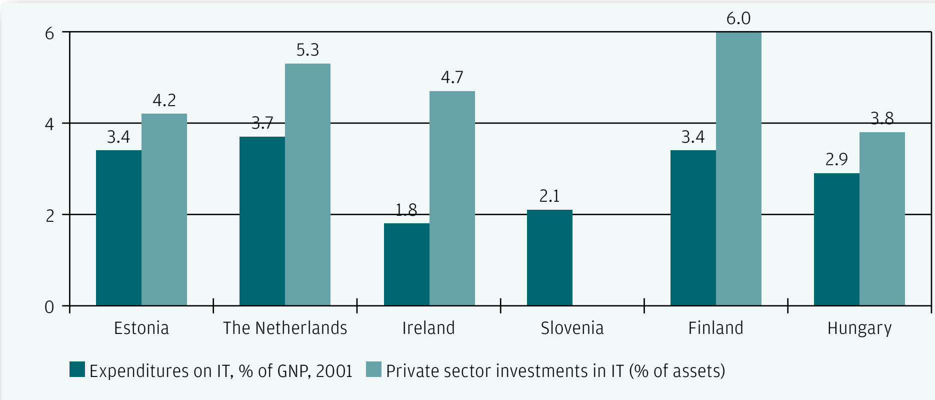


Although ICT related expenditure in Estonia and Hungary is comparable (in proportion to GDP) to the corresponding estimates of developed countries (Figure 2-8), the quality of investments differs substantially from that of developed countries, as is expressed in the small number of patent applications and indicated in the above figures concerning the development of the industry in 1990-2000.

52 The ratio given by the European Commission is 1.5 but it is misleading as it includes resident students in medicine. See also footnote no 51.

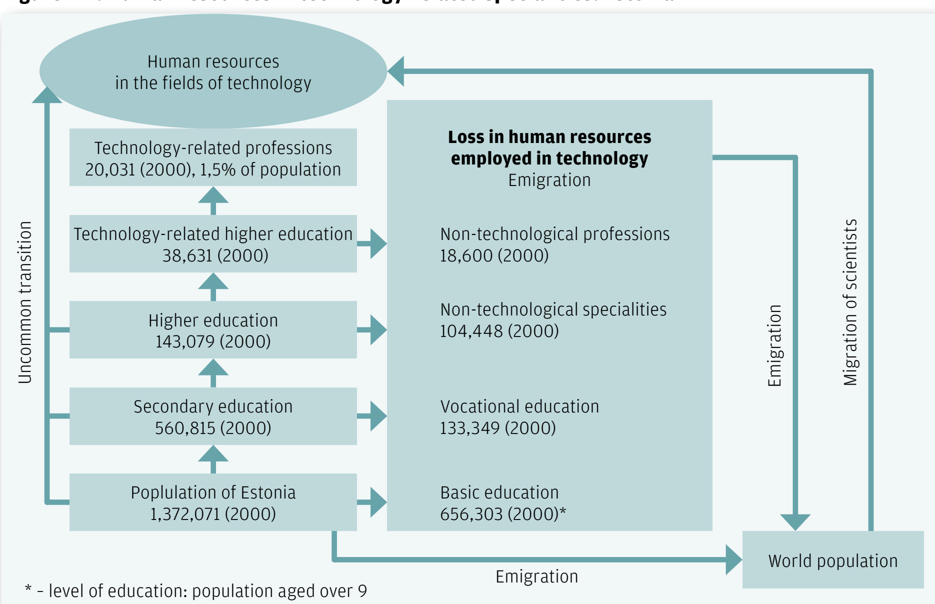
53 Source: European Commission. *Towards European Research Area – Science, Technology and Innovation Key Figures 2003-200*, Brussels, 2003; *Compendium of Patents Statistics*, OECD, 2003; calculations by Marius Kuningas.

Figure 2-8. IT-related expenditure in proportion to gross national product, and investments of the entrepreneurial sector in IT[54,55]



The following schemes illustrate the entirety of human resources in technological professions in Estonia and Finland (Figures 2-9 and 2-10). While in Estonia 1.5% of the population has specialised in technological fields, in Finland the relevant figure is 11.6%. When compared to Finland, the number of people with technology-related training available to the Estonian economy is 7 times smaller in relative figures and 30 times smaller in absolute figures.

Figure 2-9. Human resources in technology-related specialities: Estonia[56]

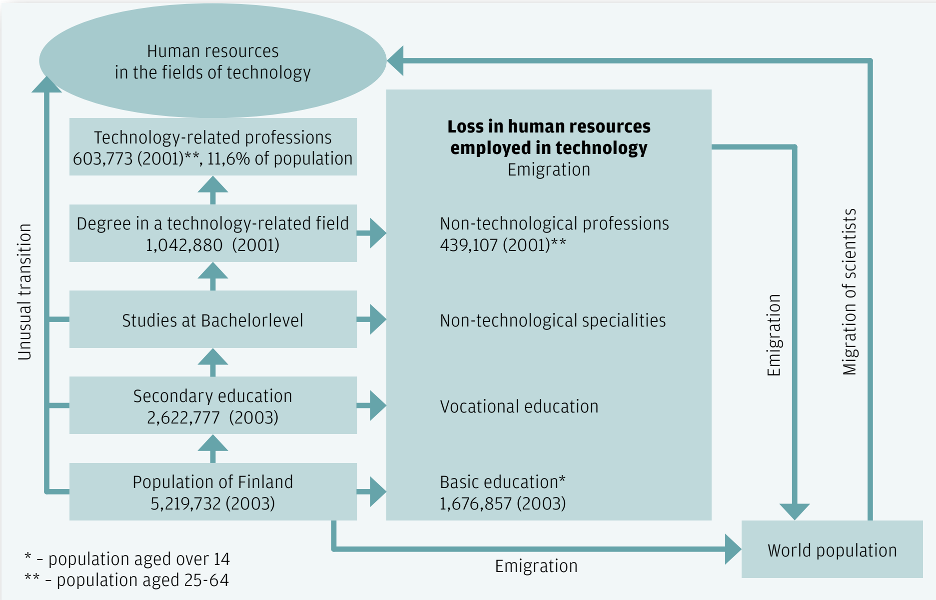


54 Sources: OECD, *OECD Economic Studies*, http://www.oecd.org, Statistical Office of Estonia; calculations by Marius Kuningas.

55 Data about investments on computer engineering in Slovenia were not available.

56 Source: Eurostat, *Catching up with the EU? Comparing Highly Qualified Human Resources in the EU and the Acceding Countries*, Science and Technology, 9-9/2003; Statistical Office of Estonia, *Education 2002/2003*, Tallinn, 2003; calculations by Marius Kuningas.

Figure 2-10. Human resources in technology-related specialities: Finland[57]

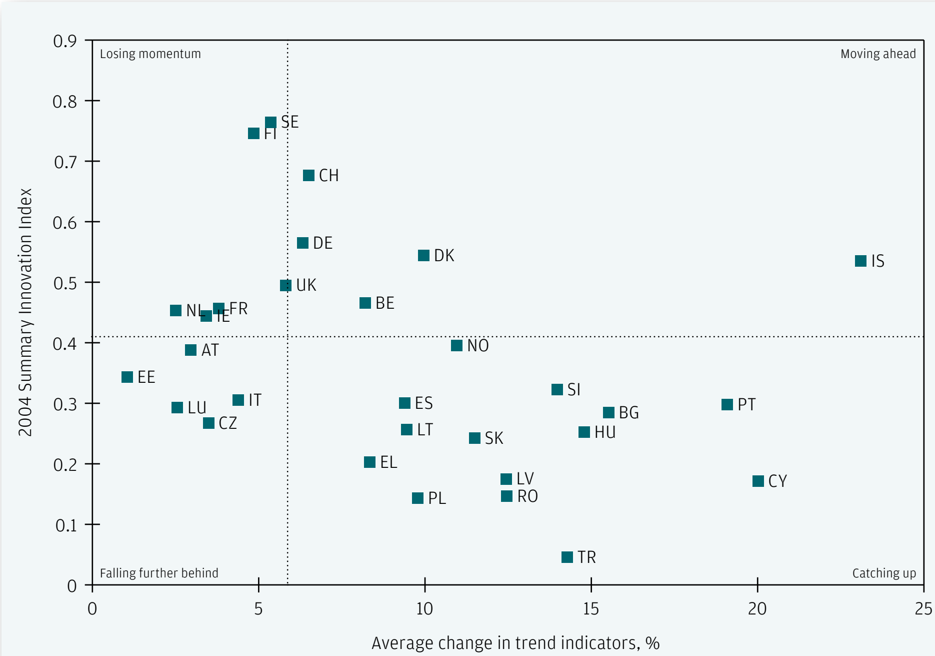


The problems of Estonia are also reflected upon in the recent innovation analysis of the EU, in which Estonia was ranked as a laggard when compared to other EU states (Figure 2-11). The backwardness primarily results from low employment rates in medium- and high-tech industries and the service sector (see Annex I), the low percentage of graduates of science and engineering (Annex II) and the small R&D expenditure and modest patenting activities of the private sector.

Consequently, it may be stated that the changes that took place with the structure of economy and industry in the 1990s can be described as negative for Estonia, which is expressed in the circumstance that in 1990, the value added per inhabitant generated by the industry was higher than in 2000. As far as the quality of manufacturing industries is concerned, Estonia has regressed. The small R&D expenditure of the private sector illustrates this statement. Although Estonia's ICT-related expenditure is comparable (in proportion to GDP) to that of developed countries (though remarkably lower in absolute volumes), this is not reflected in the numbers of patent applications, researchers, engineers or graduates in science, engineering manufacturing and construction, who have been awarded the Doctor's degree. The number of people with higher education in science, engineering manufacturing and construction has grown remarkably in 1998–2001, though as a consequence of the low starting position. The quality of curricula and the competence of Estonian technical specialities, especially ICT, are also extremely important factors.

57 Source: Eurostat, *Catching up with the EU? Comparing Highly Qualified Human Resources in the EU and the Acceding Countries*, Science and Technology, 9-9/2003; Statistics Finland, http://www.stat.fi/; calculations by Marius Kuningas.

Figure 2-11. Position of countries as per the Summary Innovation Index[58]



58 Sources: *European Innovation Scoreboard 2004*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004.

3. CURRENT SITUATION IN ESTONIAN INDUSTRY AND CHALLENGES IN THE FUTURE

3.1. Structure of Estonian Industry[59]

In order to identify any options of complex solutions in the research and education system and innovation policies (in other words: creation of a knowledge-based economy), first the technological structure and its changes since 1992, as the Estonian industry has been subject to the free market environment, must be understood. The reason for that is not theoretical, but rather practical: while technological development occurring in processing industries entails higher wages, technological development occurring in service sectors and agriculture leads to lower prices. That phenomenon can essentially be explained by the circumstance that a technological development constitutes an input in the service sector and agriculture (in the form of new instruments of production), which provides a competitive edge for a certain period only, as the same input is also freely available to the competitors in the market. Then again, in processing industries the same new technological solutions are typically protected in various ways, e.g. through patents. Therefore, extremely severe price competition is inherent in the service and agricultural sectors, which, in turn, necessitates, e.g. remarkable aids to agriculture in developed countries.

Contrarily, in processing industries the competition is much more dynamic, and competitive advantages are much deeper as to their nature, because processing industries usually require intensive development activities, a comprehensive educational base, close relations with sub-contractors, etc. In other words, the industry needs for its development, and at the same time promotes, expansive specialising i.e. distribution of work. The industry will not develop if no ground exists for the industry to be able to create new branches of value added (e.g. in the case of a lack of a number of engineers with modern education).

While the expansive distribution of work is a precondition for further development and as products can be protected from competitors, competition in processing industries is not centred around price competition, but often around the so-called positive wage competition, i.e. development creates both the room and the need for paying higher remuneration to labour, which brings about an overall improvement of the living standard, provided that a sufficient number of such clustered industries exist.

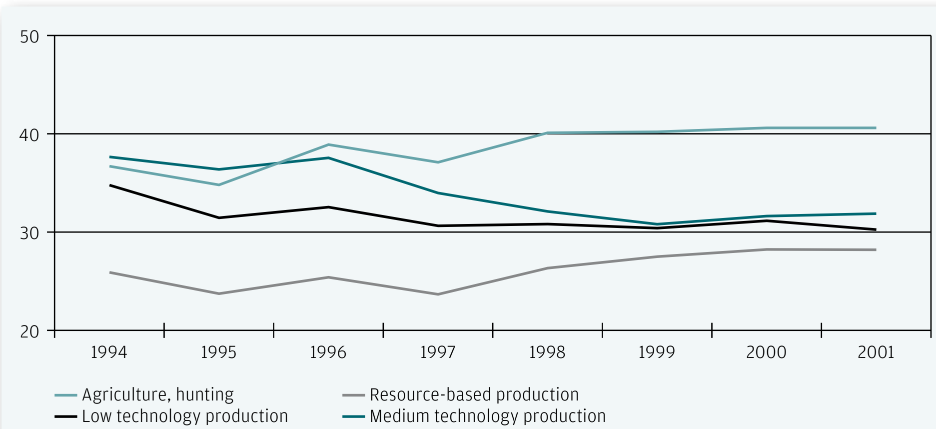
The technological base of the industry is in continuous development, which means that certain economic features of technology change over time; typically high, medium and low technologies are differentiated in order to signify the change of the technology over

59 The following is partially based on Rainer Kattel and Riivo Anton, "Estonian Genome Project and Economic Development", *Trames*, 8, 1/2, 2004, 106-128 and Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71.

time. The lower the technology, the more important the price competition, and the other way round – the higher the technology, the more important the environment, education, development activities i.e. the wage competition.

Hence, the higher the specialisation of the industry in a particular country, the better the opportunities for further improvement of the living standard and economic growth. When comparing the years 1994 and 2001, the agricultural sector is characterised by the greatest growth of value added in the gross production in the Estonian economy. The relative share of value added in the gross production created by enterprises using more complex technology was greater in the year 1994 than in the year 2001 (Figure 3-1).

Figure 3-1. Relative share of added value of Estonian industry and agriculture in the value of the gross production (%), 1994-2001[60]



There is nothing surprising in the level of value added in agricultural production – agriculture has exceeded industry in terms of productivity in almost all developed countries during the last one hundred years.[61] Why are the massive subsidies and protection of agriculture from market forces so essential in developed countries? This question can be answered quite unambiguously by the logic described above: a substantial part of the value added generated by agriculture results from technological modernisation and development, while the majority of agricultural producers have an equal position – all of them can buy new technologies. On the other hand, technology-providers often enjoy almost a monopoly. In other words, profit generated by technological development and innovation (i.e. the factor entailing the increase in value added) is not retained by agricultural producers, but by the industry. In Estonia, the increase of agricultural production and resource-intensive production has, to some extent, definitely been caused by the modernisation of production buildings and facilities as a consequence of the corresponding requirement of the EU.[62] Employment levels illustrate the same. Employment in processing

60 Source: Statistical Office of Estonia; calculations by the author. See also Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71.

61 See, e.g., Geoff Bowlby and Michael Trant, *Agricultural Employment and Productivity Trends, Observations and Measurement Methods*, OECD, 2002.

62 More detailed calculations can be found in the Yearbook of the Ministry of Agriculture 2002/2003, *Agriculture and Development of Rural Economy, Overview 2002/2003*, http://www.agri.ee/trykised/aastaraamatud/aastaraamat2003.html.

industries has decreased by almost 60% from 1989 until 2003. In the agricultural sector, the number of employees has decreased by more than 3.5 times. While in 1989 the relative share of employment in the industry accounted for 26% in the overall employment level, at the end of 2003 the relative share was 23%; in agriculture the corresponding figures were 18% and less than 6% in 2003.[63]

At the same time, as regards employment, the number of unskilled labour has remained basically the same from 1989 through 2002, the number of top specialists has decreased by almost one third, the number of skilled labour and craftsmen has decreased by one half, and the number of skilled labour in agriculture and fishing has declined by more than four times.[64] That trend refers to intensive modernisation on the one hand, and to strong concentration and a decrease in specialisation on the other hand. Estonian medium and low-tech companies operate currently in the situation where their positive scale effect is decreasing (value added decreases as volumes grow). This trend indicates the limitedness of the technological solutions applied by the companies, as well as to extremely severe price competition. This is also confirmed by the change in the structure in exports (Figure 2-1 in Chapter 2).

Figuratively speaking, Estonian agricultural producers, and the manufacturers using natural resources, have been exceptionally successful in providing themselves with new technologies and these companies are incredibly efficient today, but practically none of those technologies have been produced or developed in Estonia. In other words, a large part of revenues generated by very efficient Estonian agricultural and other resource-intensive producers does not remain in Estonia or create further specialisation in Estonia, but is transferred back to the clusters where the technology and development thereof originated from. The relatively high level of concentration in the agricultural, food and timber sectors, as well as the disappearance of many medium-tech product groups from industries only backs up the same conclusion.[65] We can probably conclude that these sectors are primarily those that belong in various added-value chains of the Nordic countries.

The technological structure of the Estonian industry is not becoming more complex, but the other way round – distribution of work, specialisation, skills, skilled labour and development opportunities are all decreasing, as are the opportunities to use new and emerging technologies. Changes do not occur in an economy overnight – and this means that the developments of the last decade refer to how and towards which technological structure the Estonian economy will develop in the near future, unless substantial changes occur in the economic environment.

Estonia should put an emphasis on further modernisation of the hitherto relatively efficient resource-intensive and low-tech sectors and, first of all, bring the value chains of the so-called next generation medium-level technologies i.e. today's high technologies like ICT and ICT-based industries and knowledge-intensive services to Estonia. These value chains must be linked to the value chains existing in Estonia or otherwise their contribution to the improvement of the living standard will be modest. On the other hand, there must be a willingness and capacity to join with such value chains in Estonia.

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63 Statistical Office of Estonia, http://www.stat.ee; authors' calculations.

64 Statistical Office of Estonia, *Statistical Yearbook of Estonia*, 2004.

65 Statistical Office of Estonia, *Industrial Products. Annual Statistics*, http://www.stat.ee.

3.2. Estonian ICT Sector and ICT Manufacturing and Software Industry[66]

3.2.1. The Development of Estonian Information Society and ICT Market

The development of the Estonian ICT sector and first of all the information society (basically applications of ICT solutions) have deserved high acknowledgements all over the world. Indeed, Estonia could be characterised with modern telecommunications infrastructures, the Tiger Leap programme focusing on computerising the education sector[67], the support programme for ICT in Higher Education Tiger University[68], a proper regulatory environment and several large-scale programmes initiated by the government, NGOs and the private sector[69]. Reasons like early liberalisation of the telecommunications market, favourable technical infrastructure at the beginning of the 1990s as well as the general favourable attitude of the population towards the adoption of new technologies lay behind the progress.

On the other hand, the need to analyse the current situation is more urgent than ever before. Although Estonia has retained its leading position in the field of e-governance[70], experts are expressing growing concern over the fact that the Estonian ICT industry has not turned out to be able to break through to the global market[71]. The orientation towards the domestic market does not serve as a solution because the IT spending per capita is only 150 EUR in Estonia (2003), which is much lower than the IT spending in Western Europe (735 EUR per capita), although it is still higher than the CEE average (111 EUR).[72]

The Estonian ICT market is estimated to be 740 million EUR per year[73] (Table 3-2). It is dominated by telecommunication network services (market share was 58% in 2003) and foremost the mobile communication services (27%). This is also illustrated by the fact that the TOP 4 Estonian ICT companies by turnover are telecom operators: three mobile operators and a former incumbent fixed line operator (Table 7-4, Annex III).

66 The current sub-chapter is partly based on the following report: Tarmo Kalvet, *The Estonian ICT Manufacturing and Software Industry: Current State and Future Outlook*, Sevilla: Institute for Prospective Technological Studies – Directorate General Joint Research Centre, European Commission, 2004, http://www.jrc.es/home/publications/publication.cfm?pub=1200.

67 See http://www.tiigrihype.ee.

68 See http://www.eitsa.ee/tiigriylikool/index.asp.

69 See Andre Krull, *ICT Infrastructure and E-Readiness Assessment Report: ESTONIA*, PRAXIS Working Paper No 5/2003, http://www.praxis.ee/innopubl; Tarmo Kalvet. *Analysis of the Estonian ICT Sector Innovation System. ICT, Innovations and Innovation Policy: The Case of Estonia*, Tartu: SA Archimedes, 2002, http://www.esis.ee/eVikings/evaluation/eVikings_WP_Tarmo_Kalvet.pdf.

70 *E-government in Central Europe: Rethinking Public Administration*, Economist Intelligence Unit, 2004, http://graphics.eiu.com/files/ad_pdfs/Central_Europe_egov.pdf.

71 See for example Tõnu Grünberg, "Tehnoloogiasektori arengus pall ettevõtjate käes", *Äripäev*, 20 May 2003; Allan Martinson, "Kas Eesti IT-tööstus on kriisis?", *Postimees*, 9 May 2003; Kalle Tammemäe, "Eesti IT ei tohi olla seebimull", *Postimees*, 5 May 2004.

72 *European Information Technology Observatory*, European Information Technology Observatory (EITO) and European Economic Interest Grouping (EEIG), 2004, 73.

73 It should be noticed that these are EITO estimations. The authors have used EITO data as it is internationally acknowledged and offers valuable material for making comparisons.

Table 3-2. Estonian domestic ICT market, Mil EUR, 2001-2003[74]

	2001	2002	2003	% 2003
Hardware (computers)	81	88	94	12.7
Office machinery	6	7	7	0.9
Communication equipment for final consumer	37	35	34	4.6
Data communication and network equipment	88	91	90	12.1
Total ICT equipment	**212**	**221**	**225**	**30.4**
System software	13	14	15	2.0
Application software	19	22	25	3.4
Total software	**32**	**36**	**40**	**5.4**
IT services	**38**	**43**	**49**	**6.6**
Fixed voice telephone services	138	153	151	20.4
Fixed data communication services	40	49	59	8.0
Mobile communication services	159	0	0	26.6
Cable television services	15	18	20	2.7
Total communication services	**352**	**399**	**427**	**57.6**
Total ICT	**634**	**699**	**741**	**100.0**

3.2.2. Estonian ICT Manufacturing Industry

The production of the Estonian ICT manufacturing industry[75] experienced a severe slowdown in the 1990s but grew by 30% per annum on average over the period 1992-2001 and is currently 234 million EUR (Table 3-3).[76]

Table 3-3. Estonian ICT manufacturing production and exports in current prices, 2002[77]

	Production in current prices (Mil EUR)	% of total ICT manufacturing	Exports (% of production)
Manufacture of electrical machinery and apparatus	97	35.5	56.6
Manufacture of radio, television and communication equipment and apparatus	95	34.7	89.7
Manufacture of medical, precision and optical instruments	60	21.9	76.8
Manufacture of office machinery and computers	22	7.9	1.2 (2001)
Total	273	100.0	

As supported by various empirical evidence (exports-imports, ownership, FDI, value-added, etc), the Estonian ICT manufacturing sector is actually part of the larger Nordic ICT manufacturing cluster.[78] The main branches of the Estonian ICT manufacturing industry

74 European Information Technology Observatory, European Information Technology Observatory (EITO) and European Economic Interest Grouping (EEIG), 2004, 290.

75 The definition is based on a widely used categorisation according to which ICT manufacturing includes manufacture of electrical machinery and apparatus (NACE 30); manufacture of electrical machinery and apparatus (NACE 31); manufacture of radio, television and communication equipment and apparatus (NACE 32); manufacture of medical, precision and optical instruments (NACE 33).

76 Source: Statistical Office of Estonia, http://www.stat.ee.

77 *Ibid*.

78 See also Tarmo Kalvet, Tarmo Pihl, Marek Tiits, *Analysis of the Estonian IT Sector Innovation System. Executive Summary*. Tartu: SA Archimedes, 2002, http://www.esis.ee/eVikings/evaluation/eVikings_executive_summary.pdf.

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 (2000) and Finnish electronics output increased by 32% in 2000, by 13% in 1999, 29% in 1998, and 29% in 1997).[79] 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 organisational innovation – combine the rapid dispersion of the value chain across firm and national boundaries.[80] The emergence of these networks is connected with the rapid advance of information and communication technologies and the liberalisation of product and financial markets. As a result of these processes, the meaning and role of geography and the proximity of target markets in the socio-economic development have changed significantly (see also Ch. 1). The value chains of the global economy are no longer formed in line with geographical borders, but more and more within particular industrial sectors. At the same time, an increasing number of economic units is being established and positioned in the states and regions where the socio-economic environment is the most advantageous for the level of production in question. Therefore, specialisation based on skills and knowledge has become an even more decisive determinant of the living standard in all the states and economies. Flagships of Estonian ICT manufacturing belonging to the Nordic ICT cluster are mainly Finnish or Swedish companies which have their branches, sub-companies or collective enterprises 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 3-4). 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, the 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.[81]

Table 3-4. Value added of some economic activities, basic prices, 2001-2002[82]

Economic activity	Value added (2001)		Value added (2002)	
	Mil EUR	% of total	Mil EUR	% of total
manufacture of electrical machinery and apparatus	36	3.5	45	3.9
manufacture of radio, television and communication equipment and apparatus	32	3.1	29	2.5
manufacture of medical, precision and optical instruments	10	1	13	1.1
manufacture of office machinery and computers	3	0.3	3	0.3
manufacture of food products and beverages	193	18.9	203	17.5
manufacture of wood and of products of wood and cork	137	13.4	0.9	14.5

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

80 Dieter Ernst and Linsu Kim, "Global Production Networks, Knowledge Diffusion, and Local Capability Formation", *Research Policy*, 31, 8-9, 2002, 1417-1429.

81 Ülo Kaasik, *Value-Added of Estonian Export Commodities*, Tallinn: Eesti Pank, 2003.

82 Sources: Statistical Office of Estonia, *National Accounts of Estonia 2001*, 2003; *National Accounts of Estonia 2002*, 2004.

The sub-contracting nature of the Estonian ICT manufacturing industry is also confirmed by the labour productivity statistics: labour productivity is considerably higher in the fields of wood and food and beverages products manufacturing (Table 3-5). The exception is the manufacture of office machinery and computers but its share in the exports and value added created by ICT manufacturing industry is modest (Table 3-4). Thus, taking into consideration everything mentioned above, it could be stated that **Estonian ICT manufacturing is not moving from low value added manufacturing towards higher value added production unlike the information society**.

Table 3-5. Productivity indicators in some fields of activity, 2004, 2nd quarter[83]

	Labour productivity, EUR	Hour productivity, EUR
Economic activities total	10.80	25.31
Manufacturing	10.86	25.12
manufacture of food products and beverages	14.32	33.43
manufacture of textiles	7.09	17.19
manufacture of wood and wood products	16.11	36.49
manufacture of office machinery and computers	19.62	44.99
manufacture of electrical machinery and apparatus	10.48	23.01
manufacture of radio, television and communication equipment and apparatus	6.39	14.51
manufacture of medical, precision and optical instruments	7.80	18.53

3.2.3. Estonian Software Industry

The share of the software industry is currently under 10% in all the OECD countries[84] but the area is growing rapidly and faces some important challenges.[85] The software industry is characterised by a closer clustering with local economies when compared with the Estonian ICT manufacturing industry, which enjoys the scale effects of global operation.

Compared to the Estonian ICT manufacturing industry, which is largely consolidated, heavily export-intensive and based on foreign capital, the Estonian software industry is very different. The number of companies in the sector is very high, production volumes and exports are low and specialisation 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 localisation.

The development of the Estonian software industry has been largely influenced by the public sector, which is the main creator of framework conditions as well as direct procurer[86]. At least as important a role has been played by the banking sector: a modern banking system was already established in Estonia in 1993 and Internet banking services were

83 Source: Statistical Office of Estonia, http://www.stat.ee.

84 *OECD Information Technology Outlook. ICTs and the Information Economy*, OECD, Paris: OECD Publications, 2002, 13.

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

86 Public Sector ICT related projects, see the yearbooks *ICT in Public Administration 1998-2003*, Estonian Informatics Centre, http://www.ria.ee/atp/index.html?id=308.

introduced in 1996.[87] 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 IT divisions of Hansabank and Estonian Union Bank have more personnel than the biggest Estonian software companies.[88]

3.2.4. Estonian ICT Manufacturing Sector Companies

522 ICT manufacturing and software companies were registered in Estonia in 2001 (Table 3-6), though the number of active enterprises[89] was actually 296.[90]

Table 3-6. Number of companies in the ICT manufacturing and software sectors in Estonia, 2001[91]

		Active companies		Activity	NACE
No	%	No	%		
1	0.2	1	0.3	Manufacture of office machinery	3001
12	2.3	6	2.0	Manufacture of computers and other information processing equipment	3002
4	0.8	3	1.0	Manufacture of insulated wire and cable	3130
37	7.1	29	9.8	Manufacture of electronic valves and tubes and other electronic components	3210
3	0.6	1	0.3	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	3220
16	3.1	9	3.0	Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods	3230
33	6.3	23	7.8	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	Manufacture of industrial process control equipment	3330
380	72.8	203	68.6	Software consultancy and supply	7220
13	2.5	8	2.7	Data processing	7230
8	1.5	5	1.7	Database activities	7240
522	**100.0**	**296**	**100.0**	**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). 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 3-7).[92]

87 On the history of Internet banking in Estonia and an analysis of success factors, see Katri Kerem, *Internet Banking in Estonia*, PRAXIS Working Paper No 7/2003, 2003, http://www.praxis.ee/innopubl.

88 For example, 250 out of the 2,245 employees of Hansabank are IT specialists and there are 139 IT specialists in Estonian Union Bank. *Äripäev*, 10 March 2003; *Hansapank Annual Report 2003*, http://www.hansagroup.com/aa2003/Hansabank2003_eng.pdf, 25.

89 Defined henceforth as companies reporting of one or more employees in 2001.

90 Thorough mapping was conducted in 2003 based on most up-to-date data available. Although more up-to-date data would be available today in the opinion of the authors, no considerable changes have taken place at the market that concern the standpoints of the current research. Therefore attention has not been paid to an additional mapping of the sector. See also Tarmo Kalvet, *The Estonian ICT Manufacturing and Software Industry: Current State and Future Outlook*, Sevilla: Institute for Prospective Technological Studies - Directorate General Joint Research Centre, European Commission, 2004, http://www.jrc.es/home/publications/publication.cfm?pub=1200.

91 Source: Centre of Registers, Ministry of Justice, Central Commercial Register, May 2003.

92 Further specifications were not possible because the Statistical Office gives out only aggregated data due to privacy restrictions.

Table 3-7. ICT manufacturing companies in Estonia according to the Estonian Statistical Office, 2001[93]

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). In reality, the sector employs many more people but 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 Estonia's TOP 500 largest companies (Annex III), there are 26 ICT companies (5.2% of the total in 2003). The four largest of these are telecommunications companies. The total number of ICT manufacturing companies in the TOP 500 is six, although the line between computer manufacturing companies and retail/wholesale companies remains blurred (see also Table 3-7, the column 'Industrial production from net sales'). Overall, there are 10 ICT wholesale and retail companies and 8 software companies (these are again heavily involved also in other ICT-related activities) in the list.

The ranking of Estonian ICT companies, based on sales, sales growth, profits, annual profit and profit growth, profit margin and return on assets, compiled by the daily business newspaper "Äripäev" also confirms that the market is undergoing constant change and the standings are very dynamic (Annex IV).

93 Source: Statistical Office of Estonia, http://www.stat.ee.

3.3. Challenges of the Estonian ICT Manufacturing Sector and Software Industry[94]

Certain limitations and world trends have to be taken into account in order to obtain a generalised understanding of the long-term challenges which the Estonian ICT manufacturing and software industries are facing. The fact that Estonia is a small country brings about several implications: heavy dependence on international demand; impossibility to achieve scale effects on the domestic market, resulting in relatively high prices; limited domestic clustering; limited resources (knowledge, capital, natural resources); threat to lock-in in production of few low value added goods; distinctive policy-making and its implementation which characterises small states (see Ch 1).

3.3.1. Cost-based Competition and Globalisation

The relatively low labour costs compared to employees with the same qualification in the neighbouring countries have ensured the rapid growth of the Estonian ICT manufacturing industry. Finnish and Swedish ICT companies which expand their business in Estonia have expressed the following kind of reasoning in their yearbooks:

- "Migration of manufacturing to low cost countries like China and Estonia has allowed to increase competitiveness in production and it could be further made good use of. We procure components from the market in a most cost-effective way."[95]
- "With the aim of lowering manufacturing costs, a greater amount of electronics manufacturing and assembly was relocated to Estonia."[96]

Indeed, relatively low-cost labour attracts the manufacture to Estonia: the average annual gross earnings in the industry was 27,581 EUR in Finland (2000), 30,643 EUR in Sweden and 3,647 EUR in Estonia, 8 times lower.[97] Several flagships that currently have ICT manufacturing in Estonia are also expanding their manufacturing activities in China (production workers in China typically cost 5% of their U.S. or European counterparts)[98] and a small state could not compete in ICT mass-production and does not have to. The more technologies and products mature, the stronger the cost-competition and the more attractive less developed countries for volume production will be. In the initial phases of a technology life-cycle when manufacturing is knowledge intensive (and expensive) and dynamic competition advantages (adaptively of the educational system; the national innovation system etc) play an important role, it would be impossible. When technologies mature, however, they are using highly standardised, mechanised and automated processes which could take place as well in less-developed (and low cost) regions (Figure 3-8).[99]

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94 The current sub-chapter is partly based on the following report: Tarmo Kalvet, *The Estonian ICT Manufacturing and Software Industry: Current State and Future Outlook*, Sevilla: Institute for Prospective Technological Studies - Directorate General Joint Research Centre, European Commission, 2004, http://www.jrc.es/home/publications/publication.cfm?pub=1200.

95 Efore OYJ, *Annual Report 2003*, http://www.efore.fi, 2004, 5.

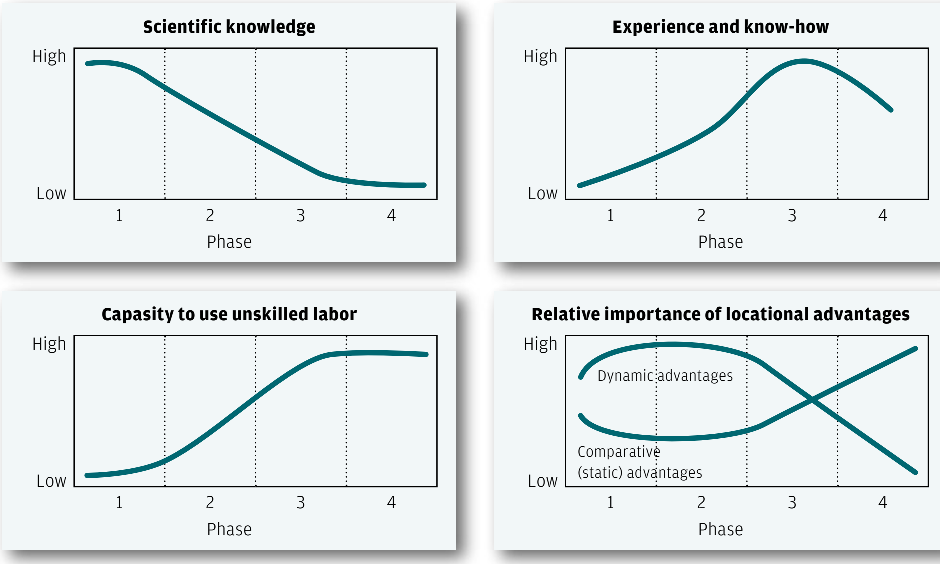
96 Incap Corporation, *Annual Report 2003*, http://www.incap.fi/englanti/acrobat/2004/InCap_vsk_Engl.pdf, 2004, 20.

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

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

99 Carlota Perez, "Technological Change and Opportunities for Development as a Moving Target", *Cepal Review*, 75, 2001, 111-112.

Figure 3-8. Changing entry requirements as technologies evolve to maturity[100]



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. But, once a network supplier successfully upgrades its capabilities, this creates an incentive for flagships to transfer more sophisticated technology and switch even in product and process development. This is certainly a major challenge of the Estonian ICT manufacturing industry: how to move further in the value chain from the position of supplier of low value added and labour-intensive goods to offering speed, flexibility and quality instead. The role of low taxes and a stable macroeconomic environment should not be overrated as these are conditions which could possibly be followed by the competitors. Investments in human capital in the fields of engineering and technology are far more important and render the acquisition of permanent competition advantages possible. They also serve as key for entering in more profitable manufacturing phases (Phase 2 and 3, Figure 3-8) and turning short-term location-based competitive advantage as well as the change in global production dynamics (outsourcing accounted for 21% of total assembly and box-build activity in Europe in 2000, it is forecast to account for over 40% by 2007[101]) into a long-term advantage.

3.3.2. New Emerging Paradigms: *Ambient Intelligence*

The concept of *Ambient Intelligence* (*AmI*) surrounding everyday life and work is central to EU strategies and respective financing programmes in the ICT field and expected to be a reality by 2010.[102] The concept of AmI is a long-term vision of the development of the In-

100 *Ibid*, 112.

101 *Yearbook of World Electronics Data 2003, Volume 1 - West Europe*, Reed Electronics Research, 2002, 8.

102 See 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. For practical examples see also *Scenarios for Ambient Intelligence in 2010*, ISTAG, 2001, ftp://ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf.

formation Society with emphasis on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. People will be surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects. AmI is capable of recognising and responding to the presence of different individuals. Most importantly the surrounding intelligence operates seamlessly, unobtrusively and often invisibly.

Basically, this vision argues for the extreme clustering of the ICT manufacturing and software industries with other industries and service sectors. To a certain extent, it is a quick rise of the still developing technological trajectory (first phases in Figure 3-8).

A lot of additional scientific research and technological development should be conducted to fulfil the vision of AmI during the coming ten years. At the most general level, technologies are blending into each other, the environment melts into one with computers and communications and furthermore – intelligent intuitive user interfaces which adjust to customers are created. The former means the change in paradigm. The Development of central mainframe computing is displaced with the development of personal computers, personal digital assistants and computers integrated into different objects as a result of which the miniaturised IT systems surround us everywhere. In addition, mutual communication of objects including convergence and cross-usage of infrastructure systems, broadband wireless communication, digital broadcasting, satellite communications are added. Interfaces (sensors, language recognition, biometrics, etc), especially their user-friendliness, form the third pillar of the AmI. Significant scientific achievements in different fields are the prerequisite for the implementation of these plans.[103]

Estonian companies have created a few applications of new technologies (e.g. banking, government) which have been recognised at the global level. A powerful advance with similar applications (for example, in the fields of mobile telecommunications, e-health applications) would be the implementation of *Ambient Intelligence*.

At the same time the possible threats should be taken into account. The elaborated applications are connected with the local service sector where the innovation is less knowledge-intensive and the ability to protect application for example with patents is limited compared to the manufacturing industries. Therefore the innovative solutions are vulnerable to imitators. Furthermore, the small scale of the economy limits the development and opportunities to offer knowledge intensive services. Still, the Government has got instruments to diminish these risks.

In a longer perspective (10-20 years), a large scale revolution is foreseen based on the convergence of information-, bio- and nanotechnologies which like ICT has an impact on all the areas of everyday life and offers opportunities for more rapid economic growth than any other field of technology or science.[104]

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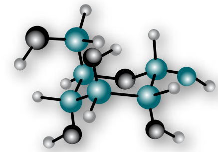
103 See IST Advisory Group, *Grand Challenges in the Evolution of the Information Society*, July 2004, ftp://ftp.cordis.lu/pub/ist/docs/fet/7fp-pre-6.pdf, 11; In the frames of the project FISTERA (*Thematic Network on Foresight on Information Society Technologies in the European Research Area*) development of about 100 IT components or systems until 2020 are evaluated using four key elements: technology, its functionality, services and surrounding Ambient Intelligence, see *Key European Technology Trajectories*, Telecom Italia Lab, 2003, http://fistera.jrc.es/docs/D2&appendix.pdf, interactive tool could be found http://fistera.telecomitalialab.com/#.

104 See Marek Tiits, Rainer Kattel, Tarmo Kalvet, *Made in Estonia*, Tartu: Institute of Baltic Studies, 2005.



4. ESTONIAN ICT SECTOR EDUCATION AND RESEARCH SYSTEM

4.1. Estonian ICT Sector Education System Institutions

The main providers of ICT education[105] in Estonia are the two public universities – Tallinn University of Technology and the University of Tartu – and the Estonian Information Technology College which is a private institution (Annexes V and VI). A large share of the first two emerges in the field of academic higher education and the latter plays an important role in the field of applied higher education. Applied higher education is also provided in several other private institutions of higher education, the largest among which are the College of Computer Science (195 students), Mainor Higher School (320) and Tallinn School of Economics (226).

Table 4-1. Number of students in Computer Sciences, 2004[106]

		2004	2004 (%)
PhD level	Total	1, 717	
	Computer Sciences	98	5.7%
	incl. Tallinn University of Technology	77	4.5%
	incl. University of Tartu	21	1.2%
Master's level	Total	7,238	
	Computer Sciences	346	4.8%
	incl. Tallinn University of Technology	250	3.5%
	incl. University of Tartu	63	0.9%
BA	Total	30,707	
	Computer Sciences	2,102	6.8%
	incl. Tallinn University of Technology	1,252	4.1%
	incl. University of Tartu	511	1.7%
Professional higher education, applied higher education, diploma studies	Total	24,144	
	Computer Sciences	1,500	6.2%
	incl. Tallinn University of Technology	238	1.0%
	incl. IT College	364	1.5%
	incl. University of Tartu	55	0.2%
Total	Total of all fields	63,806	
	Computer Sciences	4,046	6.3%
	incl. Tallinn University of Technology	1,817	2.8%
	incl. University of Tartu	650	1.0%
	incl. IT College	364	0.6%

105 Only the fields of computer science which are registered in the Higher Education Accreditation Centre are described.

106 Sources: Statistical Office of Estonia (1993-2003); AS Andmevara, register of students 2004 (1 November 2004).

4.1.1. Tallinn University of Technology

The faculty of IT at Tallinn University of Technology is the largest institution providing ICT education in Estonia. In 2004, 1,817 students in total have specialised on ICT or closely related specialities (Table 4-2; Annexes V and VI). 150 lecturers, researchers and engineers are working in the faculty.[107]

The faculty consists of 7 institutes (Computer Science, Computer Engineering, Computer Control, Engineering, Radio and Communication Engineering, Informatics, IT Further Education Centre). The faculty cooperates actively (overlapping of lecturers, researchers etc) with the Institute of Cybernetics which is without a doubt the forerunner of ICT science in Estonia (see also Ch 1.2).

Table 4-2. Study programmes of computer sciences at Tallinn University of Technology, 2003[108]

Study programme	Level	Code	Accreditation	Comments
Informatics	Higher vocational education	5464158	Accreditation until 2009	
ICT	Doctor	8464157	Accreditation until 2009	
Computer and Systems Engineering (D.)	Doctor	8542301	Accredited in 2002 until 2009	Evaluation of the expert committee (14 May 2002): The University has made good use of the feedback from the industry. The graduates of the Doctoral degree programme are able to compete on the international labour market. The system of internal quality evaluation as well as the student counselling are working satisfactorily. Shortcomings: the evaluation systems of lecturers as well as the consideration of students' feedback in the development process of curricula are insufficient. The long-term personnel development plan is missing. The current staff is insufficient for scientific work in the Doctoral degree programme. Financing for the improvement of the efficiency of the teaching process is insufficient.
Informatics (D.)	Doctor	8464109	Accredited in 2002 until 2009	
Informatics	Diploma	5464110	Accredited in 2002 until 2009	
Computer Systems	Diploma	5542308	Accredited in 2002 until 2009	
Network	Diploma	5464120	Accredited in 2002 until 2009	
Informatics (B.)	Bachelor	6464110	Accredited in 1999 until 2006	Evaluation of the expert committee (18 February 1999): The study programmes are inflexible – the first year students cannot choose freely the field of study nor can they change it during their studies; an integrated development plan is missing; the admission rates seem not to meet the actual market demands in the case of several fields of studies; study materials are scarce in the libraries; practice in businesses is functioning well in the case of the well-developed fields in Estonia, the number of visiting lectures should be increased; the average age of the lectures is high, a special development plan to deal with the issue is needed; lecturers are engaged in the industrial companies to the extent that their contribution in scientific work suffers.
Computer and Systems Engineering	Bachelor	6542307	Accredited in 1999 until 2006	
Informatics (M.)	Master	7464109	Accredited in 1999 until 2006	
Computer and Systems Engineering (M.)	Master	7542301	Accredited in 1999 until 2006	
Business Information Technology	Bachelor	6464136	Accreditation until 2006	
Informatics	Bachelor	6464158	Accreditation until 2006	
Business Information Technology	Bachelor	6464164	Accreditation until 2006	
Computer and Systems Engineering	Bachelor	6542371	Accreditation until 2006	
Informatics for Non-informatics	Master	7464160	Accreditation until 2006	

107 http://est.ttu.ee/teaduskonnad_asutused/infoteaduskond.

108 Source: Ministry of Education and Research and accreditation reports and decisions of the Higher Education Quality Assessment Council, http://www.ekak.archimedes.ee.

4.1.2. University of Tartu

The Faculty of Mathematics and Computer Science consists of four institutes: Institute of Computer Science, Institute of Mathematical Statistics, Institute of Pure Mathematics, Institute of Applied Mathematics. The total number of employees is 90, including 53 lecturers (12 professors, 22 docents, 15 lecturers, 4 assistants), 15 senior researchers, 22 other staff (2003).[109]

Table 4-3. Study programme in Computer Science at the University of Tartu, 2003[110]

Study programme	Level	Code	Accreditation	Comments
Information Technology	Diploma	5464103	Accredited in 2003 until 2010	Recommendations of the accreditation committee (23 April 2003): improve the counselling of diploma students; increase the financial support to Doctoral students; increase the number of lecturers with a PhD degree in the Doctoral degree programme; pay more attention to scientific work connected with hardware; pay more attention to the system of collecting feedback from employers.
Informatics	Doctor	8464110	Accredited in 2003 until 2010	
Information Technology	Bachelor	6464162	Accredited in 2003 until 2010	
Informatics	Bachelor	6464120	Accredited in 1999 until 2006	Recommendations of the accreditation committee (20 February 1999): the qualification of lecturers is good but the average age is high; the quality insurance system is not actually implemented in the teaching process; the admission quota in informatics do not meet the society demands in Estonia; specialisation on computer sciences too late in the study programme; the Bachelor's degree programme is not sufficiently flexible taking into account the current situation in Estonia; degree students are too overloaded with teaching; special courses focused on high technology should be broadened; as a result of under-financing it is not clear if the most recent new knowledge and skills could be used in the teaching process.
Informatics	Master	7464110	Accredited in 1999 until 2006	
Informatics	Bachelor	6464158	Accreditation until 2006	
Informatics	Master	7464158	Accreditation until 2006	
Applied Informatics	Diploma	5464115		
Information Technology	Master	7464162		

109 http://www.math.ut.ee/yld/statistika.

110 Source: Ministry of Education and Research and accreditation reports and decisions of the Higher Education Quality Assessment Council, http://www.ekak.archimedes.ee.

4.1.3. IT College

The Estonian Information Technology College is a private institution of applied higher education which was founded by the Estonian Information Technology Foundation (EITF) and started its activities on 1 September in 2000. The founders of EITF were the Republic of Estonia, the University of Tartu, Tallinn University of Technology, Eesti Telekom and the Association of Estonian Information Technology and Telecommunications Companies.

The aim of the college is to prepare specialists in the field of ICT systems (computer networks, telecommunication and internet systems, electronic media, databases etc) according to the demands of employers. Professional higher education (nominal three-year study period, 120 credit points) could be acquired in three areas (Table 4-4) plus Technical Communication as a new speciality since 2004. the IT College obtained 90 student places on the basis of state-commissioned education in 2004.

Table 4-4. Study programmes at the Estonian IT College, 2003[111]

Study programme	Level	Code	Accreditation	Comments
IT Systems Development	Higher vocational education	5464111	Accredited in 2003 until 2010	Recommendations of the accreditation committee (19 February 2003): decrease the number of both general and specialised courses added on during the second year; employ more full-time lecturers connected with computer sciences; develop scientific work.
IT Systems Administrator	Higher vocational education	5464112		
Information Technology Systems	Diploma	5464154		
Information Systems Analysis	Higher vocational education	5464113	Under way	
Technical Communication	Higher vocational education	5464167	To be accredited in 2006	

4.2. Comparison of Incomes of People with Higher ICT Education on the Basis of Income Tax[112]

The following is an analysis of the income tax payable on the incomes of people who have obtained higher ICT education, which is based on the sub-register of the students, university students and Doctor residents of the Estonian Education Information System as well as on monthly social tax, mandatory funded pension and unemployment insurance premium statements of the Tax and Customs Board for the period 1999-2003. The analysis is founded upon the people who have acquired higher education in computer sciences, computer use, electronics or control engineering from 2001-2003 and who have paid income tax on their income from employment from 2001-2003. The total number of people with higher ICT education in computer sciences was 1,148 and in electronics and control engineering 293 (see Annex VII for a more detailed description of the methodology).

The data show that the people with higher ICT education pay the highest income tax in comparison with the people from other fields of study (Table 4-5).

111 *Ibid.*

112 The authors are grateful to Liis Kraut for the data analyses.

Table 4-5. The average income tax of higher education (including professional higher education and applied higher education) graduates of academic years 2000/2001 and 2002/2003 from the year of graduation by completed fields of study (EUR)[113]

	Average income tax	Comparison with the average of all fields of study (=100)
Teacher training and educational science	672	72
Arts	548	59
Humanities	604	65
Social and behavioural sciences	945	102
Journalism and information	951	103
Business and administration	1195	129
Law	1071	116
Life sciences	482	52
Physical sciences	740	80
Mathematics and statistics	649	70
Computer sciences	**1674**	**181**
Technical fields	1080	116
Electronics and control engineering	**1191**	**128**
Manufacturing and processing	621	67
Architecture and building	895	97
Agriculture, forestry and fishery	542	58
Veterinary	523	56
Health	694	75
Social services	775	84
Personal services	533	58
Transport services	912	98
Environmental production	505	54
Security services	1261	136
Average of all the fields of study	**927**	**100**

The majority of the computer sciences graduates found jobs in the field of computers and related occupations (31%),[114] followed by the field of education (14%), other business (9%) and public administration, national defence and statutory social insurance (9%). Accordingly, more than 90% of the computer sciences graduates found jobs in the service sector. The Estonian ICT exporting branches of the processing industry provided jobs for 3.6% of the computer sciences graduates. All in all 6.4% of the graduates went to work in the processing industry.

The biggest employers of the electronics and control engineering graduates are wholesale trade (17%), telecommunications (13%), public administration, national defence and statutory social insurance (13%) as well as education (12%). The Estonian ICT exporting branches of the processing industry provided jobs for 9.2% of the electronics and control engineering graduates. All in all 13% percent of the graduates went to work in the processing industry (Table 4-6).

113 Sources: the Estonian Education Information System, data of the Tax and Customs Board, calculations of PRAXIS.

114 Hereinafter attention should be paid to the fact that only the reference code of the field of activity of the graduate's or non-graduate's employer is known and not the position of the employee.

The analysis of income tax payers by sectors distinguishes much higher income taxes in the fields of financial intermediation and telecommunications, whilst the income tax payable in the field of education is substantially lower. Although the data about the processing industry cannot be disclosed in detail due to data protection and the reliability of the data is questionable due to their small number, we may still observe that the income tax paid by those employed in the spheres of radio, television and communications equipment exceeds the average of the processing industry substantially.

Table 4-6. The average annual income tax of ICT graduates from the year of graduation by the fields of activity of major employers (EUR)[115]

Field of activity of major employer	Average income tax of all the fields of study	Computer sciences			Electronics or control engineering		
		No	%	Average income tax	No	%	Average income tax
Manufacturing	1224	42	6.5	1645	22	13.3	1104
Manufacture of office machinery and computers		3	0.5		1	0.6	
Manufacture of medical, precision and optical instruments		10	1.6		6	3.6	
Manufacture of television and radio transmitters and data communication equipment		9	1.4		11	6.6	
Manufacture of food products and beverages		3	0.5		0	0.0	
Electricity, gas and water supply		7	1.1		2	1.2	
Construction		8	1.2		10	6.0	
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	1155	76	11.8	1370	28	16.9	2309
Wholesale trade and commission trade, except for motor vehicles and motorcycles		27	4.2		23	13.9	
Retail trade, except for motor vehicles and motorcycles		49	7.6		5	3.0	
Hotels and restaurants	804	2	0.3		1	0.6	
Transport, storage and communications	1458	45	7.0	2228	25	15.1	1756
Post and communications		30	4.7		24	14.5	
Supporting and auxiliary transport activities		7	1.1		0	0.0	
Financial intermediation	2116	46	7.2	3189	8	4.8	1208
Real estate, renting and business activities	1211	257	40.0	1990	20	12.0	1030
Computers and related activities		176	27.4		6	3.6	
Real estate activities		14	2.2		1	0.6	
Other business activities		59	9.2		11	6.6	
Research and development		8	1.2		2	1.2	
Public administration and defence; compulsory social security	1304	54	8.4	1694	21	12.7	1658
Education	850	86	13.4	1293	18	10.8	1084
Health and social work	864	6	0.9		5	3.0	
Other community, social and personal service activities	796	12	1.9		5	3.0	
Other		16	2.5		13	7.8	
Average annual income tax	**1157**		**0.0**	**1852**		**0.0**	**1491**
Number of tax payers	**1563**	**642**	**100.0**		**166**	**100.0**	

115 Sources: the Estonian Education Information System, data of the Tax and Customs Board, calculations of PRAXIS.

Table 4-7. The average income tax paid by the graduates of computer sciences, computer use, electronics and control engineering in 2003 by the acquired level of education (school averages) (EUR)[116]

Level		Computer sciences				Computer use				Electronics and control engineering			
		Year of graduation											
		00-01	01-02	02-03	03-04	00-01	01-02	02-03	03-04	00-01	01-02	02-03	03-04
Doctor	Average annual income tax	N/A	N/A	N/A							N/A	N/A	N/A
	Number of graduates												
Master, Master of Science	Average annual income tax	2677	3152	2652	2905					N/A	N/A	2245	N/A
	Number of graduates	20	28	35	8							14	
Bachelor	Average annual income tax	2495	2052	1541	1285		N/A			2279	1925	940	N/A
	Number of graduates	112	124	143	10					27	36	50	
Applied higher education and Diploma studies	Average annual income tax	2297	1746	1379	N/A					1169	1307	1044	N/A
	Number of graduates	20	40	80						7	6	15	
Professional higher education	Average annual income tax			793									
	Number of graduates			25									
Professional secondary education	Average annual income tax	889	575			1447		1605		1162			
	Number of graduates	93	10			13		7		40			
Vocational secondary education	Average annual income tax	687	617			581	567	N/A		819	516		
	Number of graduates	164	219			375	278			58	143		

116 Source: the Estonian Education Information System, data of the Tax and Customs Board, calculations of PRAXIS. To ensure privacy of individuals, information about the groups of up to 5 graduates have been omitted (marked as N/A).

In the case of Bachelor, applied higher education and diploma graduates, the income increase is observed to depend on the years of experience (in the case of other levels of education such a clear distinction cannot be made; Table 4-7). That seems to point to the fact that due to poor practical training, it takes quite a long time for the graduates (from a couple of months to 1 year) to meet the requirements and interests of their employers (see chapter 4.4 for details) and hence comes the willingness of the employers to considerably increase the salaries of the employees in conjunction with acquisition of experience. However, such dynamics cannot be observed in the case of Master graduates, which evidently refers to the fact that Master students already work during their studies.

Whereas data are available only for a relatively short period of time and the absolute figures on graduates are occasionally extremely small, it would be premature to make definitive statements about the performance of the schools and the efficiency of their study programmes. However, vast differences can be noticed in the progress made by the graduates of different schools and study programmes. It is also worth mentioning that the income tax payable by the graduates of the Estonian Information Technology College is comparable to that of the Bachelor graduates.[117]

The comparison of the fields of activity of the graduates' main employers by schools shows that the majority of the specialists for the processing industry come from Tallinn Technical University. The majority of the University of Tartu graduates find jobs in the spheres of property, lease, business and education. The high relative importance of Tallinn Pedagogical University appears in the sphere of education.

4.3. Scientific Excellence[118]

When we analyse the financing of different branches of science in Estonia and the publication of relevant scientists, we can bring out the following generalised conclusions (Figure 4-8): firstly, biotechnology is without any competition the most successful branch internationally. The share of biotechnology in the support given by the public sector to the financing of different sciences is also remarkable when compared to other areas. At the same time, when considering the quality of biotechnology, development activities in this area are clearly under-financed.

Secondly, internationally strong areas of science such as chemistry and environmental science are probably under-financed on the side of science, and chemistry separately and environmental science are also under-financed on the side of development activities. However, these areas are extremely important for the technological development of Estonia. Since many of the aforementioned technological problems (for example, in the timber, paper and textile industries and on a wider scale in middle technological industry) are today or will in the future be facing the bottlenecks solved by these areas of science, a large part of the added value and export of the Estonian industry depends on these low and middle technology sectors. On the other hand, it is these sciences and technologies that have already become and will in the nearest years and decades be extremely important links between traditional science and high-technological biotechnology. In Estonia today, the chemical industry and environmental sciences are basically the key to the possible positive effect

117 In the case of other specialities, it appears that the income earned by the graduates of state institutions of higher education is considerably higher than the income of the graduates of private institutions of higher education.

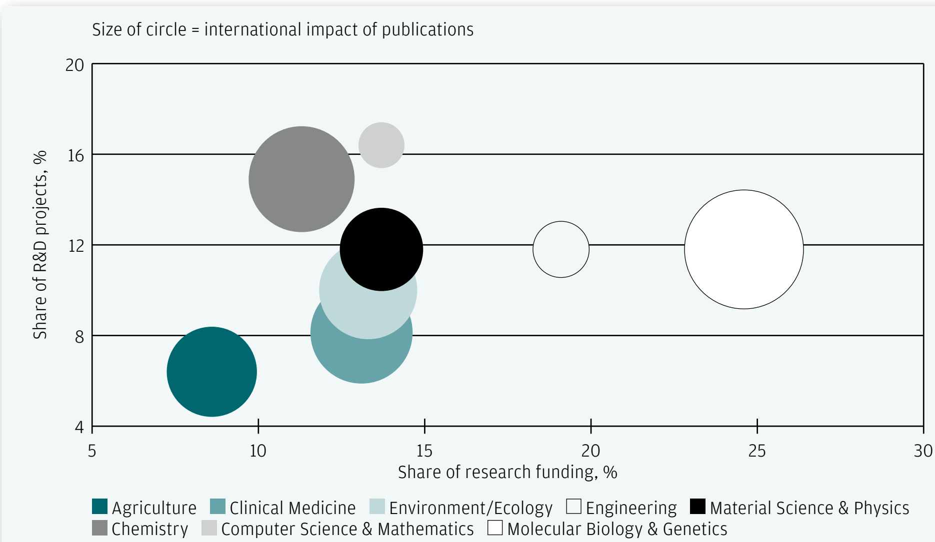
118 The following is partly based on Rainer Kattel, "Governance of Innovation Policy: The Case of Estonia", *Governance and Good Governance*, Tallinn: PRAXIS, 2004, 53-71.

that the development of the currently strong (biomedical) biotechnology can have on the standard of life of the entire country: through these areas, it will be possible to continue the modernisation of low and middle technological industry in Estonia and achieve the clustering or in other words the occurrence of higher added value in the country. Therefore, these areas should be one of the cornerstones of the Estonian innovation policy.

Thirdly, information technology and engineering, which are not so strong in international science, are important in the financing of both science and development, because these are technologies that support the scientific paradigm (see Chapter 1). The increase of scientific competence is important in these areas; otherwise it will be very difficult for Estonia to leave the role of a cheap subcontractor in the area of information technology.

Fourthly, all the areas brought out in Knowledge-based Estonia have an important place in Estonian R&D financing.

Figure 4-8. International "competitiveness" of Estonian science and Estonian R&D support, 2001-2003[119,120]



119 Data presented in the figure are relatively superficial because different Estonian R&D institutions classify fields of activities differently and their classification, in turn, differs from international classification. As regards biotechnology, publications about molecular biology, pharmacology, biology and microbiology have been summarised; as regards material science, publications about physics and material science have been summarised. As for information technology, publications about mathematics and computer science have been summarised; as regards support to R&D in the field of chemistry, support to oil shale chemistry has been included; as regards clinical medicine, R&D support includes the spheres of medicine and medicinal technology; as for environmental science, R&D support in the fields of energy and environmental technologies has been included. As for agriculture, publications about plant and animal science were included. Research funding (the EstSF and targeted financing through the MER in 2001–2003) includes science in the sphere of information technology; biotechnology includes chemistry and molecular biology, as well as bio- and geosciences; environmental sciences include bio- and geosciences as well; material science is included in science; engineering sciences are included in technology sciences; chemistry is included in chemistry and molecular biology. The international impact of publications is based on the data collected by Allik 2003 from the ISI Essential Science Indicators database as of November 2002.

120 Source: Jüri Allik, "The Quality of Science in Estonia, Latvia, and Lithuania after the First Decade of Independence", *Trames*, 7, 2003, 40-52; Enterprise Estonia (http://www.eas.ee); Estonian Science Foundation (ETF) (http://www.etf.ee); Scientific Competence Council 2003; calculations of the authors.

When we take a closer look at the publications of and references to Estonian ICT scientists in the databases of *ISI Web of Science*[121] as of November 2004, we can bring out the following generalisations:[122]

Firstly, the international scientific level of the University of Tartu, when measured by the number of publications and references per research employee, is undisputedly higher than that of the others (Table 4-9). At the same time, more than 90% of the publications and references concerning the University of Tartu in the ICT field are only from and to one scientist. Without the contribution of the said scientist, the aggregate grade of the University of Tartu would be 71. This demonstrates the clear tendency that the Institute of Cybernetics at Tallinn University of Technology is on a considerably higher level than other institutions (Table 4-9).[123]

Table 4-9. International publications by Estonian ICT scientists, ISI Web of Science, 1979-2004

Institution	No of scientists	Total no of articles	References	Reference/articles	Total for institution	Average per person
Cybernetica	13	11	10	0.9	21	1.6
TUT, IC	27	143	268	1.9	411	15.2
TUT	91	149	168	1.1	317	3.5
UT	19	41	778	19.0	819	43.1
UT[124]	18	27	44	1.6	71	3.9
Total[125]	155	326	1,202			

Secondly, more than 80% of all publications of and references to Estonian ICT scientists from 1979-2004 are for 10 people:

- 4 for the Institute of Cybernetics (IC),
- 3 for Tallinn University of Technology (TUT),
- 1 for the University of Tartu (UT),
- two people hold the position of research employee in two institutions (TUT and IC; TUT and UT, respectively).

The research fields of these 10 people are semiconductors, programming, bio-informatics, optics and non-linear management systems. These areas therefore also describe the areas where Estonian ICT can compare to the international level.

When considering the fact that the ISI database covers the years 1979-2004 (incl. many Soviet Union publications and magazines) and that at the same time the minimum requirement in Estonia for running for the place of a professor is 5 international peer-reviewed publications, then on the basis of the *ISI Web of Science*, only 17 professors and research employees have met these requirements as of now. The ISI database obviously

121 See http://isiknowledge.com.

122 The research was conducted upon financing the project eVikings (see also http://ev2.ioc.ee). For detailed results see Kristi Hakkaja, *Estonian ICT Research and its Impacts – Bibliometric Analysis*, PRAXIS Working Paper No 22, PRAXIS Center for Policy Studies, 2005.

123 Considering that the IT College is focused on applied higher education, other important criteria (participation in business requiring high levels of scientific input, etc) must be considered in the evaluation of its lecturers. The respective indicators of the IT College are: 14 scientists; 5 articles; 1 reference; reference/article: 0.2; total for institution 6; average per person 0.5.

124 Without Dr Jaak Vilo.

125 Some researchers work in different organisations coincidently and are therefore calculated repeatedly under different organisations. As a result of this, the total number is not equal to the sum of the columns.

does not cover all peer-reviewed magazines and databases and the statistics of patenting are also important for ICT, but as of the moment, it is the best possibility of comparison, which (through the so-called CC articles) has basically become the official measure of the level of science in Estonia as well. It allows for saying that Estonian ICT science consists of a few top scientists, 2-3 of whom are extremely competitive on the international level; the rest have difficulties in meeting the minimal scientific requirements accepted in Estonia. This shows that Estonian ICT science covers very few areas on the internationally accepted level and these are more coincidental than proceeding from actual necessity.

A similar situation also prevails in engineering science, and things are no better in the social sciences and humanities.[126] However, when we consider that ICT is the technology that leads the paradigm today and within the next twenty-odd years, then it is in ICT research activities where quick and radical changes are required. Science lives first and foremost from the so-called intersubjective verification, where colleagues check, correct and develop each other's work and it is through the work of colleagues that scientific work is published, financed and mapped (peer-review).[127] This means that the following is important from the viewpoint of science: 1) establishment and observance of standards and 2) constant and extensive education of new generations through degree and especially Doctoral studies. For the first point, the autonomy of the universities in Estonia has created the situation where different requirements are applied in different universities to, for example, running for professorships and defence of Doctoral theses. Even though a considerable development has been achieved here on the basis of the so-called rectors' agreement, this agreement does not have the force of law and therefore it is possible that unhealthy competition will occur in the future, e.g. requirements are lowered or not observed too strictly in order to grab more students who pay for their education. Therefore it is necessary to achieve agreements in uniform standards and these should also be enforced. This would create the preconditions to actual and essential cooperation between different institutions, because all partners will be equal and this can be considered in planning financing, etc.

Considering the aforementioned scientific competence, it is absolutely clear that when it comes to Doctoral studies in ICT – and almost in any other branch of Estonian science – it is impossible to give the Doctoral education required for the development of science only on the basis of Estonian competence. It is necessary to create international Doctoral schools, which would really bring together the Doctoral students and lecturers from different countries. An important role could be played here by the connections with Russia, with which many scientists have relatively good relationships from the past, as well as with the other Baltic States and the Nordic States. The same also applies to bringing visiting lecturers here. Today, we are in a situation where the funding provided by structural funds meant for Doctoral schools and visiting lecturers are divided between the so-called key areas ranging from law to technology. Here we should proceed mainly from ICT as the technology that leads the paradigm and *Knowledge-based Estonia*, which stipulates ICT as a key area. In other words, what we need here is for the state to set strong priorities.

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126 See Jüri Allik, "The Quality of Science in Estonia, Latvia, and Lithuania after the First Decade of Independence", *Trames*, 7, 2003, 40-52.

127 From the viewpoint of the history and development of science, see Shapin, Steven, *A Social History of Truth. Civility and Science in Seventeenth-Century England*, Chicago: The University of Chicago Press, 1994.

4.4. Current Problems of the ICT Education System According to Entrepreneurs

Two independent studies among entrepreneurs have come to similar results about the main problems of ICT education in Estonia. Both studies emphasise the lack of qualified employees (Figures 4-10 and 4-11). More than half of the companies (52%) have mentioned that they cannot find the sort of people they would like to employ in the labour market. The problems here are the lack of experience and the required level and motivation in employees.[128]

Figure 4-10. Which of the following impedes the development of your company the most? (several answers allowed), 2001[129]

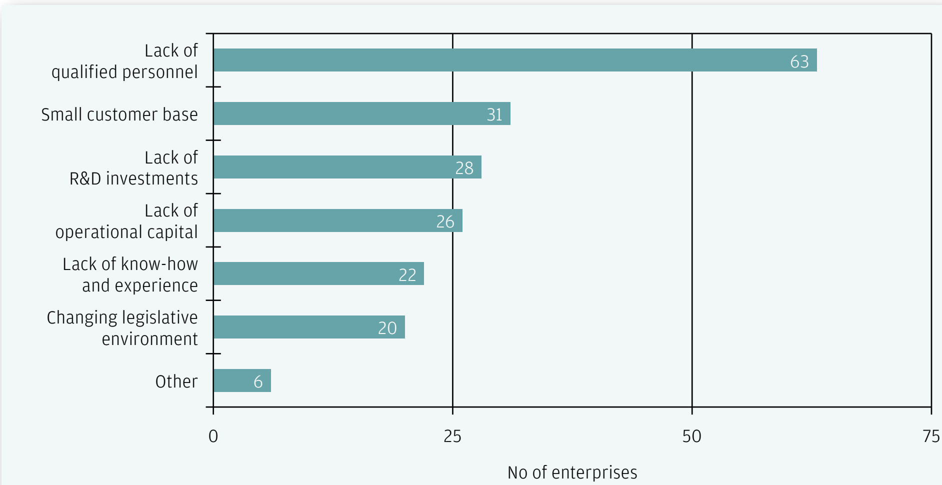
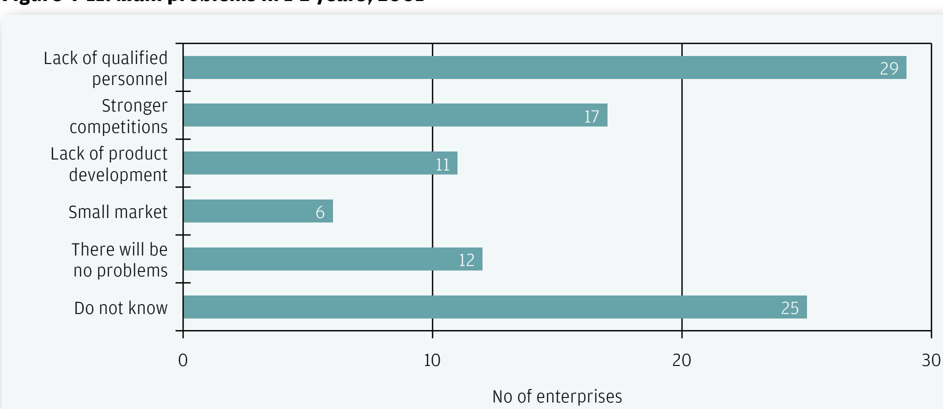


Figure 4-11. Main problems in 1-2 years, 2001[130]



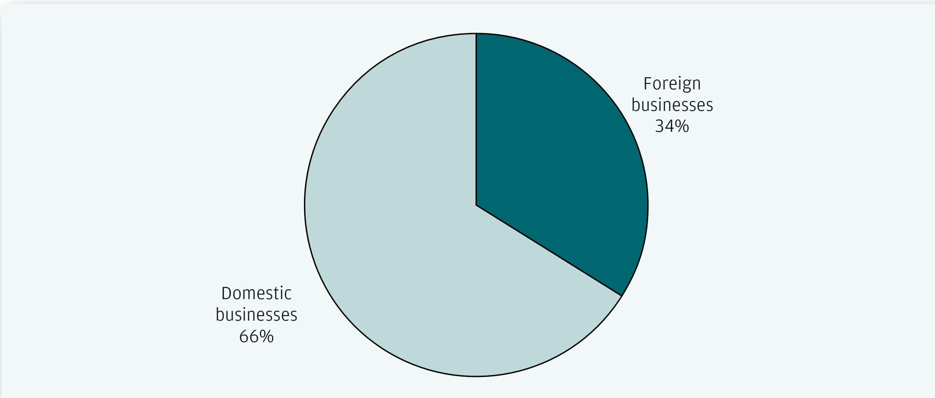
128 PW Partners, *Sector Research of Estonian Information Technology and Telecommunications*, foundation Vocational Education and Training Reform in Estonia (FVETRE): http://www.innove.ee/ee/files/IT%20uuring%20final.pdf, 2002, 35-36.

129 Source: Project eViikings poll, 99 companies, May 2001.

130 75 companies were questioned. PW Partners, *Sector Research of Estonian Information Technology and Telecommunications*, foundation Vocational Education and Training Reform in Estonia (FVETRE), 2002, http://www.innove.ee/ee/files/IT%20uuring%20final.pdf.

It is surprising that fewer of them emphasise the smallness of the market as a problem. This is probably because local software companies compete for the local software market, whereas the ICT manufacturing industry is more export-oriented and competes in more global conditions (Figure 4-12).

Graph 4-12. Whom do you consider your main competitors? 2001[131]



56% of Estonian ICT companies were lacking specialists in the areas of specific products or technologies; 39% were looking for project managers and sales staff. Only 10% needed research and development staff and 20% presumed that the need for research and development staff would arise at some point in the future.[132] In these conditions, companies were forced to develop their human resources themselves as when asked “Does your company invest in training for staff?”, 86% answered yes. The share of costs was usually 1% of turnover (30 companies), 5% of turnover (19 companies) or 2% of turnover (13 companies).[133]

Another set of problems emerged from the circumstance that 50% of the ICT companies included in the study announced that their “strategic” business plans had been prepared for up to a year or that they did not have one at all.[134] The second study also came to the same conclusion: “It is a serious problem that many companies (1/4 of the respondents) have not acknowledged (been interested in) what the problems of the sector will be in a couple of years’ time.”[135] When asked “Which of the following national support systems interests you most?”, the most popular reply was “information about the possible technology development scenarios within the next 10 years,” followed by “support of R&D activities (research and development support, start-up and seed financing) and “international market survey.”[136]

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131 Source: Project eViikings poll, 99 companies, May 2001.

132 Tarmo Kalvet, Tarmo Pihl, Marek Tiits, *Analysis of the Estonian IT Sector Innovation System. Executive Summary*. Tartu: SA Archimedes, 2002, http://www.esis.ee/eVikings/evaluation/eVikings_executive_summary.pdf.

133 Project eVikings poll, 99 companies, May 2001.

134 Tarmo Kalvet, Tarmo Pihl, Marek Tiits, *Analysis of the Estonian IT Sector Innovation System. Executive Summary*. Tartu: SA Archimedes, 2002, http://www.esis.ee/eVikings/evaluation/eVikings_executive_summary.pdf.

135 PW Partners, *Sector Research of Estonian Information Technology and Telecommunications*, SA Eesti Kutsehariduse Reform: http://www.innove.ee/ee/files/IT%20uuring%20final.pdf, 2002, 20.

136 Project eVikings poll, 99 companies, May 2001; http://www.esis.ee/eVikings/evaluation/eV_kysitlus_joonistega_est.pdf.

In 2004, the outlined problems seem to be the same: this is confirmed by the interviews conducted in the framework of this project among some Estonian ICT companies. [137] At the moment, the biggest Estonian ICT companies are in a development phase where they are looking for possibilities to move on into sectors with higher added value. All interviewed companies admitted that the lack of skilled labour is the main factor that hinders their development, whereas skilled labour would allow them to rapidly move ahead in areas where they already have a certain competence for development activities. Important shortcomings that were brought out are **insufficient specialisation** and in certain areas also weak basic education (e.g. system analysis). The problem can be summarised as follows: people who have acquired higher education need **from a couple of months to a year before they meet the requirements and interests of companies and on the other hand, the knowledge and skill base of experienced people is relatively low**, making it a starting point from which it is hard to strongly and rapidly move toward R&D activities. This can be explained by the relatively narrow ICT education: engineering, business and design are not sufficiently represented in curricula, meaning there is **insufficient inter-disciplinarity** (more below). Insufficient hardware production can become the main weakness of the Estonian ICT sector in the future: the lack of strong hardware development and production makes it hard to keep up with software development, at least for many companies. It is extremely important to consider two aspects here: the life cycle of products has become very short in present-day hardware production and competition from Asia is very strong here. At the same time, ICT-based hardware has made its way into almost all areas of life and not only through software solutions, but increasingly through hardware solutions.

At the same time, no company knows today what their activities will be like in 3-5 years or whether they need assistance from the state in training employees or what could even be the specific areas where state order could be applied, such as system analysts. **Today's internship system will not give the solution here**, because internships are too short and heighten the company's risks and costs, because someone has to find tasks that can be performed quickly and with little effort. This means that internships are little more than formalities and not actual challenges and creation of a connection with business.

4.5. Analysis of Curricula

When we analyse the curricula of informatics, information technology, electronics and other similar subjects through international comparison on the level of Bachelor, Master and Doctoral studies,[138] it is possible to bring out several important conclusions (summary given in Table 4-13).

The following stands out about successful countries such as Finland, Ireland and South Korea: 1) the big share of internships and practical tasks in curricula, which in some cases may be as much as 50% of the volume of the curriculum; 2) strong inter-disciplinarity with engineering and design areas; 3) performance of projects as group work, ranging

137 Representatives of the following companies were interviewed: Elcoteq Tallinn AS, AS EMT, AS MicroLink, AS Reaalsüsteemid, October-November 2004.

138 3 institutions of higher education and 35 curricula were observed for Estonia: 13 institutions of higher education and 20 curricula were observed for the Netherlands; 2 institutions of higher education and 6 curricula were observed for Slovenia; 5 institutions of higher education and 11 curricula were observed for Hungary; 14 institutions of higher education and 34 curricula were observed for South Korea; 11 institutions of higher education and 53 curricula were observed for Ireland; 6 universities and 17 curricula and 11 polytechnics and 13 curricula were observed for Finland.

Table 4-13. Comparison of Estonian ICT Curricula with Other Countries[139]

	Specific Features of Curricula	Internship, etc.
Finland[140]	Universities: 1. Good representation of study fields of systems analysis, testing of information systems, bio-informatics, technologies of mobile communications, network technologies. 2. No substantial connection to areas of design, multimedia or other similar areas. Polytechnics: 1. Good representation: industrial business, global business networks; innovation; strategic marketing; business management; systems analysis; software engineering; mobile communications, networking 2. Many modules in English	Student counseling plays an important role on the level of both universities and polytechnics, which often allows personal curricula. Few internships and practical subjects on university level. Length of the internships in polytechnics is 3-12 months; it is possible to apply for state assistance for remuneration.
Ireland	1. Good representation: Business process analysis; Logistics and management; E-commerce. 2. Many subjects and curricula are related to software engineering and development, such as software development and business enterprise. 3. Also relatively many graphics and design courses. 4. Very strong orientation on software and especially its links to the business environment. There are also many curricula that focus specifically on software.	1. Internships differ a lot according to institutions, their length is often one semester or 6 months. 2. In addition, many projects and laboratory work take place, all of which are aimed at group work and the solution of practical tasks.
The Netherlands	1. Good representation: Security; ICT in social context; E-business; Software. 2. Strong inter-disciplinarity, especially in the areas of engineering and design. 3. Subjects taught in English.	1. Internship may be a year of work in a company. 2. In addition, a lot of project work takes place; in some cases every semester a team project is envisaged and it may be related to business. To sum it up, every curriculum contains many initiatives like those mentioned above.
South Korea	Many curricula contain several subjects associated with areas of engineering and design. For example: wireless; mobile; multimedia; graphics design; games; e-business (incl. ICT outsourcing, etc). ICT higher education is generally very varied, which seems very practical and at the same time also highly connected to top technology; it seems that the development of curricula here is very rapid and dynamic. For example, in the area of computer games, Korea is one of the business leaders and this is reflected in many curricula, whereas none of the other countries used in the comparison has a subject called Games. It is possible to obtain a BA degree in this in Korea. Also, such a level of specialisation was lacking everywhere else.	Many courses are associated with internships; there is a lot of separate project work and field studies, many related to companies.
Slovenia	1. Good representation: Management and business environment; Information society. 2. Lacking or modestly represented: Software; Engineering; Design. 3. As is characteristic of Central and Eastern Europe, subjects of (pure) economics and business management have a rather prominent place in curricula, unlike the application of ICT in the business environment.	Up to 1 semester, but generally remarkably few.
Hungary	1. Good representation: Business management (not ICT-related); marketing. 2. Biomedical electronics and biomedical engineering are also existent. 3. Good representation of electronic engineering and software engineering. 4. As is characteristic of Central and Eastern Europe, subjects of (pure) economics and business management have a rather prominent place in curricula, unlike the application of ICT in the business environment. 5. The existence of subjects related to biomedicine and emphasis on software is positive.	Few internships, but rather much laboratory work.
Estonia	1. Remarkably few subjects related to: a. application of ICT in business, incl. e-business b. engineering and design 2. What stands out in general is a lack of specifics and inter-disciplinarity; emphasis is more on underlying education and not on strong application. 3. Insufficient ICT stands out in bio- and material sciences and product development – also applies vice versa.	The IT College is an exception, where internships cover nearly 1/5 of the volume of the curriculum. Both Tallinn Technical University and the University of Tartu offer very few internships and practical team projects, etc

139 It must be noted here that this is not an in-depth content analysis, but rather a formal observation. Specific features have been brought out in comparison to different countries and the *Career Space* ideas given below. Curricula in product development, material technologies and biotechnology were also observed for Estonia.

140 In Finland, there is an important difference between polytechnic and university (incl. technology universities) education, even though both give Bachelor's degrees. Polytechnics are focused purely on professional education, universities on science. This is why they were observed separately.

from ICT to business; 4) ICT business applications, incl. e-business, have an important place. We see a strong integration between different underlying ICT branches (natural and computer sciences) and closely associated subjects (see Figure 4-14 below).

This is not a tendency characteristic only of ICT higher education, but of all areas of technology. It is probably best characterised by the work methods of one of the most successful design companies, IDEO[141]: all new tasks – whether changing the procedure how patients are received in hospitals or the design of a game console – are solved in work groups consisting of people educated in the social sciences, engineering, ICT and design. In this way, the work groups try to cover all viewpoints and problems that may occur at the very start and they are able to immediately turn an idea into a primitive prototype. Basically, it means squeezing the entire product development process together up to the resolution of ethical and other issues. In its way, here we see the ideal higher education of the ICT paradigm: a person who is able to have a say in the product development system from design to environmental problems. The fact that this is not a utopian plan is evidenced by the circumstance that IDEO is trying to establish a D-school or design school, where education would be built on the said principle.[142] Here we see the ICT paradigm-based education par excellence.

Problems with curricula and unsatisfaction by entrepreneurs follow from the insufficient association with practical problems and thus the lack of expertise and skills by students. The existence of such problems has found confirmation all over Europe in the thorough work done in the framework of the Career Space project[143] in the development of skills profiles for the European ICT industry. The descriptions were prepared for the following technical skills profiles:

- in the area of telecommunications
  - Radio Frequency (RF) Engineering;
  - Digital Design;
  - Data Communications Engineering,
  - DSP (Digital Signal Processing) Applications Design;
  - Communications Network Design;
- the areas of software and services
  - Software & Services;
  - Software & Applications Development;
  - Software Architecture and Design;
  - Multimedia Design;
  - IT Business Consultancy;
  - Technical Support;
- products and systems
  - Products & Systems;
  - Product Design;
  - Integration & Test/Implementation & Test Engineering;
  - System Specialists;

141 http://www.ideo.com, see also http://www.businessweek.com/pdf/240512BWePrint2.pdf; Tom Kelley and Jonathan Littman, *The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm*, 2001 (http://theartofinnovation.com); Tom Kelley and Jonathan Littman, *The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm*, 2001 (see also http://theartofinnovation.com).

142 See, for example, "The Power of Design", *Business Week*, 17 May 2004, http://www.businessweek.com/@@DVT3kIYQ68sxyREA/magazine/content/04_20/b3883001_mz001.htm.

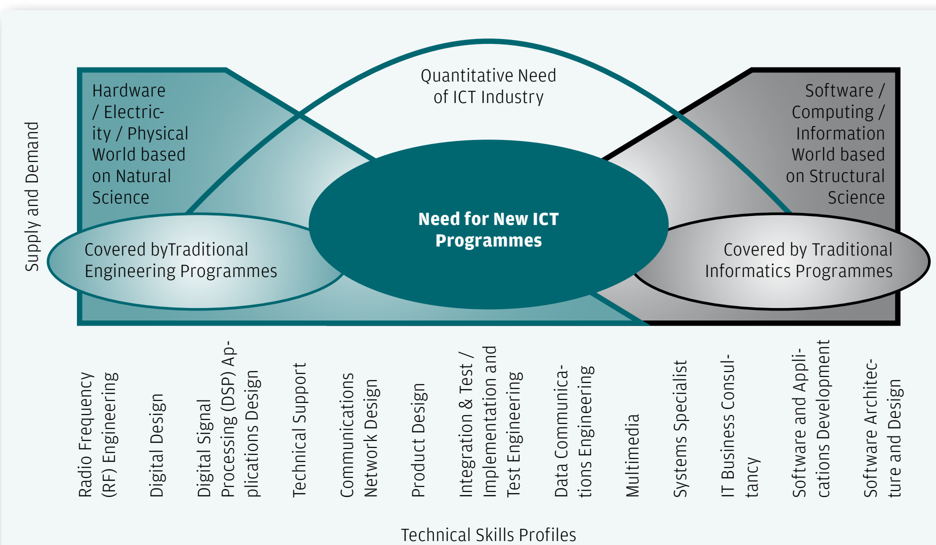
143 *Career Space* is a consortium of the world's leading ICT companies – BT, Cisco Systems, IBM Europe, Intel, Microsoft Europe, Nokia, Nortel Networks, Philips Semiconductors, Siemens AG, Telefonica S.A., Thales and the European Information and Communication Technology Association (EICTA) – which works in a partnership with the European Commission. See http://www.career-space.com.

- inter-disciplinary vocations
  - ICT Marketing Management;
  - ICT Project Management;
  - Research and Technology Development;
  - ICT Management;
  - ICT Sales Management.144

Thereafter, it was analysed how the existing curricula prepare people for the relevant specialities.[145]

It appeared that they prepare people rather poorly and the roots of the problems as seen by managers of leading ICT companies lie in the circumstance that ICT curricula stem from traditional branches of study and science – on one side from physics and engineering and on the other side from mathematics and informatics – even though the needs of the present-day industry presume a synthesis of both areas and more. Since modern ICT companies do not just produce, install and maintain ICT tools and systems, but they have to be in touch with business systems and able to see ICT tools in this context, then in addition to the engineering and informatics background they also need to be ready for an inter-disciplinary approach, where the emphasis is on the problem and not on the final solution-centred approach. Even though traditional curricula that focus on engineering and informatics are necessary, there is also a need for curricula that integrate both areas and are inter-disciplinary (Figure 4-14).

Graph 4-14. The profile of ICT industry's needs for Degree Qualifications[146]



144 For more, see http://www.career-space.com/downloads/serv1.htm.

145 Even though descriptions of vocations and the education processes associated therewith were mapped in 1999-2001, they are still topical and their recommendations are relevant. More and more universities in Europe are reforming their curricula proceeding from the recommendations of *Career Space*.

146 Source: *Curriculum Development Guidelines, New ICT Curricula for the 21st Century Designing Tomorrow's Education, Career Space* and International Co-operation Europe Ltd, 2001, http://www.career-space.com/cdguide/serv2.htm.

It has also been assessed in this light how existing curricula prepare people for the relevant specialities. The conclusion reached about the analysed curricula (100 curricula in thirteen countries and nine European countries) was that the insufficient reform of the curricula has resulted in their non-correspondence to the offered vocation standards (Table 4-15).

Table 4-15. Extent to which current curricula match skills requirements of Career Space Core (2001)[147]

	Requirements Fully Met (%)	Partly Met (%)	Not met (%)
Software & Applications Development	54	31	15
Systems Specialist	48	37	15
Software Architecture and Design	45	42	13
Data Communications Engineering	35	40	25
IT Business Consultancy	32	23	45
Digital Design	31	33	36
Communications Network Design	29	45	26
Product Design	26	48	26
Technical Support	23	42	35
Integration & Test/Implementation & Test Engineering	20	60	20
DSP (Digital Signal Processing) Applications Design	17	42	41
Multimedia Design	15	54	31
Radio Frequency (RF) Engineering	11	25	64

One of the most important conclusions that might help to improve the situation is that university curricula should be developed in strong cooperation with ICT sector employers, as a result of which – based on the offered skills profiles – people will then specialise. In the opinion of the authors, such cooperation has also worked on a modest level in Estonia. Therefore we need to find solutions that 1) would lead students and their studies closer to the actual activities of companies and 2) would manage the risks of both businesses and the state in the development of training and curricula.

147 Source: *Curriculum Development Guidelines, New ICT Curricula for the 21st Century Designing Tomorrow's Education, Career Space* and International Co-operation Europe Ltd, 2001, http://www.career-space.com/cdguide/serv3.htm.

5. VOCATIONAL ICT EDUCATION SYSTEM

Vocational education has been and continues to be a sphere of great importance to economic development: vocational education – and in the Estonian context applied higher education as well – is perhaps the most closely related to actual business activities. Therefore, the quality of vocational education is directly associated with the competitive ability of businesses and, thereby, also with the development and living standard of the state. Over the last two hundred years the role of vocational education, applied higher education as well as in-service training and retraining has been marked in the development of thriving states.

5.1. Estonian Vocational Training System 1992-2005[148]

Like the other levels of the Estonian education system, vocational education has also undergone major changes since the re-establishment of independence in 1991 (triggered by ideological shifts and extensive reshaping of the labour market), and the need for further changes is persistently still admitted.

The vocational education reform can be successful only if changes are implemented on all levels of the system and are in conformity with one another: legislation, institutional framework, organisational setting, requirements for teachers, etc.[149] In the Estonian vocational education system all of the aforementioned aspects have been subject to reform, but the changes have not always been consistent and designed in a perspective.

In the 1990s, general and higher education were considered priority areas. Substantive reforming of the vocational education system started only in the second half of the 1990s in conjunction with the development of the general framework for the modernisation of the Estonian vocational education, which has been set down in the following documents: *Conceptual Bases of Vocational Education,*[150] *Action Plan for Development Estonian VET System in 2002-2004*[151] and the *Estonian Vocational Education Development Plan for 2005-2008,*[152] completed in 2005.

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148 The authors are grateful to Margit Suurna for compiling the sub-chapter.

149 Nieuwenhuis L. F. M. *Change in VET: a Systems' Approach, referred in Organisation of the Network of Vocational Educational Institutions on the Basis of Regional Specialisation*. Tallinn: PRAXIS, 2003, http://www.praxis.ee/data/Koolivqrk.pdf.

150 Approved by the Government of the Republic on 13 January 1998, http://www.hm.ee. The concept provided a new legal framework to specify the role of important constituents of the vocational education system: "Vocational Educational Institutions Act" (1998), "Institutions of Applied Higher Education Act" (1998), "Private Schools Act" (1998).

151 Approved by the Government of the Republic on 12 June 2001, http://www.innove.ee/ee/files/Kutsehariduse_tegevuskava.pdf. This is a programme document, which was adopted as a follow-up measure to enhance the vocational education reform. However, the goals set in the activity plan were too ambitious. See Helmut Zelloth, Haralabos Fragoulis, Tiina Annus, Martin Dodd, Raul Eamets, Katrin Jõgi, *Country Monograph Vocational Education and Training Systems and Structure and Public and Private Employment Services in Estonia*, 2003, http://innove.ee/ee/files/Monograafia%20eestik.pdf and the *Development Plan of the Estonian Vocational Education System for 2005-2008, Annex 2*, http://www.hm.ee. An important document in the sphere of vocational education is also the *Estonian National Development Plan for Implementation of the EU Structural Funds – single programme document for 2004-2006* (also programme supplement), http://www.struktuurifondid.ee.

152 Approved by the Government of the Republic on 14 July 2005, available at http://www.hm.ee.

On the institutional level the changes were also initiated in the second half of the 1990s with the formation of national structures for the development of fundamentals of the vocational education system such as study programmes and the establishment of a professional qualification system.[153] In connection with the latter, social partners have been appreciably involved in the administrative and advisory bodies of the education system during the last decade, which is best manifested in their participation in the Professional Councils established on the basis of the 1998 "Vocational Educational Institutions Act".

Since 1998 a number of reforms have been carried out in fundamental redefinition of both second as well as third level vocational education in conjunction with changing the period of study and content of subjects (on the level of applied higher education the content of practical training and requirements of the teachers have also been changed).[154] However, national vocational education curricula are still lacking although the establishment thereof has already been stipulated by the 1998 "Vocational Educational Institutions Act".[155] The work on updating study programmes has been successful as this was the focus of international support programmes for education (primarily Phare support). In 2000, all secondary vocational study programmes of vocational educational institutions were module-based; in 2005 the study programmes have been adjusted to professional standards. Changes in the diversification of study programmes to adjust them to the changing needs of the economy are discernible on one hand in the reduced number of secondary vocational study programmes designed on the basis of basic education primarily in the spheres of technology, production and construction and, on the other hand, in the increased number of study programmes designed on the basis of general secondary education (especially in the sphere of computer sciences).[156]

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153 The establishment of the Estonian Vocational Education Reform Foundation in 1996, National Examination and Qualification Centre in 1997 and Estonian Qualification Authority (*Kutsekoda*) in 2001. (The latter continued the development of qualification systems created by the Estonian Chamber of Commerce and Industry in 1997).

154 "The Vocational Educational Institutions Act" (1998) establishes two levels of vocational education: vocational secondary education and professional higher education. As a second outcome of the reform, some of the specialities which were earlier included in the professional secondary education curricula were transferred to the higher vocational education, curricula and some to the professional secondary education curricula. Furthermore, the former diploma study programmes of vocational educational institutions were classified as higher professional study programmes. In the course of the higher education reform in the academic year 2002/2003, higher professional education and Diploma studies were replaced by the study programmes of applied higher education, *Education 2003/2004*, Statistical Office of Estonia, 2004. See also *Review of National Policies for Education. Estonia*, OECD, 2001, 116-118, 148 and Helmut Zelloth, Haralabos Fragoulis, Tiina Annus, Martin Dodd, Raul Eamets, Katrin Jõgi, *Country Monograph Vocational Education and Training Systems and Structure and Public and Private Employment Services in Estonia*, 2003. See 2002. a "Standard of Higher Education" and the changes made in 2002 to "Study programme for basic and secondary school" concerning the compulsory share of general education in the curricula of vocational education. In addition, starting from 2003, Master studies in the applied higher education institution were made possible in cooperation with universities. For more details, see *Structures of Education, Vocational Training and Adult Education Systems in Europe, Estonia*, Eurydice, CEDEFOP, ETF, 2003, http://eurydice.org/Documents/struct2/en/ESTONIA_EN.pdf.

155 The main weaknesses have been the lack of state support structures for the development of study programmes and varying approaches to the national curricula of the vocational education and in-service training. Frequent structural changes of the Ministry of Education and Science (hereinafter HTM) within the last 15 years have left a trace on the vocational education system reform in general as the majority of the vocational educational institutions belongs to the HTM. For further details see *Overviews of National Education Policies, Estonia*, OECD, 2001, 47 and Helmut Zelloth, Haralabos Fragoulis, Tiina Annus, Martin Dodd, Raul Eamets, Katrin Jõgi, *Country Monograph Vocational Education and Training Systems and Structure and Public and Private Employment Services in Estonia*, 2003.

156 See *Organisation of the Network of Vocational Educational Institutions on the Basis of Regional Specialisation*. Tallinn: Praxis, 2003, http://www.praxis.ee/data/Koolivqrk.pdf.

As for professional qualification, a number of important laws have been passed[157], but the teachers' professional qualification system has just been introduced and the graduation certificate of a vocational educational institution does not prove the existence of official professional qualifications, yet. However, the opportunity for taking voluntary professional qualification exams has widened since 2004 (in 2004, about 8% of graduates took the exam).[158]

As regards the organisational level or developments in vocational educational institutions, the activities have centred on the reorganisation of school networks, the development of cooperation between vocational educational institutions and institutions of applied higher education, as well as on creating a more defined foundation for the development of cooperation between vocational educational institutions and employers and for the organisation of practical training.[159]

Since the academic year 1994/1995 the number of state institutions of vocational education in the vocational education system has been decreasing[160] and the number of private vocational educational institutions has been increasing[161] whilst the number of municipal educational institutions has remained quite stable (see Table 5-1).

In 2004, post-basic vocational education could be obtained in 41 and post-secondary vocational education in 60 out of 68 vocational educational institutions, and applied higher education could be obtained in 10 vocational educational institutions, 25 institutions of applied higher education and 9 universities[162]. At this point, increasing attention is being paid to the possibilities of study on different levels of vocational education based on regional levels.[163]

157 "Professions Act" (2000) and "Recognition of Foreign Professional Qualification Act". "Standard of Vocational Education" has been prepared for adoption in 2005.

158 Kersti Kõiv, Evelin Silla, Katrin Ausmees, *Initial Vocational Education and Training in Estonia*, INNOVE Lifelong Learning Development Foundation, 2005, http://www.innove.ee/ee/files/THEME_04_FINAL.pdf.

159 See "Amendment Act for Vocational Education Institutions Act, Institutions of Applied Higher Education Act, Republic of Estonia Education Act and Language Act", RTI 65,375,2001.

160 On the one hand, 13 vocational educational institutions have been transferred from the administrative area of the Ministry of Agriculture to that of the HTM by the year 2000 (1998 "Vocational Educational Institutions Act") whilst on the other hand, since 1990 the school network has been reorganised by mergers of vocational educational institutions and establishment of vocational training centres (with the support of Phare into "Regional Vocational Training Centres" since 1999/2000). That also follows from the increase in the average size of vocational educational institutions – while in 1992/93, the average number of students per school was 353 (both second and third-level vocational education), in the academic year 2002/03, the figure was already 435 (Helmut Zelloth, Haralabos Fragoulis, Tiina Annus, Martin Dodd, Raul Eamets, Katrin Jõgi, *Country Monograph Vocational Education and Training Systems and Structure and Public and Private Employment Services in Estonia*, 2003).

161 At the same time, private vocational educational institutions mainly teach non-technical professions, which requires much less investment into the learning environment in comparison with other technical professions.

162 Kersti Kõiv, Evelin Silla, Katrin Ausmees, *Initial Vocational Education and Training in Estonia*, INNOVE Lifelong Learning Development Foundation, 2005, http://www.innove.ee/ee/files/THEME_04_FINAL.pdf.

163 See *Organisation of the Network of Vocational Educational Institutions on the Basis of Regional Specialisation*. Tallinn: Praxis, 2003, http://www.praxis.ee/data/Koolivqrk.pdf, concerning the developments in the future, the *Development Plan of the Estonian Vocational Education System for 2005-2008* adopted by the Government on 17 February 2005 is of major importance.

Table 5-1. Number of vocational educational institutions (2nd and 3rd level vocational education) between 1993/94 and 2004/05[164]

Ownership	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05
State vocational education institutions	77	77	72	73	73	70	67	62	58	57	53	47
Municipal vocational educational institutions	3	3	3	5	4	3	2	2	3	1	1	3
Private vocational educational institutions	0	4	7	10	12	13	16	17	23	21	19	18
Total	**80**	**84**	**82**	**88**	**89**	**86**	**85**	**81**	**84**	**79**	**73**	**68**

A marked trend has been observed towards ending the sharp discrimination between general and vocational education, for example, through cooperation in offering youth the possibilities for preliminary vocational training[165]. The role of vocational educational institutions in in-service training and retraining adults has been relatively moderate.[166] Cooperation with companies has not been successful either: thus far no national system has been worked out for the organisation of practical training in companies, and the organisation of practical training has developed since 2002 primarily with the assistance of the Phare support programme.[167]

In reforming vocational education, attention has also been paid to vocational teachers and the improvement of their professional qualifications. Since 1992, reforms have been effected to set up a training system for vocational teachers (as well as training providers), to abridge the categories of vocational teachers and to extend qualification requirements for vocational teachers (and headmasters of vocational educational institutions) in respect of both pedagogical education and experience as well as practical experience.[168] Whereas it has not actually been possible to implement the initial standards, the majority of them have been changed later and abandoned to a great extent.[169]

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164 Sources: *Organisation of the Network of Vocational Educational Institutions on the Basis of Regional Specialisation*. Tallinn: Praxis, 2003, http://www.praxis.ee/data/Koolivqrk.pdf; for academic year 2003/04 *Development Plan of the Estonian Vocational Education System for 2005-2008*, http://www.hm.ee; for the academic year 2004/05 see Kersti Kõiv, Evelin Silla, Katrin Ausmees. *Initial Vocational Education and Training in Estonia*, Foundation for Lifelong Learning Development, 2005, http://www.innove.ee/ee/files/THEME_04_FINAL.pdf.

165 For more details, see "Vocational Education Institutions Act" (2001) § 141. Preparations are under way for providing education to youth without basic education. Summary Sheets on Education Systems in Europe, Estonia, Eurydice, 2004, http://www.eurydice.org/Documents/Fiches_nationales/files/ESTONIA_EN.pdf; Development Plan of the Estonian Vocational Education System for 2005-2008, http://www.hm.ee.

166 The role of vocational education institutions in provision of continuing vocational training is emphasised by *Adult Education Development Plan for 2005-2008* and *School Network Development Plan for 2005-2008*, both completed in 2005.

167 For more details, see Kersti Kõiv, Evelin Silla, Katrin Ausmees. *Initial Vocational Education and Training in Estonia*, Foundation for Lifelong Learning Development, 2005, http://www.innove.ee/ee/files/THEME_04_FINAL.pdf.

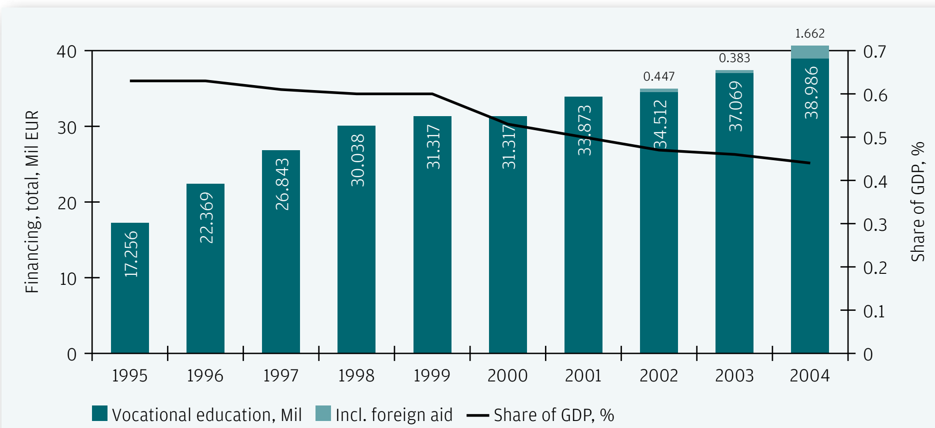
168 Regulation No 18 of the Ministry of Education and Research "The Statute of a VET Teacher/Trainer" (1995); Regulation No 35 of the Minister of Education "Qualification Requirements for Teachers" (1998); Government of the Republic Regulation No 381 "General Requirements for Teacher Training" (2000) and Regulation No 65 of the Minister of Education "Qualification Requirements for Teachers" (2002) and amendments to aforenamed regulations.

169 For more details see also *Information Collection on the Situation of VET Teachers and Trainers in Candidate Countries*, Final draft, Foundation VET Reform in Estonia/Estonian National Observatory, 2002, http://www.innove.ee/ee/files/TTT_uus.pdf; Helmut Zelloth, Haralabos Fragoulis, Tiina Annus, Martin Dodd, Raul Eamets, Katrin Jõgi, *Country Monograph Vocational Education and Training Systems and Structure and Public and Private Employment Services in Estonia*, 2003 and The Thematic Overview of Vocational Education and Training in Estonia, 2005, http://www.innove.ee/ee/files/THEMATIC_OVERVIEW_OF_ESTONIA1.pdf. By 2004, the reforms have not reached the expected results neither concerning the requirement of qualification (e.g. 73% of the teacher in vocational education institutions have higher education (university level) or e.g. 55% have not completed pedagogical training), nor making the profession of teachers of vocational education more attractive – 41% of teachers of vocational education are older that 50 and only 30% younger than 30. (The Thematic Overview of Vocational Education and Training in Estonia, 2005). At the level of Doctoral and Master studies there is a lack of trainers of VET teachers.

In addition to substantial vocational education reforms, changes in financing schemes and scopes are also of great importance to support the reforms. Main changes include the implementation of the student-based financing principle since 1996 and the transfer to a multilevel financing scheme in 2001 by increasing the qualifications of the headmasters of vocational educational institutions in the determination of expense items.[170]

As for the allocation of funds, vocational education is the smallest division of education, which only accounts for 10% of the total education expenses of the public sector (the share of general education is 61% and the share of higher education is 19%, see also Figure 5-2). During the last decade the funds allocated to vocational education have increased by 2.3 times – from 17.2 million EUR in 1995 to 38.9 million EUR in 2004 (provisional data). Without foreign aid, the funds would have increased by 2.2 times (the costs of general education grew by 2.9 times from 1995-2003). Expressed as a percentage of GDP, the funding has decreased from 0.63% to its all-time low of 0.44% (2004).[171]

Figure 5-2. Vocational education expenditures (public sector budget) between 1995 and 2004[172]



The success of vocational education system reform (above all, the improvement of reputation and quality)[173] can be measured by the number of vocational students in the education system (at this point, the general depopulation in Estonian, the re-division of vocational education levels and an increased number of non-graduates in recent years should be taken into account) and by the capability of graduates to enter the labour market.

170 For more details see *Educational Systems and Financing of Education in the EU and Estonia*, Tallinn: State Chancellery, University of Tartu, Euro College, 2003, http://www.praxis.ee/data/peatukid_35.pdf and M. Sepp, P. Tarto, K. Jõgi, *Financing: Investment in Human Resources*, Tallinn: Estonian National Observatory, 2003, http://www.innove.ee/ee/files/Financing.pdf.

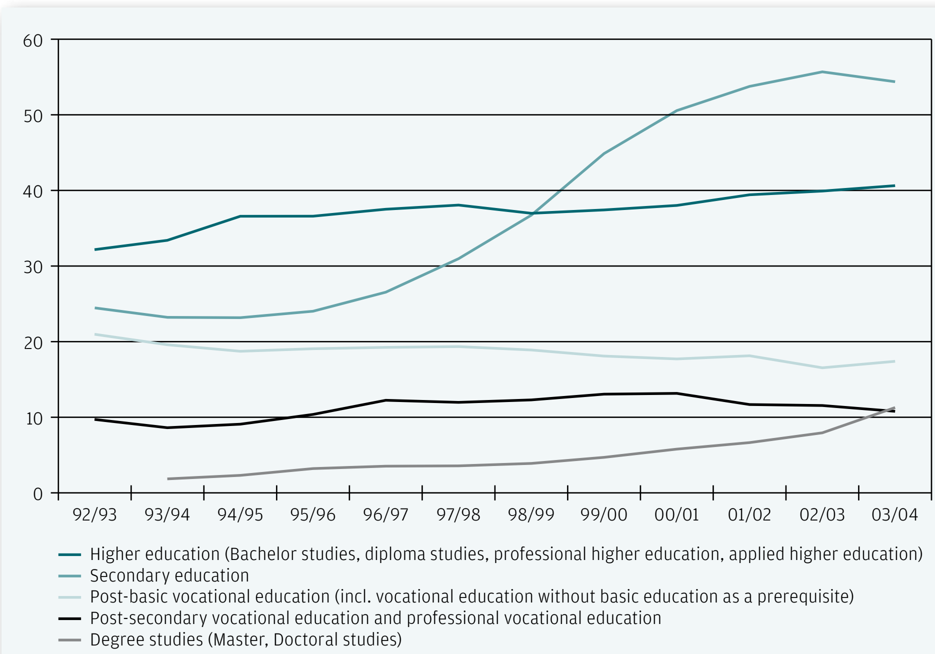
171 See the *Development Plan of the Estonian Vocational Education System for 2005-2008*, http://www.hm.ee.

172 *Ibid*.

173 A critical factor in vocational education has been the lack of possibilities for continuing studies, especially access to higher education: such a situation was created for those who had graduated in vocational secondary education on the basis of basic education with the implementation of the 1998 Vocational Educational Institutions Act and 2002 Higher Education Standard (*Organisation of the Network of Vocational Educational Institutions on the Basis of Regional Specialisation*, PRAXIS, 2003). From the year 2005, students who have obtained vocational secondary education based on basic education can study subjects of general education during an additional year, which are necessary to avoid a deadlock situation and continue studies on the third level. Furthermore, the new 2005 education allowances system also includes the students obtaining vocational education on the basis of basic education. Kersti Kõiv, Evelin Silla, Katrin Ausmees. *Initial Vocational Education and Training in Estonia*, Foundation for Lifelong Learning Development, 2005, http://www.innove.ee/ee/files/THEME_04_FINAL.pdf.

Between 1995 and 2003, the number of vocational students on the level of secondary vocational education has been relatively stable. In recent years, the number of professional high school students has increased (see Figure 5-3).[174] But the popularity of vocational education has not grown. In 2004, 28.4% of daytime basic school graduates and approximately 20% of secondary school graduates continued their studies in a vocational educational institution, whilst in 1995 27.5% of secondary school graduates continued studies in a vocational education institution. Especially among the basic school graduates the percentage of students who continue their studies in upper-secondary school instead of vocational educational institutions has been growing since 1991: from 56.2% in 1991 to 73.9% in the academic year 2002/2003, although in recent years (2002-2004) an increase of ca 16% in the number of vocational students can be noticed.[175] The possibilities of vocational school graduates to enter the labour market are still limited, which is best manifested in the highest percentage of the graduates among the unemployed (see Table 5-4).

Figure 5-3. Number of students in the formal education system by divisions/levels of education between the academic years 1992/1993 and 2003/2004[176]



174 Within the structure of specialities, the number of students on the level of vocational secondary education has increased substantially in the spheres of service industries, social sciences, business and law, and recently also in the spheres of science (primarily in the sphere of information technology), whilst the number of students in agricultural specialities has decreased. The spheres of technology, construction and production have always been in a good state, although in the mid-1990s a certain decline was observed. In applied higher education, an expansion of the spheres of health and well-being, education and arts can be noticed in addition to the aforementioned spheres. (Education and Employment Monitoring Centre (2004), relevant tables can be found at http://www.rajaleidja.ee (statistics)).

175 See the *Development Plan of the Estonian Vocational Education System for 2005-2008*, http://www.hm.ee and Helmut Zelloth, Haralabos Fragoulis, Tiina Annus, Martin Dodd, Raul Eamets, Katrin Jõgi, *Country Monograph Vocational Education and Training Systems and Structure and Public and Private Employment Services in Estonia*, 2003.

176 Source: Education and Employment Observatory, table could be found at http://www.rajaleidja.ee.

Table 5-4. Graduates of the academic years 1993/4 and 2003/2004 registered as unemployed[177]

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Basic School	62	96	161	169	131	100	143	138	65	118	42
Secondary School	197	332	795	570	329	423	519	409	453	294	122
Vocational Education Institution	222	261	467	612	607	937	906	903	1194	697	396
Higher Education Institution	46	38	81	176	93	149	184	274	129	186	134
Total	**527**	**727**	**1,504**	**1,527**	**1,160**	**1,609**	**1,752**	**1,724**	**1,841**	**1,295**	**694**

** until 1999 (included), the data also include non-graduates*

In summary, it may be said that the vocational education reforms effected thus far have not achieved the goals with respect to improving either the quality or reputation of vocational education despite the fact that changes, although inconsistent and insufficiently funded, have encompassed all levels of the vocational education system.

5.2. Institutions of Vocational ICT Education System[178]

ICT education can be obtained in vocational educational institutions on the basis of both post-basic and post-secondary as well as at the level of applied higher education. The major vocational educational institutions on the level of post-basic vocational ICT education are Kehtna School of Economics and Technology (168 students), Tallinn School of Transportation and Tallinn Polytechnic School. The major vocational educational institutions by the number of students on the level of secondary vocational education are Tallinn School of Transportation (176 students), Kohtla-Järve Polytechnic School and Vocational Training Centre of Narva (Table 5-5).

Table 5-5. Students of computer sciences by levels of study, 2004[179]

Vocational Studies	2004	2004 (%)
Post-basic vocational secondary education		
All fields of study	18,978	
Computer sciences in total	822	4.3%
Incl. Kehtna School of Economics and Technology	168	0.9%
Incl. Tallinn School of Transportation	151	0.8%
Incl. Tallinn Polytechnic School	115	0.6%
Electronics and control engineering	1,007	
Post-secondary vocational secondary education		
All fields of study	10,434	
Computer sciences in total	928	8.9%
Incl. Tallinn School of Transportation	176	1.7%
Incl. Kohtla-Järve Polytechnic School	164	1.6%
Incl. Vocational Training Centre of Narva	142	1.4%
Electronics and control engineering	433	

177 Source: Labour Market Board (2003), Education and Employment Observatory (2004); in the course of conducting the survey *Organisation of the Network of Vocational Educational Institutions on the Basis of Regional Specialisation*, PRAXIS analysed the graduates of vocational education institutions based on paid income tax in 2000-2002. It revealed that the share of tax payers is smaller in the case of vocational education based on basic education and is larger in the case of graduates of higher vocational education, see http://www.praxis.ee/data/Koolivqrk0.pdf.

178 The authors are grateful to Margit Suurna for compiling the sub-chapter.

179 Sources: Statistical Office of Estonia (1993-2003); AS Andmevara, register of students 2004 (1 November 2004).

The major secondary vocational educational institutions to provide ICT education on the basis of both basic as well as secondary education are the following state vocational educational institutions (Table 5-6): Tallinn School of Transportation (327 students), Vocational Training Centre of Narva (234 students), Tallinn Polytechnic School and Kehtna School of Economics and Technology (199 students in both) as well as Kohtla-Järve Polytechnic School (164 students). The Vocational Education Centre of Tartu with its 206 students is the major municipal vocational educational institution in the given sphere.

Table 5-6. Students of computer sciences by vocational educational institutions, 2004[180]

Name of the educational institution	Study level (Vocational secondary education …)	No of students at different levels	Total no of students
Tallinn School of Transportation	…based on secondary education	176	327
	…based on basic education	151	
Vocational Training Centre of Narva	…based on secondary education	142	234
	…based on basic education	92	
Vocational Education Center of Tartu	…based on secondary education	103	206
	…based on basic education	103	
Kehtna School of Economics and Technology	…based on secondary education	31	199
	…based on basic education	168	
Tallinn Polytechnic School	…based on secondary education	84	199
	…based on basic education	115	
Kohtla-Järve Polytechnic School	…based on secondary education	164	164
Sillamäe Vocational School	…based on secondary education	128	128
School of Informatics and Computer Science	…based on basic education	102	102
Viljandi Joint Vocational Secondary School	…based on secondary education	37	37
Jõhvi Vocational School	…based on basic education	27	27
Pärnumaa Vocational Education Centre	…based on secondary education	26	26
Inter Vocational School of Computing	…based on basic education	25	25
Lääne-Virumaa Higher Vocational School	…based on secondary education	25	25
Luua Forestry School	…based on basic education	19	19
Väike-Maarja Training Centre	…based on basic education	13	13
Pärnu German School of Technology	…based on secondary education	11	11
Paide Vocational School	…based on basic education	7	7
Tallinn School of Economics	…based on secondary education	1	1
Kuremaa Agricultural Polytechnic School[181]	…based on secondary education	0	0
	…based on basic education	0	
Kuressaare Vocational School[182]	…based on secondary education	0	0
School of Business Informatics[183]	…based on secondary education	0	0
Tallinn School of Communications[184]	…based on secondary education	0	0
Tallinn Industrial Education Centre[185]	…based on secondary education	0	0

180 Source: Andmevara, register of students 2004, 1 November 2004.

181 Since 2004 Kuremaa department of Luua Forestry School, http://kuremaapt.edu.ee/index.php?link=teated.

182 During the period 1 October 2003-30 September 2004, there were 17 graduates at Kuressaare Vocational School specialised on *Basis of Information Technology*.

183 During the period 1 October 2003-30 September 2004, there were 12 graduates at the School of Business Informatics specialised on *Business informatics*.

184 Tallinn School of Communications was merged with Tallinn Polytechnic School in 2004, *Development Plan of the Estonian Vocational Education System for 2005-2008*, http://www.hm.ee.

185 During the period 1 October 2003-30 September 2004, there were 18 graduates at Tallinn Industrial Education Centre specialised on *Information Technology*.

5.2.1. Tallinn School of Transportation

One of the major vocational educational institutions providing ICT education is Tallinn School of Transportation[186], where the secondary vocational study programmes (both post-basic and post-secondary) are followed closely to a great degree in the sphere of computer sciences. In autumn 2005, students are admitted to a daytime *IT support specialist* study programme on both levels of secondary vocational education and the programmes are taught on both levels in two languages (Estonian and Russian) and all groups (all in all 4) of the study programme consist of 30 students (see Table 5-7).[187]

Table 5-7. Computer Sciences study programmes at Tallinn School of Transportation in 2004 and 2005[188]

Group of study programmes	Study programme	Base education	No of school years	Code of the study programme
Computer sciences	IT support specialist	Basic education	3	2112
Computer sciences	IT support specialist	Secondary education	2	2113
Computer use	Basis of information technology	Secondary education	1	2111

5.2.2. Vocational Training Centre of Narva

The services, light industry and information technology departments of the Vocational Training Centre of Narva[189] conducted the following ICT courses in the academic year 2004/2005: *Computers and Computer Networks* (daytime form of study) on the basis of both basic as well as secondary school; *Basics of Information Technology*[190] (evening form of study) on the basis of secondary school (see also Table 5-8).[191]

Table 5-8. Computer Sciences and Computer Use study programmes at the Vocational Training Centre of Narva in 2004[192]

Group of study programmes	Study programme	Base education	No of school years	Code of the study programme
Computer sciences	Computers and computer networks	Basic education	3	924
Computer sciences	Information technology	Basic education	3	926
Computer sciences	Computers and computer networks	Secondary education	2	3048
Computer sciences	Information technology	Secondary education	2	925
Computer use	Basis of information technology	Secondary education	2 (1)	923

186 See also http://www.ttrk.ee.

187 Tallinn School of Transport http://www.ttrk.ee, information from the register of the Estonian Education Information System is added, http://ehis.hm.ee/avalik/ok/oppekavad_otsing.uix.

188 Source: the register of the Estonian Education Information System, http://ehis.hm.ee/avalik/ok/oppekavad_otsing.uix.

189 See also http://www.nvtc.ee.

190 At the web site of Vocational Training Center of Narva (http://www.nvtc.ee/section.php?S=study&SubS=enrolment&LocM=nabor), data about graduates specialised on *Information Technology* are missing (both based on basic and secondary education).

191 The code of study programme is taken from the register of the Estonian Education Information System. There the study period of the speciality *Basis of Information Technology* is given as 1 year.

192 Sources: the Estonian Education Information System, http://ehis.hm.ee/avalik/ok/oppekavad_otsing.uix.

5.2.3. Tartu Vocational Education Centre

As of November 2004, the Tartu Vocational Education Centre had the largest number of study programmes of the computer sciences and computer use study programme group (especially programmes based on secondary education).[193]

Table 5-9. Computer Sciences study programmes at Tartu Vocational Education Centre in 2005[194]

Group of study programmes	Study programme	Base education	No of school years	No and validity of the education licence	Code of the study programme
Computer sciences	Computer technician- IT technical support specialist	Basic education	3	2286HM, valid until 31.08.05	2234
Computer sciences	Data processing and web design	Basic education	3 years 6 months	3129HTM, valid until 31.07.08	3267
Computer sciences	Computer networks	Secondary education	2	3178HTM, valid until 31.08.06	2250
Computer sciences	Programming and data processing	Secondary education	2	3131HTM, valid until 31.08.06	3306
Computer sciences	Web design and e-business	Secondary education		3176HTM, valid until 31.08.06	2132
Computer sciences	Data processing	Secondary education	2	3177HTM, valid until 31.08.06	2232
Computer sciences	Data processing and web design	Secondary education	2 years 6 months	2800HTM, valid until 31.08.05	3009

5.2.4. Tallinn Polytechnic School

In the academic year 2003/2004, Tallinn Polytechnic School[195] taught ICT courses in the *Computers and Computer Networks* speciality on the basis of both basic as well as secondary education, but only in the Estonian language and daytime form of study. Students studying on the basis of secondary education also had a possibility to take short courses (period of study: 1 year) in the speciality of *Basics of Information Technology*.

193 AS Andmevara, on the basis of the 2004 register of students: *Study Levels of Higher and Vocational Education, Field of Computer Sciences, as of November 1, 2004*, the basic education-based syllabuses of the Tartu Vocational Education Centre in 2004 included *Data Processing and Web Design* as well as *Information Technology-Computer Engineering*, and secondary education-based syllabuses included *Data Processing, Data Processing and Computer Networks, Computer Networks, Information Technology-Computer Engineering, Programming and Information Processing* as well as *Principles of Information Technology*.

194 Sources: the Estonian Education Information System, http://ehis.hm.ee/avalik/ok/oppekavad_otsing.uix.; Andmevara, register of students (1 November 2004); Tartu Vocational Education Centre http://www.khk.tartu.ee/?_m=3&_p=83&um=32, in addition, data is used from the compendium *Guide for the Decision Maker – Vocational Education Institutions 2005*, Tallinn: Education and Employment Observatory, http://www.innove.ee/ee/files/Abiks_otsustajale_sisu_veebi.pdf and the codes of study programme from the register of the Estonian Education Information System.

195 See also http://www.tpt.edu.ee.

Table 5-10. Computer Sciences and Computer Use study programmes at Tallinn Polytechnic School in 2004[196]

Group of study programmes	Study programme	Base education	No of school years	Code of the study programme
Computer sciences	Computers and computer networks	Basic education	3 years 10 moths	1788
Computer sciences	Computers and computer networks	Secondary education	2	3006
Computer sciences	Computers and computer networks (IT support specialist)	Secondary education	2 years 6 months	1789
Computer use	Basis of information technology	Secondary education	1	1779

5.2.5. Kehtna School of Economics and Technology

Kehtna School of Economics and Technology[197] offers programmes for obtaining secondary vocational education on the basis of both basic as well as secondary education in the speciality of *Computers and Computer Networks*. In addition to daytime studies, the school also offers a possibility (on both levels of study) to learn the same profession by way of distance learning (see Table 5-11) after obtaining secondary education.

Table 5-11. Computer Sciences study programmes at Kehtna School of Economics and Technology in 2004 and 2005[198]

Group of study programmes	Study programme	Base education	No of school years	Code of the study programme
Computer sciences	Computers and computer networks	Basic education	4	699
Computer sciences	Computers and computer networks	Secondary education	2	3047

5.2.6. Kohtla-Järve Polytechnic School

ICT training at Kohtla-Järve Polytechnic School[199] is organised by the Department of Information Technology, the staff of which consisted of 9 teachers and 2 laboratory assistants in the academic year 2003/2004. The Department of Information Technology trains professionals in the speciality of *Information Technology* on two levels of study (applied higher education and secondary vocational education). The secondary vocational speciality of Information Technology was modified in the academic year 2003 and the new programme is titled *Data Processing*. The objective was to make the programme more specialised. Furthermore, the programme would serve as a pre-entry level to the higher professional speciality of *Information Technology* (see Table 5-12). In the academic year 2005/2006, the Ida-Virumaa Vocational Education Centre admits only secondary school graduates to the speciality of *Data Processing* taught in the Russian language.

196 Sources: the Estonian Education Information System; Tallinn Polytechnic School http://green.tpt.edu.ee.

197 See also http://www.kehtna.edu.ee/est.

198 Sources: the Estonian Education Information System; AS Andmevara, register of students 2004: *Study levels of higher education and vocational education, computer sciences study programmes*, on 11 January 2004 Kehtna School of Economics and Technology offered opportunity to specialise on Basis of Information Technology in 2004, too.

199 http://www.kjpt.edu.ee, according to the letter no 8-4/1595 of the Ministry of Education and Research and the order of the Government on 17 February 2005 the name of Kohtla-Järve Polytechnic School was changed to Ida-Virumaa Vocational Education Center because of the merger of Kohtla-Järve Polytechnic School, Jõhvi Vocational School and Kohtla-Järve Vocational Education School.

Table 5-12. Computer Sciences study programmes at Kohtla-Järve Polytechnic School in 2004[200]

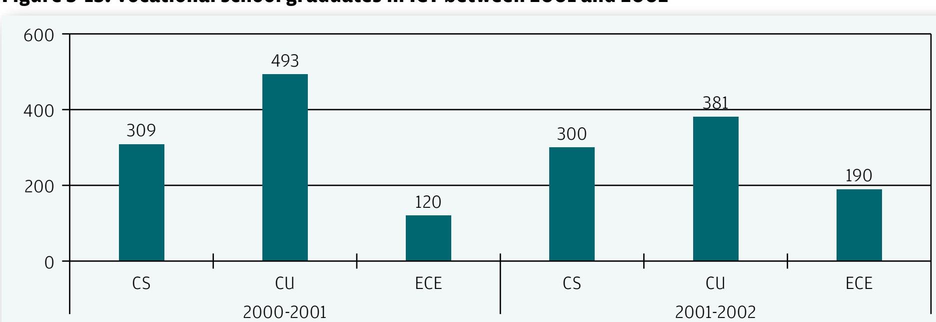
Group of study programmes	Study programme	Base education	No of school years	Code of the study programme
Computer sciences	Information technology	Secondary education	4	699
Computer sciences	Data processing	Secondary education	2	3047

5.3. Analysis of Income Tax Paid by ICT Graduates from Vocational Schools[201]

Now follows a comparison of the incomes of ICT graduates from vocational schools on the basis of income tax paid. The analysis covers income tax payable on the wages and salaries of people who have acquired vocational ICT education, which is based on the sub-register of the students, university students and Doctor residents of the Estonian Education Information System as well as on monthly social tax, mandatory funded pension and unemployment insurance premium statements of the Tax and Customs Board for the period 1999-2003. The analysis is founded upon the data from the years 2001 and 2002 about the vocational school graduates in computer sciences, computer use, electronics or control engineering who have paid income tax on their income from employment between 2001 and 2003 (for a detailed description of the methodology used see Annex VII).

In the academic years 2000/2001 and 2001/2002, the number of vocational school graduates in the specialities of computer sciences and computer use has decreased: while in 2001, the total number of graduates in the said specialities was 801, in 2002, the total number of the graduates was 681. The number of student places has dropped especially in the speciality of computer use (Figure 5-13).

Figure 5-13. Vocational school graduates in ICT between 2001 and 2002[202]



On the level of vocational education, the field of computer sciences is regarded as declining in Estonia, which is also manifested in the relevant training order prognosis. The 700 computer sciences student places funded in 2004 are intended to be reduced to 540 by

200 Kohtla-Järve Polytechnic School http://www.kjpt.edu.ee/?lang=ee, also data from the register of the Estonian Education Information System has been used.

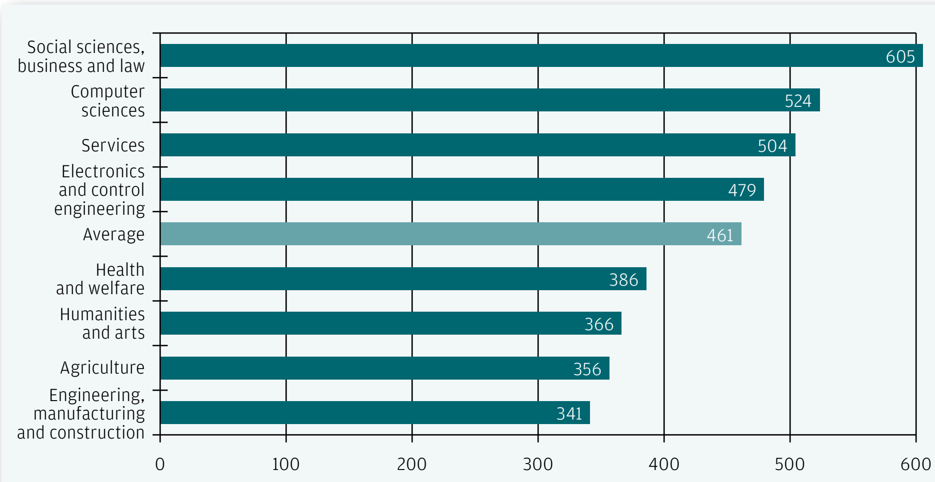
201 The authors are grateful to Anne Jürgensoni for compiling the sub-chapter and Liis Kraut for data analysis.

202 Sources: the Estonian Education Information System, data of the Tax and Customs Board, calculations of PRAXIS; CS – computer sciences, CU – computer use and ECE – electronics or control engineering.

the year 2009.[203] The reason for that is the need for highly trained IT professionals in connection with industrial automation and expansion of computer and system technology to traditional fields of production.[204]

Despite the fact that state orders for ICT professionals are decreasing, the ICT graduates are among the most successful on the labour market in comparison with other specialities. They pay the highest amount of income tax after law and business economics graduates (Figure 5-14).

Figure 5-14. Average annual income tax paid by vocational school graduates by specialities (EUR)[205]



When comparing the income tax paid by the ICT graduates of vocational schools with the graduates of institutions of higher education, it appears that the sums of income tax payable by the vocational school graduates are roughly one-third the size of the sums paid by the holders of a Bachelor's degree (see Figure 5-15).

At this point, the following schools may be distinguished by the larger amounts of income tax paid by their graduates:

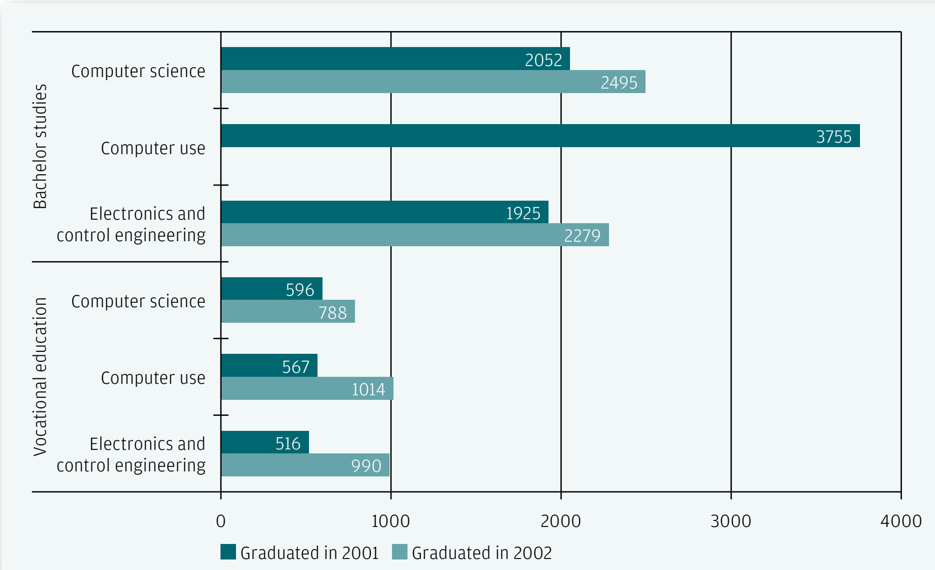
- Mainor Higher School (speciality of data processing),
- Tallinn School of Economics (speciality of data processing),
- Tallinn Polytechnics (specialities: computers and computer networks, personal computers and computer networks, telecommunications equipment, telecommunications systems),
- the former Tallinn School of Communication (information technology, specialities of line telephony structures and radio equipment installation electrician),
- Tartu Vocational Education Centre (specialities of data processing and data networks),
- Estonian Mining Education Centre (specialities: programming of electronic computers and automated systems),
- Kohtla-Järve Polytechnic School (speciality of information technology).

203 *School Network Development Plan for 2005-2008. Project.Ministry of Education and Research*, 2004.

204 *Guide for Decision-Maker – Vocational Education Institutions 2005*. Ministry of Education and Research, Education and Employment Observatory, 23.

205 Sources: the Estonian Education Information System, data of the Tax and Customs Board, calculations of PRAXIS.

Figure 5-15. Average income tax paid by ICT graduates of 2001 and 2002 from vocational schools and institutions of higher education in 2003 (EUR)[206]



23% of the computer sciences graduates have found jobs in wholesale and retail trade, 19% in the manufacturing industry and the rest divided in smaller proportions between other spheres of activity (Table 5-16).[207] However, in the manufacturing industry the graduates have found jobs in traditional branches of the industry (e.g. food processing, clothing industry, timber industry, furniture industry) rather than in ICT areas. In the service sector, the graduates have found jobs in trade businesses and other areas of business rather than concentrating on computer-related activities (only 3%). The electronics and control engineering graduates have also found the most jobs in the industry and trade businesses and, unlike computer sciences graduates, in construction.

The highest income subject to income tax is earned in the spheres of the mining industry, financial intermediation, post and telecommunications, water transport and, surprisingly, also in the textile industry (specialities of computer use and electronics as well as control engineering). A very small number of electronics and control engineering graduates have found lucrative jobs in the spheres of air transport and transportation.

The high percentage of the sector of ICT users in the employment of ICT professionals is similar to that of other states.[208] For example, in Europe (on the basis of EU-15 data) 40% of the ICT professionals are employed in the ICT sector and 60% in the users' sector whilst in the US altogether 60% of the ICT professionals are employed in non-ICT sector companies (Table 5-17).[209] That in its turn implies active use of ICT in different industrial sectors and related productivity growth, especially in the US.[210]

206 *Ibid*.

207 Calculations are based on the major field of activity of the employer.

208 Also includes ICT specialists with higher education and degree.

209 See also OECD, *New Perspectives on ICT Skills and Employment*, 2005, http://www.oecd.org/dataoecd/26/35/34769393.pdf.

210 USA is often brought out as a country where the contribution of ICT to productivity growth is high. See e.g. *OECD ICT Outlook 2004*, Paris: OECD, 2005.

Table 5-16. Vocational educational institution graduates in ICT between 2001 and 2002 by area of activity of principal employer[211]

Main field of activity of the employer		Humanities and arts	Social sciences, business and law	Computing	Incl. computer sciences	Incl. Computer use	Engineering, manufacturing and construction	Incl. electronics and control engineering	Agriculture	Health and welfare	Services
Agriculture, hunting, forestry, fishing	No of tax payers	1	36	11	5	6	89	2	48	6	44
	%	0.4	1.3	0.9	1.0	0.9	1.7	0.8	13.0	1.4	1.4
Mining and quarrying	No of tax payers	0	19	21	14	7	55	7	4	2	5
	%	0.0	0.7	1.8	2.9	1.0	1.1	2.9	1.1	0.5	0.2
Manufacturing industry	No of tax payers	53	425	210	79	131	1,925	70	65	22	362
	%	19.3	15.4	18.0	16.1	19.3	37.7	28.9	17.7	5.0	11.9
Incl. Manufacture of office machinery and computers	No of tax payers	1	1	6	3	3	3	0	0	0	0
	%	0.4	0.0	0.5	0.6	0.4	0.1	0.0	0.0	0.0	0.0
Incl. Manufacture of medical, precision and optical instruments, watches and clocks	No of tax payers	0	3	6	2	4	25	6	0	0	2
	%	0.0	0.1	0.5	0.4	0.6	0.5	2.5	0.0	0.0	0.1
Incl. Manufacture of television and radio transmitters and apparatus	No of tax payers	0	20	16	1	0	26	0	0	1	11
	%	0.0	0.7	1.4	0.2	0,.0	0.5	0.0	0.0	0.2	0.4
Electricity, gas and water supply	No of tax payers	0	30	13	8	5	99	7	3	1	9
	%	0.0	1.1	1.1	1.6	0.7	1.9	2.9	0.8	0.2	0.3
Construction	No of tax payers	4	88	40	17	23	767	33	13	3	72
	%	1.5	3.2	3.4	3.5	3.4	15.0	13.6	3.5	0.7	2.4
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	No of tax payers	43	814	273	112	161	923	50	78	36	519
	%	15.7	29.5	23.4	22.8	23.7	18.1	20.7	21.2	8.2	17.0
Hotels and restaurants	No of tax payers	4	101	38	12	26	96	2	6	12	541
	%	1.5	3.7	3.3	2.4	3.8	1.9	0.8	1.6	2.7	17.7
Transport, storage and communication	No of tax payers	10	219	77	41	36	215	19	11	11	279
	%	3.6	7.9	6.6	8.4	5.3	4.2	7.9	3.0	2.5	9.1
Financial intermediation	No of tax payers	2	120	34	14	20	29	3	1	3	40
	%	0.7	4.3	2.9	2.9	2.9	0.6	1.2	0.3	0.7	1.3
Real estate, renting and business activities	No of tax payers	21	276	134	62	72	422	18	30	10	190
	%	7.7	10.0	11.5	12.6	10.6	8.3	7.4	8.2	2.3	6.2
Incl. computers and related activities	No of tax payers	0	28	35	1	1	11	1	0	0	9
	%	0.0	1.0	3.0	0.2	0.1	0.2	0.4	0.0	0.0	0.3
Public administration and defence; compulsory social security	No of tax payers	45	382	138	58	80	244	18	67	84	683
	%	16.4	13.8	11.,8	11.8	11.8	4.8	7.4	18.2	19.,0	22.4
Education	No of tax payers	25	88	102	50	52	73	5	13	46	53
	%	9.1	3.2	8.7	10.2	7.7	1.4	2.1	3.5	10.4	1.7
Health and social work	No of tax payers	9	63	30	6	24	50	1	14	185	66
	%	3.3	2.3	2.6	1.2	3.5	1.0	0.4	3.8	42.0	2.2
Other community, social and personal service activities	No of tax payers	57	100	48	13	35	118	7	15	20	191
	%	20.8	3.6	4.1	2.6	5.2	2.3	2.9	4.1	4.5	6.3
Total	**No of tax payers**	**274**	**2,761**	**1,169**	**491**	**678**	**5,105**	**242**	**368**	**441**	**3,054**
	%	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

211 Sources: the Estonian Education Information System, data of the Tax and Customs Board, calculations of PRAXIS.

Table 5-17. Employment rate of ICT professionals in 2000 and the need for the professionals by 2010[212]

	ICT practitioners 2002	ICT practitioners (ICT sector)	ICT practitioners (user sectors)	ICT practitioners (demand p.a.)	ICT practitioners 2010
Germany	800,000 (2.1%)	300,000	500,000	50,000	1,100,000
The Netherlands	280,000 (3.5%)	110,000	170,000	17,000	380,000
Portugal	70,000 (1.5%)	26,000	44,000	4,500	99,000
...	...	...	...	...	...
Europe (EU-15)	3,700,000 2.2%)	1,700,000	2,000,000, including: 360,000 (Automotive) 200,000 (Financing/Bank) 64,000 (Graphic/Media)	230,000	5 ,100,000
USA	3,900,000 (2.8%)	1,600,000	2,300,000	?	?

5.4. Business and Vocational Education

Vocational education has always been characterised by two somewhat different and sometimes conflicting objectives: on the one hand to give practical education applicable in business and on the other hand to continuously update the skills of the workforce. This tendency can be observed then since the industrial revolution in England where a number of so-called Mechanics Institutes were established at the beginning of the 19th century.

The imminent ambivalence of vocational education – whether the education provided meets the business needs and whether this need adds to the competitive ability of companies and the economy in its entirety – has today posed two serious challenges to vocational education as such: 1) should the content of vocational education be relatively specific or rather general and 2) how to engage companies in the promotion of vocational education in a sustainable manner. These two issues are closely interrelated and the actual form (study programmes) as well as the actual success of vocational education depend a great deal on the answers and concrete solutions to the issues.

5.4.1. Content of Vocational Education

The majority of companies would consider a situation ideal where vocational school graduates are immediately able to start full-time work taking full responsibility in a concrete company. At the same time, business development is extremely fast and unpredictable: so, a company may, for example, abandon in-house maintenance of computer systems and outsource the service. For the company, it would evidently be the best solution if the employee who was previously in charge of the in-house system maintenance now were able to take over the activity related to outsourcing the same service (contract management, client relations, etc). However, the most common choice is quite the opposite: the

212 Willi Peterson, Peter Revill, Tony Ward, Carsten Wehmeyer, *ICT and E-Business Skills and Training in Europe. Towards a Comprehensive European E-Skills Reference Framework*. Final synthesis report, Cedefop Panorama Series, 93, Luxembourg: EUR-OP, 2005, 32.

employee who was in charge of the system maintenance is made redundant and a new employee is hired to manage the service. Development, in-service or re-training of the employee does not practically take place. Instead, one professional with specific skills is replaced by another employee with relatively specific skills. This was the issue that was pointed out in the extremely influential 1989 MIT report *Made in America* as one of the key concerns of US vocational education.[213]

Such a process practically means that part of the workforce is constantly growing out of date and becomes cheap. Attempts have been made to redress the issue both in theory as well as practice with integration of vocational education and actual work – hence comes also the idea of lifelong learning – yet, that does not change the nature of concrete work. It is this issue, in solution of which two pronounced tendencies have been observed in recent years:

1) the so-called flexible work practice, which means a notable increase in work rotation (movement from one work to another within one company), group work and semi-independent units as well as the spread of other similar tricks of work organisation;[214]

2) the relatively great emphasis on the development of general academic as well as the so-called social and interpersonal skills of students in the course of vocational or professional education, as a result whereof the so-called open profession is obtained.[215]

The background of both flexible work organisation as well as open professions is expansion of ICT to practically all areas of life, which means that both software and hardware skills are vital in practically all professions (see Figure 5-18).

However, for vocational ICT education this also means that training must take into account very many areas of life and their peculiarities.

Therefore, an important tendency in the content and study programmes of vocational education is the development towards the general, so-called open, professions, which conforms to flexible work organisation in business. On the one hand, this ensures the adaptability of vocational school graduates in a business environment and, on the other hand, his/her ability to continue learning. For companies, this ensures incessantly developing staff.

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213 Michael L. Dertouzos, Richard K. Lester, Robert M. Solow. *Made in America. Regaining the Productive Edge*, The MIT Commission on Industrial Productivity, Cambridge, MA: MIT Press, 1989, 91.

214 See e.g. OECD *Employment Outlook 1999*, available at http://www.oecd.org/documentprint/0,2744,en_2649_37457_31736485_1_1_1_37457,00.html.

215 See also *Development Plan of the Estonian Vocational Education System for 2005-2008*, http://www.hm.ee; Jay W. Rojewski, “Preparing the Workforce of Tomorrow: a Conceptual Framework for Career and Technical Education”, *Journal of Vocational Education Research*, 27, 1, 2001, http://scholar.lib.vt.edu/ejournals/JVER/v27n1/rojewski.html; Arthur M. Harkins, “The Futures of Career and Technical Education in a Continuous Innovation Society”, *Journal of Vocational Education Research*, 27, 1, 2001, http://scholar.lib.vt.edu/ejournals/JVER/v27n1/harkins.html.

Figure 5-18. Applicability of vocational ICT education in business[216]

ICT sector (ICT supplier companies)
Small, Medium, Large Enterprises / Companies / Organisations

Information Technology I(C)T HW / SW / Networks	Communications Technology (I)CT HW / SW / Networks (fixed, radio)
Information and Communications Technology ICT HW /SW / Information Networks / Communication Networks (fixed, radio)	

ICT user sectors (ICT user companies)
Small, Medium, Large Enterprises / Companies / Organisations

Automotive Industry	Financing and Banking	Graphic/Media Industry	Electrical, Electronics Industry	Metal Industry	Print-, Wood-, Paper Industry
Chemical Industry	Food Industry	Insurance	Wholesale and Retail Trade	Services	Government, Public Administration
Energy Supply	Construction	Transport, Distribution and Logistics	Health and Human Services	Tourism and Leisure Industry	Others

5.4.2. Involvement of Companies

The primary objective of vocational and applied higher education is to tend to business needs. Therefore, the engagement of companies in the organisation of vocational education from study programmes to extensive apprenticeship has always been of great importance. Practical training and apprenticeship are extremely expensive and here the globalising economy (see also chapter 1.2) is about to turn many current practices in vocational education upside down. First, funding of practical training and apprenticeships becomes a notable extra cost in global competition, where labour costs may already differ to a great degree. Therefore, many companies, especially in Europe, consider discontinuation of apprenticeship financing quite a tempting possibility. That is especially tempting due to the fact that many simpler functions can be outsourced from a low labour cost environment. Here, lower productivity is often unimportant because the functions to be outsourced are primitive and do not bring much added value. Understandably, such an activity is of great use to the companies, but extremely harmful to the labour markets and education systems of both developed and developing countries: in developed countries, the companies lack motivation to finance more complex activities (requiring more knowledge and skills) and education as the majority of the workforce lacks the possibility and ability to acquire new skills (lack of experience).[217]

In the given example, the vocational educational expenses of companies in developed countries are mostly borne by the public sector without much sustainable return for the latter on the investment. In Estonian vocational education, similar problems may be encountered, for example in the training of seamstresses. In Estonia, practically no substantial development is carried out in textile companies, which mainly employ subcontracts

216 Source: *ICT Practitioner Skills and Training Solutions at Sub-Degree and Vocational Level in Europe Guidelines for ICT Training and Curriculum Development*, Cedefop Panorama series, 2004, http://www2.trainingvillage.gr/etv/publication/download/panorama/5150_en.pdf.

217 See also Paul Ryan, "The Institutional Requirements of Apprenticeship: Evidence from Smaller EU Countries", *International Journal of Training and Development*, 4, 1, 2000, 42-65, 45.

and where the work is quite complex by nature and, therefore, quite labour-consuming. At the same time, positive dynamics in wage growth is almost zero.[218]

Thus, the risk of investment into vocational education has increased for the companies of both developed and developing countries and, therefore, the role of the public sector in reducing the risks becomes important. The aim of public sector intervention is to reduce the risks for engagement of the private sector. During the last 150 years the most efficient method for reducing risks in vocational education has been the development of a relatively complex regulative environment to:

1) facilitate long-term cooperation between the education system and business, as a result whereof qualification requirements, study programmes, etc, are worked out;
2) provide the parties with a fairly equal legal standing, which ensures an actual negotiation process and actual agreements.

In different cultural and political contexts such a regulation has taken up various forms and features. The best known is perhaps the so-called dual system established in Germany after World War II, where vocational education is obtained during apprenticeship accompanied with studies at the so-called *Berufschule*.[219] The system is coordinated by a complex regulative mechanism, in which *lands*, trade unions and sector-based collective agreements play an important role. While in the German system, financing has been distinctly shared – companies finance apprenticeship, the state finances the studies at school – several other European countries use tax schemes and direct aid to motivate companies (or to “punish” non-participants).[220] The latter have been used very effectively in Ireland in the implementation of the extensive apprenticeship system introduced in 1993.[221] Of the Asian countries, Singapore, for example, has developed the so-called Skill Development Fund[222], which supports the companies in in-service and re-training, and finances itself partially from the 1% wage tax.[223] In South Korea, we find, in addition to public sector vocational educational schools, educational institutions established in cooperation with the companies, where the students normally have an obligation to stay in one of the financing companies.[224] All of the aforementioned countries employ extensive apprenticeship systems, which are run in accordance with the social partnership principles and where the related costs are to be borne by both the public as well as the private sector. Sharing and mitigation of risks is essential.[225]

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218 Like the Elqotec case, where the wages of unskilled workers have remained unchanged for years. Kristiina Randmaa, Krista Taim. Unskilled Workers of Elcoteq Discontent, *Äripäev*, 9 March 2005, http://www.aripaev.ee/2824/uud_uudidx_282409.html.

219 A good short overview is given by Graham Atwell and Felix Rauner, “Training and Development in Germany”, *International Journal of Training and Development*, 3, 3, 1999, 227-233.

220 See Paul Ryan, “The Institutional Requirements of Apprenticeship: Evidence from Smaller EU Countries”, *International Journal of Training and Development*, 4, 1, 2000, 42-65.

221 Ireland made very skillful use of the EU structural funds. *Ibid*., 58-61.

222 See also http://www.sdf.gov.sg.

223 A Ahad M Osman-Gani and Wee-Liang Tan, “Training and Development in Singapore”, *International Journal of Training and Development*, 4, 4, 2000, 305-323; see also http://www.mom.gov.sg/MOM/ManpowerNews/mpn0902.

224 See Joshua D. Hawley and Jeeyon Paek, “Developing Human Resources for the Technical Workforce: a Comparative Study of Korea and Thailand”, *International Journal of Training and Development*, 9, 1, 2005, 79-94.

225 See also the comparison of different systems, Jonathan Winterton, “Social Dialogue over Vocational Training in Market-Led Systems”, *International Journal of Training and Development*, 4, 1, 2000, 26-41, 30-31.

5.5. International Comparison of Study Programmes

ICT has become a widespread technology and the application thereof has become a vital skill in all areas of life and education. Figures 5-19 and 5-20 illustrate the necessity of ICT skills in business environments and the need for relevant vocational study programmes.

Figure 5-19. ICT skills in business environments[226]

Business and Work Area orientated ICT Skill Needs

Behavioural and Personal Skills	Cross Section and Basic Work Skills	Soft and Method Skills

ICT Business Area

Skills linked to:
- Information Systems and Applications
- Communications Systems and Applications
- Sector-specific ICT Solutions
- Internet and Intranet Applications
- E-business and E-commerce
- Data Management and Databases
- Network Systems and Solutions
- ICT Security Solutions
- Business (Process) Applications
- Industrial IT Systems
- Embedded Systems and Control
- Multimedia Applications
- Consumer Electronics
- ICT Training Solutions

All Sectors / SMLEs

- ICT Marketing, Consulting and Sales Skills
- ICT Business and Project Management Skills
- ICT Systems and Application Development Skills
- ICT Integration and Administration Skills
- ICT Infrastructure and Integration Skills
- ICT Service and Maintenance Skills

226 Source: *ICT Practitioner Skills and Training Solutions at Sub-Degree and Vocational Level in Europe Guidelines for ICT Training and Curriculum Development*, Cedefop Panorama series, 2004, http://www2.trainingvillage.gr/etv/publication/download/panorama/5150_en.pdf.

Figure 5-20. ICT skills in business environments and vocational education[227]

ICT Business Area	ICT Work Area	VET recommendation: Generic Work Area orientated ICT Training Profiles				
		Kutse-haridus põhi-hariduse baasil	Kutse-haridus kesk-hariduse baasil	Kutse-kõrg-haridus	Baka-laureus	Magister
ICT Business Area Information and Communi-cations Technology (ICT) All Sectors / SMLEs	ICT Marketing, Consulting and Sales	ICT Business Assistant	ICT Business Technician	ICT Commerce Specialist	e.g. ICT Marketing Management (CS*)	
	ICT Business and Project Management			ICT Business Specialist		
	ICT Systems and Application Development	Infor-matics Assistant	Infor-matics Technician	Infor-matics Specialist	e.g Software Arcitec-ture and Design (CS)	
	ICT Integration and Administration			ICT Admin-istration Specialist		
	ICT Infrastructure and Integration	ICT Systems Assistant	ICT Systems Technician	ICT Systems Specialist	e.g. Communications Network Design (CS)	
	ICT Service and Maintenance	ICT Service Assistant	ICT Service Technician	ICT Service Specialist	e.g. Technical Support (CS)	

Linking different skills – from personal to specific methodological skills – and content of vocational education is important. Table 5-21 sets out a comparison of the ICT study programmes of other countries used in the survey.[228]

227 *Ibid.*

228 The comparison is methodologically similar to the survey carried out in respect of higher education; all electronically available schools and study programmes have been surveyed.

Table 5-21. Vocational ICT study programmes in Estonia compared to other countries, 2005[229]

	Practical training system in businesses	Social skills	Specific characteristics
Estonia	Small-scale and not formalised, specific financing and instruments are missing	Specific modules or requirements are missing; schools differ to a large extent and teacher plays a key role.	Not well integrated with other fields of study (ICT in businesses is an exception); few complex subjects (for example control engineering, robotics, etc); management system is not based on partnership.[230]
Ireland	Practice plays an important role in vocational education; so called apprenticeship system.	Specific modules exist; there is an opportunity to use an extra year to train social skills.	Partnership based management; different levels of education are systematically integrated; it is possible to obtain specific education (e.g. animation, computer games).
South Korea	Practice plays an important role (1/3 of the study period); connected with support of public sector to businesses; practice is often paid.	No specific modules but group work is practiced extensively.	The role of private schools is important (founded by enterprises; graduates are obliged to stay to work at the donor company); a lot of polytechnic schools; very well integrated with other fields of engineering (industrial design, 3D modelling, CAD/CAM, robotics, industrial automatics).
Slovenia	So called apprenticeship is being used (6 months; in applied higher education institutions; up to 40% of the study period).	No specific modules.	No specific characteristics.
Finland	Practice plays an important role, 6 months; usually connected with concrete contracts, examinations and professional qualifications.	No specific modules.	Share of electronics and control engineering in the study programmes remarkable.
Hungary	Proportions of practice and studies are 50%:50% (includes practice at schools)	No specific modules.	No specific characteristics.
The Netherlands	Practice at the companies constitutes up to 60% of the study period.	Extensive use of group work.	Different educational levels are systematically integrated.

The most important common denominator of ICT study programmes of the countries subject to the survey is practical training in real business and its extremely high relative importance in the study programme. The development of social skills (especially in Ireland) and the existence of a relatively complex regulative environment and management schemes are also noticeable.

229 At this point it should be noted that it is a formal survey rather than a detailed analysis.

230 "Most of the vocational education institutions are public schools and inclusion of social partners in the decisions-making as well as their responsibilities are not legally stipulated. As a result of it mutual incrimination of parties continues.", *Development Plan of the Estonian Vocational Education System for 2005-2008*, 8.

5.6. Issues of Vocational ICT Education

Based on the analysis and interviews conducted in the course of this survey[231] the following key issues characteristic of the Estonian vocational ICT education can be pointed out:

1) Existing practical training in business is very often formal and wasteful of resources; neither students nor companies benefit from the practical training and the current practical training system, where it is mainly the duty of students to find a place for practical training, and it is the main hindrance to the development of vocational ICT education in Estonia. It is the practical training system through which the companies can be involved in the vocational education system and make use of their technical resources and skills. Changing the **current practical training system** in a manner that a substantial share of the risks entailed in the practical training was covered for companies should be the first priority of the changes in the vocational ICT education in Estonia.[232]

2) **Cooperation with companies** is today very occasional and depends mainly on the enthusiasm of the school and area managers (or companies). Such a situation is absolutely inadmissible and, here, the state has an important obligation to regulate and finance the development of relevant cooperation and networks.

3) **Cooperation with other schools** (on the level of both vocational as well as higher education) is rather poor and occasional. As a result, resources are squandered in respect of both material base as well as teaching staff and situations where the study programmes of different levels do not facilitate smooth continuation of studies are not rare either.

4) **The qualification of teaching staff** varies greatly by schools and in many schools lack an extremely large number of teachers. At the same time, many teachers do not have practical experience in contemporary business and, thus, a network for self-development and training. The need for continuous in-service training of teachers is also urgent. However, the relevant financing facilities are scarce and contacts as well as access (e.g. to international databases and surveys) are often lacking. At the same time, a large number of teachers are earning extra income from training and teaching in other schools due to their low salary, which in its turn may put them in a situation where they often lack time for self-education.[233]

5) **ICT's relation to other fields of business** (e.g. car repairs, textile) is extremely faint, or if it exists, then on a very primitive level (e.g. use of MS Excel). Here, the problem lies in study programmes, teaching staff as well as technical resources. Still, there is no sphere of life today where ICT's role has not grown. But it is also obvious that the vocational education system will never be able to keep up with business as regards technological development. The technological lag can only be eliminated through extensive cooperation. Today, the tendency

231 In the course of the survey, 8 in-depth interviews with the ICT and electronics companies and 5 interviews with the coordinators of ICT studies of different vocational schools were additionally carried out.

232 See also the *Development Plan of the Estonian Vocational Education System for 2005-2008*, http://www.hm.ee.

233 *Ibid.*

in vocational ICT education in Estonia is quite the contrary: every school is desperately striving for the scarce funds of the public sector to invest into the material base, which unfortunately has already become outmoded for business operators.

6) **The study programmes and subjects are too specific** to the field of ICT, which often means that the subjects and programmes are out of date from the business perspective and they are simply replaced – at least not in name only – with new subjects or programmes. There is no systematic evaluation and development of study programmes, which is directly due to the lack of systematic feedback mechanisms in public sector policy formulation. The steps taken by the public sector to advance vocational education are rather sporadic.

7) **Teaching social skills** in vocational schools is often inadequate. Yet, teaching these skills is a foundation of the graduates' breakthrough and development ability. Here, the structural logic of the study programmes should be reviewed.

8) The importance and quality of **English** teaching is very poor. The problem here is a lack of teachers as well as the Russian background and education of many specialists. At the same time, business has a close relation to the English environment, wherefore the teachers diverge from the business world even more.

9) **The tainted reputation of vocational schools** is a widely known problem and vocational schools are usually the second choice for young people. Therefore, the drop-out rate for example in the ICT area is very high (in some of the schools interviewed the rate even exceeded 50%), which among other things may be the result of spending a year in a vocational school before continuing studies at a university. Whilst interviewing the schools, the fact that more complex subjects are just too difficult to learn for many students appeared to be another reason. Their earlier school education (e.g. in mathematics, drawing) is simply poor. Profession, work and technology must reach young people much earlier, starting from 12-14 years. At this point, the cooperation between business operators and vocational schools, basic schools and institutions of higher education must be substantially expanded and relevant study programmes must be changed.

In summary, it may be said that in the sphere of ICT practically two independent education systems exist in Estonia: training provided by private sector companies (before employment or during probation) and the vocational education system of the public sector. The most important and difficult task of the public sector is to do away with the aforementioned double system and squandering resources as soon as possible.

6. OPPORTUNITIES AND OPTIONS OF ESTONIA

This chapter is divided into the following sections:

1) General challenges, problems and recommendations relating to Estonia's R&D activities and policies;
2) Specific problems and recommendations relating to ICT sectors;
3) Specific problems and recommendations relating to higher education provided in the fields of ICT;
4) ICT practical training system;
5) Specific recommendations for ICT vocational education.

6.1. General Problems and Recommendations

As regards the R&D and innovation policies of Estonia, three major problems can be highlighted at present:

1) **Clearly insufficient participation of the private sector in R&D and innovation-related activities.** This can be explained by two main reasons: (a) The public sector policy practically lacks any measures to regulate that sphere; and (b) more importantly, innovation and particularly R&D activities are too expensive and risky for the major part of the Estonian private sector.[234] The latter circumstance can also be put in other words: a large share of Estonian companies is able to earn profits much more easily pursuing activities that do not comprise innovation much, let alone R&D. However, these profits are not reflected in growing wages or profitability much: the private sector is not investing in people and their skills. Hence, the Estonian economy is not sustainable, because the development of the private sector fails to ensure the increase of the country's welfare. Yet it would be very short-sighted to blame the private sector for the lack of sustainability, as it would be short-sighted to appeal to companies' sense of mission, etc. Private companies are established for the purpose of earning money. The public sector must create an institutional environment where the risks of investing specifically in people and skills would be reduced to some extent (see further the next item). In view of the export and current account dynamics, Estonia has no other development option than increasing the intensity of skills and technology in the industry and more broadly in the whole economy. Any other development options will inevitably entail either an economic crisis or extremely uneven development within the country. The latter development would be rather costly, not just in political and social terms, but above all in economic terms: poverty is an expensive luxury for the public economy, entailing increasing social, health care, regional and security-related costs at the expense of the resources that might have been invested in education, science, culture, etc. Almost all of Europe faces similar

234 For an overview of innovation constrains of Estonian companies see Silja Kurik, Rünno Lumiste, Erik Terk, Aavo Heinlo, *Innovation in Estonian Enterprises 1998-2000*, 2002, http://www.eas.ee.

problems: the European-wide competition between salaries and productivity and in particular the competition with Asia is exerting tremendous pressure on the decrease of salaries, which, however, can in no way ensure larger investments in development activities that comprise the only sustainable source of productivity and accordingly of exports.

2) **The design and coordination of public sector policies is low-level.** Regular assessment and coordination of public policies in the spheres of R&D and innovation is non-existent. Therefore, practically no one has an overview of the impacts, weaknesses or strengths of the existing policies. The administrative level suffers from the lack of an interim level that would link general strategies (like *Knowledge-based Estonia*) with the activities of particular departments and agencies. Furthermore, there is no connecting mechanism between the Knowledge-based Estonia and the Single Programming Document devised in view of the use of structural funds, both in practical and administrative terms. And practically no one is responsible for creating such a connection. As a result, activities of sub-sectors are under-coordinated, which has entailed a situation where a large part of innovation policy measures are too general to actually be efficient. Public sector policies are weakly connected with the problems of the real economy: Estonia today lacks any policy measures that would make it possible to tackle, e.g. the factors that inhibit the growth of productivity of the chemical or engineering industry.235 Estonia's R&D and innovation policies are largely targeted at the practical application and commercialisation of science and thereby at the settlement of the entrepreneurial sector's problems. However, such a development rarely actually occurs in real private entrepreneurship, because innovation *almost always consists in the novel application of existing knowledge and skills*. The issue does not lie in basic or applied research, but rather in the price of novel application of the knowledge and skills payable (literally) by Estonian companies. If the price is too high, they just will not pay it. The market sets the limit. By essence, a market is a set of institutions that distributes revenues and expenses (for example, minimum wages, occupational safety requirements, etc, constitute parts of a market, not institutions beyond it; similarly, R&D projects financed by the state and state-financed education are parts of a market). R&D and innovation policies must be capable of reducing Estonian companies' costs relating to the innovation and novel application of technologies and skills. For example, the development activities of the international company Sadolin will probably never be transferred to Estonia because of low taxes – this could only happen on account of the existence of highly qualified and motivated engineers with interdisciplinary training who nevertheless assent to relatively low wages, because the company would not have to pay for their training – the state of Estonia has already done that. As far as private companies are concerned, the resources saved through lower taxes are substantially smaller and less important when compared to the resources saved through such engineers and the competitive edges achieved.

3) **No measures in priority sectors.** Notwithstanding the priority sectors emphasised in the *Knowledge-based Estonia* and the need to establish national programmes in these sectors, no programmes have actually been initiated in these sectors yet. More importantly, no R&D policy or innovation policy is even specifically targeted at these sectors. The *Knowledge-based Estonia* has certainly been a most necessary strategic document. Moreover, no one now doubts the

235 *Ibid*.

correctness of the selection of the priority sectors. Yet no political or administrative mechanism for development of the priority sectors exists at present. No regulation passed in view of using the resources of structural funds deals with the priority sectors either.

To sum it up: the R&D and innovation system of Estonia is incapable of resolving the needs and problems of the private sector (in other words: as to the development of the economy, the hitherto R&D and innovation policies are practically insignificant), and the mechanism of design and coordination of policies as such is too weak to create any conditions for the development of priority sectors.

Hence the obvious need to reconsider the complex of the said strategic problems and to bring out the solutions that would 1) be concrete and 2) create long-term and durable mechanisms. *The Success of Estonia 2014* initiative has partially grown from similar comprehensions, yet it tries to place too many problems (from the environment to crime) in a too narrow framework, thus remaining an unamalgamated set of sectoral problems for the time being. On the one hand, the new national development plan for the implementation of structural funds is too specific to be able to resolve the said problems (the logic of structural funds), and on the other hand it has to be broader than the set of problems relating to R&D and innovation.

Thus, a strategy ensuring an agreement in the following two issues is needed: (1) how the real problems of the private sector within the scope of R&D and innovation policies should be dealt with, and (2) what a materially improved mechanism for the design, assessment and coordination of R&D and innovation policies should consist in. *Knowledge-based Estonia II* could answer these questions.

Bearing in mind the experience of the rest of the world, the Knowledge-based Estonia II should focus primarily on two spheres:

1) **Consistent monitoring of economic sectors.** In practice this would mean the activity of inter-sector working groups formed on the basis of private sector and R&D establishments in 5-6 sectors (the entire Estonian economy would be divided in sectors in line with the technological interconnection; such sectors can also be called clusters). The activity of the working groups could consist in, e.g. annual reviews addressing technological and skills-related problems of the sector in question. Such monitoring should obligatorily involve the foreign owners of companies and form a mandatory part of the design and assessment of policies for the relevant ministries. Moreover, such monitoring should make substantial use of foresight tools. From that activity, all other strategies and activities – such as the new state development plan concerning the use of structural funds that will enter into force in 2007 – could receive real input regarding, e.g. needs for changes in curricula, vocational training practices, financing of R&D activities, etc. Such commissions (working groups) could operate in the field of administration of the Research and Development Council, which could ensure for the latter a real function and, in principle, make it possible to implement the *Success of Estonia 2014* in a modified form. In turn, those working groups could receive their inputs from the developments of various R&D financing schemes of the EU like the VII Framework Programme, etc. That would create a connection between the financing of R&D effected by the EU and the real economy of Estonia.

2) **Specific technology programmes** that would be narrower than priority sectors, yet contain a priority field as an obligatory element: for instance, biomedical engineering. These programmes should be established upon the said economic sectors as high-tech and education-intensive activities, thus creating the preconditions necessary for ensuring that the current R&D activities (both basic and applied research) carried out in Estonia would eventually prove to be lucrative for the country. These programmes (5-6, as well) should obligatorily range from interdisciplinary curricula to schemes aiming at the engagement of foreign investments and support to exports, thus creating a) actual new sectors where Estonia already possesses strong R&D potential, which are b) nevertheless connected with real economic activities, c) interdisciplinary and d) founded upon cooperation between Tartu and Tallinn.

Therefore, *Knowledge-based Estonia II* could (1) determine the 5-6 sectors for the purposes of both industry monitoring and technology programmes, and (2) create policy mechanisms for consistent evaluation and renovation.

6.2. Specific Problems and Recommendations Concerning the ICT Sectors

In brief, the current challenges and possible solutions concerning the Estonian ICT sectors can be divided into three groups:

1) The largest local companies have started their activities as subcontractors for large-scale Scandinavian companies. Subcontracting is often their primary field of activity at the present as well. Largely due to that very reason, these companies have not engaged in long-term planning yet. However, the improvement of the living standard in Estonia, accompanied by the appreciation of the labour, places many such subcontractors in a situation where it is quite difficult to continue pursuing the hitherto strategy due to the lack of inexpensive qualified workforce. Hence, the almost inevitable situation has been created where large-scale companies operating in the ICT sectors like Elcoteq Tallinn AS and AS Microlink see the upward movement in the value-added chain, which always entails more complex or skill-intensive production or other business activities, as the only long-term sustainable development option. Therefore, the people whom these companies are able to recruit from the Estonian market gain more importance on a growing basis. To be able to move upwards in the value chain at all, by increasing R&D activities or more skill-intensive production or by transiting from software writing to the provision of related business consultations, etc, **engineers and other highly educated specialists are needed first of all**. The same applies to attracting foreign investments into Estonia. As a result of the competition involving wages and productivity in Europe as described above, many industries have become extremely mobile (automobile industry and mechanical engineering, ICT, etc). That trend provides countries like Estonia with the opportunity to import high-tech and medium-tech industries. However, since cheap labour is not an advantage of Estonia any longer, Estonia should rely on qualified labour instead. It is the only way to ensure that mobile industries remain, develop and expand here, instead of moving out of Estonia.

2) As regards the ICT service and software industries, the small size of the market is clearly a factor that inhibits the development of companies. As in the earlier development, the public sector plays a material role here. The state can substantially increase the number of services that are related, e.g. to ID cards and to the provision of many other public sector services. **The state should make use of the opportunities offered by public procurements:** public procurements, orders, competitions, etc, could be organised for the development of relevant technologies or for elaborating skills and training systems. At the same time, the winner of a procurement, competition, etc, should be obliged to involve both the vocational education and higher education structures of Estonia. The process could be completed by the issuance of grants and/or loans and/or co-financing on the part of Enterprise Estonia to Estonian companies for the purpose of application of the technological solutions developed. Here it should certainly be remembered that unsuccessful procurements, etc, are also very important, as they have involved the creation of a large amount of new knowledge, experience, cooperation opportunities, etc.[236] Moreover, the solutions that have been developed for the public sector in Estonia can quite successfully be exported; countries located within the territory of the former Soviet Union should in particular be kept in mind in this regard. The state could make substantial use of the programme concerning the provision of foreign aid on the part of Estonia, which should obligatorily engage Estonian software developers. The lack of specialists with specific education, in particular systems analysts, constitutes an emerging challenge in this area.

3) The small scale of hardware production could become the major weakness of the Estonian ICT sectors in the near future – it would be difficult to keep up with software development for many companies without engaging in the development and production of hardware. Two aspects must definitely be kept in mind here: the life cycle of hardware products has become extremely quick by now, and the competition provided by Asia in this sphere is rather severe. Then again, ICT-based hardware has invaded almost all spheres – and not just through software solutions, but growingly through hardware solutions. **The development of competencies in these new sectors that are interdisciplinary by essence should be one of the priorities or constitute the core of one or more technology programmes.** Considering the scientific competence of Estonia, biomedicine should be one such priority sector, possibly followed by activities aiming at the sustainable use of energy and oil shale. The existence of specialists is an important precondition here, too.

The public sector plays a tremendous role in finding solutions for all of the problems and challenges, because the qualification of the people emerging from the higher education system is one of the most important preconditions here. On the other hand, no company is certain about which employees it will need in 5 years. Therefore, systems for the state to be able to socialise risks for all companies and employees affected by the said challenges are needed. Such systems would, firstly, reduce the need of constant intervention by the state and, secondly, provide a substantial development impetus for all those operating in the ICT sectors. Hence, the following is needed: 1) a long-term regulation precluding the need of constant intervention by the state and 2) to bring companies and the education sector together keeping in mind a long period.

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236 For example, the semiconductor industry of Taiwan came into being as a result of the unsuccessful investment made in the radio industry in the 1960s.

The Implementation of the monitoring system in the ICT sectors as described above would address the first task. Such monitoring would address the technological and skills-related problems of the ICT sectors, while essentially involving the foreign owners of companies, given that the Estonian ICT industry forms a part of the large Scandinavian cluster by essence. The relevant professional association or relevant foundation could function as the coordinator of the activity, whereas the state would act as the financer, using the resources of structural funds, and coordinate the whole process through the mediation of the Research and Development Council.

The other issue, i.e. the task of bringing companies and the education system together for a long period, would be solved by the **reform of the practical training system** as described below.

6.3. Specific Problems and Recommendations Relating to Higher Education Provided in the Fields of ICT

The problems and solutions can be divided into three groups again:

1) Estonian ICT science has a small number of top players, two or three of whom are rather competitive on the international level. Estonian ICT science as a whole covers very few spheres on an internationally acceptable level, and these spheres are occasional rather than based on real needs. Yet, when considering that ICT is today and will, in the next twenty or thirty years, constitute the so-called paradigm-leading technology, it is the ICT-related scientific activities that need quick and radical changes. The development of science is contingent upon **(1) the establishment and observance of uniform scientific standards and (2) the consistent and broad-based creation of the posterity through degree studies, in particular Doctoral studies**. As regards the former issue, more attention should be paid to **bringing visiting lecturers to Estonia**. Also, the involvement of **lecturers from the private sector** could be considered. For instance, the title of a visiting professor could be granted to people from the private sector. In addition, people from the private sector should be fairly remunerated for supervising Doctoral and Master's theses and for participating in the work of relevant commissions. Top players of the private sector would find it difficult to commit themselves to teaching, unless additional seriously motivating financial schemes were implemented.[237]

2) Comparisons of curricula and interviews have brought to light the **lack of specialisation** (e.g. systems development, wireless, mobile communications, etc), the weak presence of hardware, the weak representation of engineering science and design in curricula, and the small scale of interdisciplinarity as the major weaknesses of education provided in the field of ICT in Estonia.

3) The question of how and in which spheres **curricula should be changed** must be answered by the monitoring system where all the parties concerned can express their opinions. Similarly to what was suggested by the Career Space consortium, the elaboration of curricula for universities and other educational institutions must be based on extensive cooperation with employers of the ICT sector, as a result of which (based on the skills profiles suggested

237 See also chapter 4.2.

and developed by *Career Space*) specialisation will occur. As far as curricula are concerned, it is advisable to observe that a curriculum should comprise the creation of a scientific base (30%), the technological base (30%), an application base and systems thinking of (25%) and a personal and business skills element (15%). In addition, practical training in companies should last at least three months, ideally even longer.[238]

4) The greatest shortcoming of the education provided today in the fields of ICT consists in the **weakness of the practical training system** (see Ch 6.4).

6.4. ICT Practical Training System

The greatest shortcoming of the education provided today in the fields of ICT consists in the weakness of the practical training system.

Even though a major part of the students commence work early in Estonia, practically no one can hire people with the necessary skills in the sector right away. Students probably work in relatively simple areas. Then again, companies lack the interest and immediate need to hire a person for a couple of weeks and to train him or her – that would mean finding simple work for apprentices and wasting time on supervision. In principle, practical training constitutes an additional risk for companies, while it also fails to add much to students. A system must be created where that risk would be hedged from the point of view of both students and companies.[239]

Resources of structural funds must be used for the establishment of such a system. In principle, the management scheme to be created would constitute a part of the monitoring system suggested above.

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238 See also *Curriculum Development Guidelines, New ICT Curricula for the 21st Century Designing Tomorrow's Education, Career Space* and International Cooperation Europe Ltd., 2001.

239 The authors have proposed the **system of practical training**, which by essence comprises the principle of insurance with regard to the future. The system of practical training suggested:

1) It should commence as early as in the phase of providing vocational education. In vocational education, practical training should comprise approximately 50% of the process of educating, in higher education – approximately 25% (incl. degree studies).

2) The entire system of practical training should be covered with a system of standards and remuneration levels, which the students must pass through.

3) Wages would be paid by the state during the practical training period in the form of scholarships, equally to all students on the same level. That would place both companies and students in an equal position.

4) After the practical training, students would be obliged to continue working for the company for two years, if the company so wishes. That rule would not apply when studies are continued.

5) During the said two years, e.g. 1% of the wages payable to a student (0.5% by the employee and 0.5% by the company) would be transferred to the state scholarship fund (percentages are presented for illustration, these are not expert evaluations) and the company would be able to waive the services of the student for 6 months each year. In such a case, the state would resume paying the scholarship to the student, whereas the student would be obliged to attend continuing training.

6) The entire system, incl. the scholarship fund, would be managed by the association (or by another similar institution) of companies operating in the ICT sectors, the directing body of which would comprise 33% of companies' representatives, 33% of employees' representatives and 33% of education organisations' representatives

That system should:

1) essentially bring together the educational system and companies
2) essentially motivate companies to use apprentices
3) essentially provide students with up-to-date skills required in the labour market and continuous modernisation of the skills at least within 2 years after graduation
4) provide students with work for at least 2 years after graduation
5) The management scheme should ensure the representation of the interests of all parties concerned in the elaboration of standards, etc.
6) Furthermore, such a system would reduce the need for state intervention and ensure an essentially higher quality of such intervention, since the input of the system ought to be rather strong.

That system would essentially resolve the problem of the lack of practical exercise and teamwork in the higher education provided in the sphere of ICT in Estonia today. Such a system would be materially cheap and sustainable for the state and in principle, that system would transfer material base-related costs to companies that will enable universities to use their infrastructure through the practical training system.

6.5. Specific Recommendations for ICT Vocational Education

1. The most extensive change should take place in the practical training system (see above);

2. The public sector policy-making mechanism should go through a substantial change in the area of vocational education; the described monitoring system offers a valuable tool for it;

3. The preparation and evaluation of teaching staff should become systematic and the private sector should be more extensively involved in the teaching process (the change of the practical training system would ensure a step forward);

4. Support should be offered to schools for cooperation in order to e.g. share the material base, cooperate with entrepreneurs as well as offer further training opportunities to the teaching staff (common procurement of databases and other study materials);

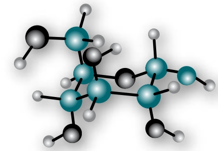
5. The development process of study programmes should become systematic and be based on effectively working cooperation;

6. The study programmes should include systematic modules focused on the development of social skills of the students;

7. The share of courses taught in English should increase in the study programmes;

8. A lot could and should be done to integrate ICT better into other fields; it is an issue of critical importance;

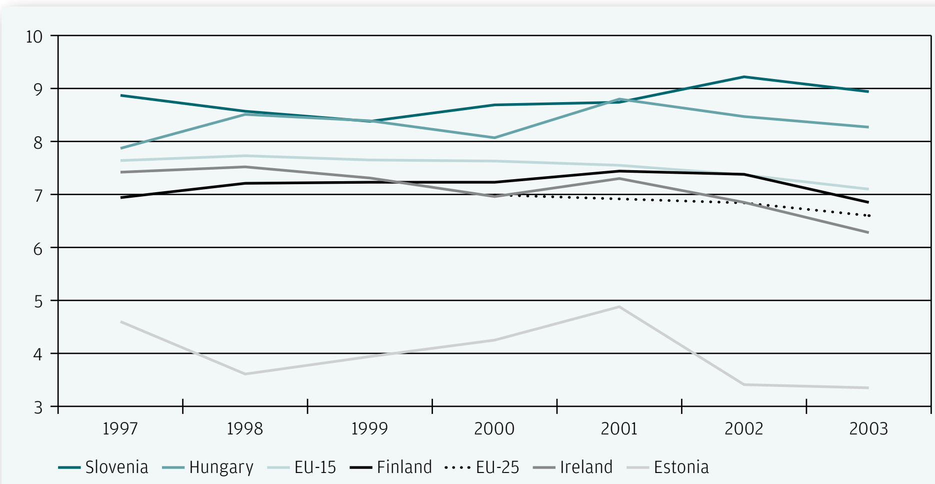
9. As far as the vocational and technological studies in the basic schools are concerned, study programmes should be revised and, again, effectively working cooperation should be established between vocational, basic and higher education institutions as well as entrepreneurs.



7. ANNEXES

7.1. Annex I. Employment in Middle and High Technology Manufacturing and Service Sectors

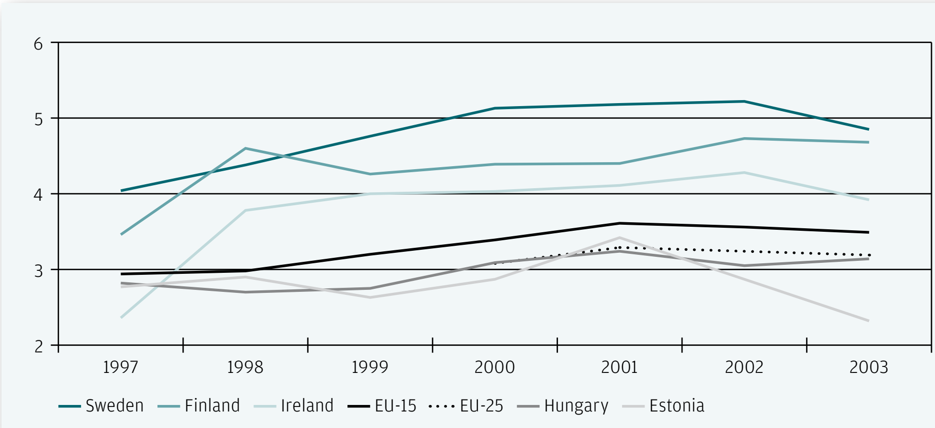
Figure 7-1. Employment in middle and high technology industry[240], share of total employment in industry and service sectors (%), 1997-2003[241]



240 The following fields of activities are included: manufacture of chemicals and chemical products (NACE 24), manufacture of machinery and equipment (NACE 29), manufacture of office machinery and computers (NACE 30), manufacture of electrical machinery and apparatus (NACE 31), manufacture of radio, television and communication transmitters and apparatus (NACE 32), manufacture of medical, precision and optical instruments, watches and clocks (NACE 33), manufacture of motor vehicles, trailers and semi-trailers (NACE 34) and manufacture of other transport equipment (NACE 35).

241 Source: *European Innovation Scoreboard 2004. Comparative Analysis of Innovation Perfomance*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004.pdf; *European Innovation Scoreboard 2004. Annex 2. Country Pages EU25 + Candidate Countries*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004_annex2.pdf.

Figure 7-2. Employment in middle and high technology service sectors[242], share of total employment in industry and service sectors (%), 1997-2003[243]



7.2. Annex II. Graduates of Science and Engineering

Table 7-3. Graduates of science and engineering[244] among youth aged 20-29, 1993-2002[245]

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ireland	19.10	21.00	21.40	21.90	21.80	22.40		23.20	21.70	20.50
Finland	13.20	13.00	13.00	13.10	15.80	15.90	17.80	16.00	17.20	
Lithuania					7.30	9.30	11.70	13.50	14.80	14.60
Sweden	6.20	6.30	7.30	7.40	7.80	7.90	9.70	11.60	12.40	13.30
Japan			12.70	12.50		12.36	12.76	12.97	13.04	
EU-15					**10.30**	**10.70**	**11.12**	**11.43**	**12.38**	**12.47**
Bulgaria					6.00	5.50	6.50	6.60	7.90	11.70
EU-25					**9.28**	**9.67**	**10.12**	**10.45**	**11.30**	**11.49**
US	10.30	10.90	11.20	11.50		9.60	9.70	10.20		
Slovenia					6.30	8.00	8.40	8.90	8.20	9.50
Latvia					6.90	5.90	6.30	7.50	7.60	8.10
Estonia					**4.20**			**7.00**	**7.30**	**6.60**
The Netherlands	5.50	5.40	5.60	6.60		6.00	5.80	5.80	6.10	6.60
Hunagry					5.00	5.00	5.10	4.50	3.70	4.80

242 The following fields of activities are included: post and telecommunications (NACE 64), computer and related activities (NACE 72), and research and development (NACE 73).

243 Source: *European Innovation Scoreboard 2004. Comparative Analysis of Innovation Perfomance*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004.pdf; *European Innovation Scoreboard 2004. Annex 2. Country Pages EU25 + Candidate Countries*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004_annex2.pdf.

244 Graduates of science and engineering (S&E) at the level of higher education (level of education 5A or higher) at the following fields are included: life sciences (ISC42), physical sciences (ISC44), mathematics and statistics (ISC46), computing (ISC48), engineering and engineering trades (ISC52), manufacturing and processing (ISC54) and architecture and constructing (ISC58).

245 Source: *European Innovation Scoreboard 2004. Comparative Analysis of Innovation Perfomance*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004.pdf; *European Innovation Scoreboard 2004. Annex 2. Country Pages EU25 + Candidate Countries*, European Commission, 2004, http://trendchart.cordis.lu/scoreboards/scoreboard2004/pdf/eis_2004_annex2.pdf.

7.3. Annex III. Estonian ICT Companies among TOP 500 Based on Turnover, 2000-2003

Table 7-4. Estonian ICT companies among TOP 500 based on turnover, 2000-2003[246,247]

Rating 2003	Rating 2002	Rating 2001	Rating 2000	Company	Turnover (2003) Mil EEK	Turnover (2002) Mil EEK	Turnover (2001) Mil EEK
7	5	5	4	EMT AS	2,377.6	2,203.7	2,015.5
8	4	3	2	Elion Ettevõtted AS (former Eesti Telefon AS)	2,274.0	2,323.7	2,771.8
21	36	57	115	Tele2 Eesti AS	1,110.7	820.7	540.0
33	32	44	69	Radiolinja Eesti AS	953.0	866.0	623.0
36	**n/a**	**n/a**	**n/a**	**MicroLink AS (consolidated)**	**905.9**	**958.2**	**n/a**
47	*62*	*45*	*43*	*Elcoteq Tallinn AS*	*695.6*	*554,.0*	*612.6*
48	92	69	100	Siemens AS	689.7	428.7	453.5
76	86	75	82	GNT Eesti AS (former CHS Eesti AS)	504.8	452.2	425.0
114				*Stoneridge Electronics AS*	*357.2*		
120	*118*	*130*	*137*	*Keila Kaabel AS*	*345.3*	*331.7*	*268.8*
123	*151*	*182*	*162*	*Harju Elekter AS*	*342.4*	*271.2*	*195.5*
167	168	176	226	Ordi AS	273.9	244.8	206.3
168	134	85	46	Ericsson Eesti AS	273.7	297.6	388.0
207	*246*	*216*	*183*	*Tarkon AS*	*215.0*	*168.1*	*162.3*
210	204	160	120	ML Arvutid AS (former MicroLink Arvutid AS)	209.3	196.8	228.7
262	254	250	273	Infotark AS	173.4	163.3	142.4
292	267	141	140	Nokia Eesti OÜ	151.3	154.7	255.0
302	454			Klisseran AS	146.0	82.9	51.6
330	330	276	258	KTK Overall AS	131.3	124.6	132.6
381	**381**	**392**	**400**	**Datel AS**	**113.2**	**107.4**	**90.7**
435	**391**	**328**	**325**	**Helmes AS**	**95.3**	**103.3**	**110.5**
442	**326**	**155**	**306**	**Abobase Systems AS**	**92.1**	**126.5**	**233.7**
474-475	**404**	**378**	**450**	**Cell Network AS**	**80.9**	**100.8**	**93.7**
n/a	110	90	81	Tech Data Eesti AS	n/a	374.4	365.2
n/a	*156*	*(131)*[248]	*45*	*JOT Eesti OÜ*	*n/a*	*263.2*	*270.7*
n/a	312	(242)[249]		Uninet AS	n/a	134.3	93.6

246 Source: Äripäev, *TOP100*, 2001-2004.

247 The authors have marked companies of the electronic sector with grey background and the companies whose main field of activity is system development and software with boldface.

248 Should have held the position of 131 in 2001 based on turnover figures, but was not included in the TOP list by Äripäev.

249 Should have held the position of 242 in 2001 based on turnover figures, but was not included in the TOP list by Äripäev.

7.4. Annex IV. Estonian ICT Companies, TOP 30, 2001-2003

Table 7-5. Estonian ICT companies, TOP 30, 2001-2003[250]

Rating 2003	Rating 2002	Rating 2001	Company	County	Turn-over Mil EEK (2003)	Profit Mil EEK (2003)	Turn-over Mil EEK (2002)	Profit Mil EEK (2002)	Growth of turn-over 2002-2003 (times)	Growth of turnover 2002-2003 (000, EEK)
1	13		Reaalsüsteemide AS	Tallinn	27,076	6,510	7,801	1,282	3.47	5,228
2			Webmedia AS	Tartu	20,354	4,393	11,088	-1,014	1.84	5,407
3	17		Aqris Software AS	Tallinn	13,520	5,978	8,833	1,904	1.53	4,074
4	51		Võrguvara AS	Tallinn	27,757	5,344	22,066	740	1.26	4,604
5			Elion Ettevõt-ted AS	Tallinn	201,780	28,320	151,970	18,200	1.33	10,120
6			Data Telecom AS	Tallinn	15,019	1,586	6,666	1,104	2.25	482
7			Microlink AS (consolidated)	Tallinn	905,928	42,327	958,184	8,326	0.95	34,001
8			Pro-STEP OÜ	Tallinn	7,926	1,863	5,916	285	1.34	1,578
9	3		Trigger Software OÜ	Tallinn	23,420	5,976	22,737	5,005	1.03	971
10			Makato Eesti OÜ	Tallinn	11,280	1,044	5,059	290	2.23	754
11	86	10	TietoEnator Eesti AS	Tallinn	29,820	2,629	25,828	-1,205	1.15	3,834
12	83		Hansa Business Solutions	Tallinn	12,219	2,211	11,319	-448	1.08	2,659
13			REGIO AS	Tartu	23,051	1,556	19,144	-4,109	1.20	5,665
14	42	6	Elvior OÜ	Tallinn	7,934	2,795	7,713	2,011	1.03	784
15	12		Ebeling Data OÜ	Tallinn	11,527	949	8,056	550	1.43	399
16	8		Klisseran AS	Tallinn	146,000	1,560	83,093	1,304	1.76	256
17	53		SmartLink OÜ	Tallinn	7,847	609	4,583	37	1.71	572
18	10	24	Ferdida AS	Tallinn	8,142	1,382	6,166	1,031	1.32	351
19			Uptime OÜ	Tallinn	11,530	506	8,602	-1,001	1.34	1,507
20	18	63	Datel AS	Tallinn	113,231	2,919	107,401	1,642	1.05	1,277
21			IT Expert OÜ	Tartu	4,338	698	2,811	314	1.54	384
22	65		EsData AS	Tallinn	13,271	1,330	9,805	81	1.35	1,249
23	2		Argo Electron-ics AS	Narva	36,375	2,407	26,223	4,074	1.39	-1,667
24	30	25	A-Kaabel YE AS	Tallinn	59,747	1,619	56,771	972	1.05	647
25	22	30	Sysdec AS	Tallinn	8,626	1,799	8,293	1,765	1.04	34
26	69		Asbis-Baltik AS	Tallinn	76,590	956	62,620	162	1.22	794
27			Santa Monica Networks AS (Cygate Estonia)	Tallinn	33,300	1,100	25,500	-2,600	1.31	3,700
28	26	31	Medisoft AS	Tallinn	16,605	2,019	18,198	1,601	0.91	418
29	84	21	Helmes AS	Tallinn	95,331	3,296	103,300	-6,345	0.92	9 ,641
30	41		GT Tarkvara OÜ	Tallinn	18,143	1,523	17 ,000	1,170	1.07	353
31	1	8	PT Mikro AS	Rakvere	80,696	3,762	67,515	5,844	1.20	-2,082

250 Source: Äripäev, *Arvutifirmade TOP*, 2001-2003.

	4	84	TRL Group OÜ	Tallinn			6,424	1,818		-1,818
56	5	14	Telegrupp AS	Tallinn	45,339	2,257	50,612	7,432	0.90	-5,175
	6	75	MicroLink Data AS	Tallinn			58,414	3,840		
53	7	28	ID Süsteemide AS	Tallinn	26,820	1,850	32,395	3,316	0.83	-1,466
63	9	66	ML Arvutid AS (MicroLink Arvutid AS)	Tallinn	209,268	5,346	196,825	5,346	1.06	0
57	11	17	Infotark AS	Tallinn	173,400	3,800	163,290	12,422	1.06	-8,622
60	14	37	Proekspert AS	Tallinn	14,828	549	11,676	1,587	1.27	-1,038
69	15	23	Net Group OÜ	Tallinn	18,764	442	22,423	737	0.84	-295
65	16	55	Profit Software AS	Tallinn	27,689	1,212	28,907	2,525	0.96	-1,313
42	19	5	Ordi AS	Tallinn	273,922	6,313	244,843	8,375	1.12	-2,062
	20		IT Arvutiteeninduse OÜ	Rapla			7,119	609		
45	21	61	Aprote AS	Tartu	9,814	795	8,804	815	1.11	-20
	23	36	IE Tarkvara OÜ	Tallinn			5,448	3,118		
91	24	22	PCT Arvutid AS	Tallinn	24,175	-498	33,588	1,121	0.72	-1,619
	25	4	MicroLink Süsteemid AS	Tallinn			115,914	10,386		
	27	12	TietoEnator Financial Solutions AS	Tallinn			7,733	1,394		
	28		Business Software Partners OÜ	Tallinn			2,503	384		
62	29	3	Cell Network AS	Tallinn	80,933	4,120	100,762	10,481	0.80	-6,361
79	31	27	Lynx Nebula OÜ	Tallinn	5,698	45	4,896	78	1.16	-33
32	38	2	Columbus IT Partner Eesti AS	Tallinn	22,959	3,174	26,661	3,115	0.86	59
52	39	15	DataGate OÜ	Tallinn	48,497	745	45,271	939	1.07	-194
41	40	7	KTK Overall AS	Tallinn	131,254	7,847	124,648	9,474	1.05	-1,627
49	43	16	Taavi Tarkvara OÜ	Tallinn	5,671	411	4,909	317	1.16	94
50	48	1	Abobase Systems AS	Tallinn	92,063	7,629	126,486	8,126	0.73	-497
54	54	18	GNT Eesti AS	Tallinn	504,849	935	452,160	978	1.12	-43
71	60	11	Esknet AS	Tallinn	14,175	635	19,000	900	0.75	-265
46	70	20	Voicecom OÜ	Tallinn	6,310	665	5,460	290	1.16	375
	78	19	Tech Data Eesti AS	Tallinn			374,426	-3,965		
	82	9	NOVO Systems AS	Tallinn			10,290	-466		
		13	Reiw-Elektroonika AS	Tallinn						
		26	Previo Estonia OÜ	Tallinn						
47		29	Infosüsteemide OÜ	Tartu						

7.5. Annex V. Students of Computer Sciences According to Educational Institutions, 2004

Table 7-6. Students of computer sciences according to educational institutions, 2004[251]

Name of the educational institution	Type of the educational institution	Title of the study programme	Educational level	ISCED 97 code	Students	Incl. state financed	Out of state budget	Admis-sion	Graduates 01.10.03-30.09.04
University Nord	university	Computer science (administration of information systems)	Bachelor	5A	9		9	0	0
College of Computer Science	applied higher education institution	Programming	Professional higher education	5B	3		3	0	0
College of Computer Science	applied higher education institution	Programming	Applied higher education	5B	192	20	172	70	34
International University Concordia Audentes	university	Information technology	Bachelor	5A	200		200	39	38
Estonian IT College	applied higher education institution	Analysis of information systems	Applied higher education	5B	38		38	23	0
Estonian IT College	applied higher education institution	Administration of IT systems	Applied higher education	5B	155	79	76	70	5
Estonian IT College	applied higher education institution	Development of IT systems	Applied higher education	5B	116	64	52	58	3
Estonian IT College	applied higher education institution	Technical communication	Applied higher education	5B	7		7	7	0
Estonian IT College	applied higher education institution	Systems of information technology	Applied higher education and university diploma studies	5B	48	1	47	0	27
Kohtla-Järve Polytechnic School	vocational education institution	Information technology (professional higher education)	Professional higher education	5B	6	6		0	17
Kohtla-Järve Polytechnic School	vocational education institution	Information technology	Applied higher education	5B	95	95		39	0
Mainor Higher School	applied higher education institution	Information technology	Professional higher education	5B	20		20	0	9

251 Source: AS Andmevara, register of students (1 November 2004).

Continued...

Name of the educational institution	Type of the educational institution	Title of the study programme	Educational level	ISCED 97 code	Students	Incl. state financed	Out of state budget	Admis-sion	Graduates 01.10.03-30.09.04
Mainor Higher School	applied higher education institution	Information technology	Applied higher education	5B	300		300	71	3
Tallinn School of Economics	vocational education institution	Data processing (vocational higher education)	Professional higher education	5B	58	58		0	0
Tallinn School of Economics	vocational education institution	Data processing	Applied higher education	5B	168	168		44	18
Tallinn University	university	Informatics	Bachelor studies	5A	130	117	13	49	16
Tallinn University	university	Informatics (multimedia)	Master studies (3+2)	5A	32	23	9	11	1
Tallinn University	university	Information technology (Multi-media)	Master studies, Master of Science	5A	1	1	0	0	9
Tallinn University	university	Information technology	Applied higher education and university diploma studies	5B	0		0	0	1
Tallinn University	university	Applied informatics	Applied higher education and university diploma studies	5B	1	1	0	0	5
Tallinn University of Technology	university	Computer and system techniques	Bachelor	5A	496	396	100	137	42
Tallinn University of Technology	university	Informatics	Bachelor	5A	337	297	40	148	0
Tallinn University of Technology	university	Informatics (B.)	Bachelor	5A	195	149	46	0	50
Tallinn University of Technology	university	Business information technology	Bachelor	5A	224	111	113	82	1
Tallinn University of Technology	university	Computer and system techniques (D.)	Doctoral studies	6	14	14		0	1
Tallinn University of Technology	university	Information and communication technology	Doctoral studies	6	56	54	2	15	0
Tallinn University of Technology	university	Informatics (D.)	Doctoral studies	6	7	7	0	0	1
Tallinn University of Technology	university	Informatics for non-informatics	Master studies (3+2)	5A	22		22	7	2
Tallinn University of Technology	university	Computer and system techniques (M.)	Master studies, Master of Science	5A	97	67	30	37	19
Tallinn University of Technology	university	Informatics (M.)	Master studies, Master of Science	5A	131	80	51	48	18

Continued...

Name of the educational institution	Type of the educational institution	Title of the study programme	Educational level	ISCED 97 code	Students	Incl. state financed	Out of state budget	Admis-sion	Graduates 01.10.03-30.09.04
Tallinn University of Technology	university	Informatics	Applied higher education	5B	56	56	0	19	0
Tallinn University of Technology	university	Computer systems	Applied higher education and university diploma studies	5B	31	21	10	0	11
Tallinn University of Technology	university	Informatics	Applied higher education and university diploma studies	5B	98	62	36	0	17
Tallinn University of Technology	university	Network software	Applied higher education and university diploma studies	5B	53	42	11	0	3
University of Tartu	university	Informatics	Bachelor	5A	249	233	16	67	22
University of Tartu	university	Information technology	Bachelor	5A	262	216	46	143	0
University of Tartu	university	Informatics	Doctoral studies	6	21	20	1	5	0
University of Tartu	university	Informatics	Master studies (3+2)	5A	7		7	2	0
University of Tartu	university	Information technology	Master studies (3+2)	5A	14	0	14	5	3
University of Tartu	university	Informatics	Master studies, Master of Science	5A	42	35	7	15	8
University of Tartu	university	Information technology	Applied higher education and university diploma studies	5B	52	51	1	0	22
University of Tartu	university	Applied informatics	Applied higher education and university diploma studies	5B	3	3	0	0	1
				Total:	**4,046**	**2,547**	**1,499**	**1,211**	**407**

7.6. Annex VI. Students of Computer Sciences According to Levels of Education, 2004

Table 7-7. Students of computer sciences according to levels of education, 2004[252]

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004 (%)
Doctoral Studies												
All fields of study	388	624	727	899	1,071	1,251	1,447	1,508	1,587	1,653	1,717	
Computer sciences	18	31	40	46	52	53	44	50	65	86	98	5.7%
incl. Tallinn University of Technology										68	77	4.5%
incl. University of Tartu										18	21	1.2%
Master Studies												
All fields of study	1,926	2,588	2,803	2,673	2,822	3,447	4,339	5,140	6,354	7,015	7,238	
Computer sciences	115	138	127	121	104	119	142	195	257	328	346	4.8%
incl. Tallinn University of Technology										231	250	3.5%
incl. University of Tartu										61	63	0.9%
Bachelor Studies												
All fields of study	17,376	17,959	18,770	20,489	21,731	25,246	27,892	28,703	29,344	29,976	30,707	
Computer sciences	419	472	465	904	946	1,084	1,401	1,539	1,833	1,922	2,102	6.8%
incl. Tallinn University of Technology										1,169	1,252	4.1%
incl. University of Tartu										411	511	1.7%
Applied Higher Education, Professional Higher Education and University Diploma Studies												
All fields of study	5,793	6,063	7,772	10,481	14,997	19,630	22,759	25,058	24,185	24,401	24,144	
Computer sciences	0	0	0	108	175	387	869	1,242	1,436	1,473	1,500	6.2%
incl. Tallinn University of Technology										305	238	1.0%
incl. Estonian IT College										211	364	1.5%
incl. University of Tartu										112	55	0.2%
Total												
All fields of study	25,483	27,234	30,072	34,542	40,621	49,574	56,437	60,409	61,470	63,045	63,806	
Computer sciences	552	641	632	1,179	1,277	1,643	2,456	3,026	3,591	3,809	4,046	6.3%
incl. Tallinn University of Technology										1,773	1,817	2.8%
incl. University of Tartu										602	650	1.0%
incl. Estonian IT College										211	364	0.6%

252 Source: Statistical Office of Estonia (1993-2003); AS Andmevara, register of students 2004 (1 November 2004).

7.7. Annex VII. Methodology: Comparison of Income of People who Have Obtained Higher Education in ICT on the Basis of Income Tax

The sources of the data are the sub-register of the students, university students and Doctoral residents of the Estonian Education Information System (hereinafter the students register) as well as those on monthly social tax, mandatory funded pension and unemployment insurance premium statements of the Tax and Customs Board for the period 1999-2003.

An extract from the **students register** included the students of computer sciences, computer use, electronics and control engineering who have been dismissed as a result of completion of the study programme (graduates) and students dismissed for other reasons (non-graduates, excluding students who have transferred during their studies to another study programme). Based on the students register, the following identifications were generated with respect to the dismissed: educational institution, study programme, level of education and stage of study, ISCED97 field, sex, age group, date of enrolment of dismissal, standard period of study, and language of instruction.

The students register was launched in 1999, wherefore the data are more likely to contain inaccuracies. Thus, when drawing conclusions, it must be remembered that the data about the graduates and non-graduates of the academic year 1999/2000 are a bit less reliable. The academic year 2003/2004 is not complete either as the extract made from the register for the purposes of this study is limited to the graduates and non-graduates of 2003 (i.e. the academic year 2003/2004 covers only the period from September to December 2003); as regards vocational education, the academic year 2002/2003 is incomplete as the data are limited to the graduates of the calendar year 2002.

The dates of enrolment in the database have been divided into academic years (defined as a period from 1 September to 31 August of the following year). On the basis thereof the dates of graduation have also been divided into academic years. However, the period of income tax receipt is a calendar year. That must be reckoned with upon comparison of the times of graduation/leaving school and income tax receipt.

Levels of study have been aggregated as follows:

Level code	Original classification of study levels	Classification of levels
313	Vocational and secondary education assuming basic education	
323	Vocational secondary education based on basic education	
413	Vocational secondary education based on secondary education	vocational
314	Professional secondary/technical school education assuming basic education	
414	Professional secondary/technical school education assuming secondary education	
514	Applied higher education	
513	Diploma study in an institution of applied higher education or university	
523	Professional higher education	
523T	Professional higher education based on vocational secondary education assuming secondary education	
511	Bachelor studies	higher
512	Bachelor studies	
732	Doctoral studies	
734	Doctoral studies	
614	Master studies (3+2)	
612	Master studies, MSc	

The names of the vocational educational institutions listed in the database date from 2002 to make the years comparable.

The sum of income tax paid on wages and salaries, number of months, code of local government receiving the income tax (EHAK[253]) and area of activity of the principal employer (EMTAK03[254]) was added for each graduate and non-graduate included in the students register (EMTAK03[255]) from the 1999-2003 declarations of income and social tax as well as mandatory funded pension and unemployment insurance premiums (hereinafter the TSD Form) obtained from the database of the Tax and Customs Board. Such data include only income tax paid on wages and salaries (i.e. it does not contain income tax on stipends or sickness or unemployment benefits).

The TSD Forms are not submitted by sole proprietors who are not employers. If a sole proprietor is an employer, he/she must withhold income tax, unemployment insurance as well as mandatory funded pension premiums and calculate social tax for his/her employees and, thus, declare the data on the TSD form. If a sole proprietor is an employer, his/her employees' area is included in the database serving as a basis for this survey. The sole proprietors themselves are not included. If a sole proprietor is not an employer, he/she is not included in any manner. However, the database also includes people from whose wages and salaries no income tax has been paid, although they earned income to the amount of the tax-exempt minimum – the reported sum of income tax is zero.

The database excludes negative sums of income tax, which would cause a shift in the calculation of the average sum of income tax. Therefore, such cases are recorded in the calculations as unpaid income tax (the sum of income tax is zero).

The database contains the sum of income tax attributable to each graduate and non-graduate for each employer or employers and the local government (which received the income tax) separately. In addition, for each sum paid the period of its payment is known. Whereas some of the graduates and non-graduates have had more than one employer (area of activity) or local government a year, two methods have been used to analyse the income tax to indicate only one sum of income tax for each graduate or non-graduate a year. At that,

1. In the tables where the area of activity of the employer or the sphere of employment of a graduate or non-graduate is important, the sum of income tax derived by each person from such an area of activity, in the case of which the number of months a year is the largest, was chosen. In the cases where there were several similar maximum numbers of months a year, the period with the largest sum of income tax was chosen. Thus, the so-called "income tax of maximum months" was obtained, accompanied with the area of activity of the respective employer. Here, in comparison of the income tax amounts it must be remembered that the period of their receipt varies.

2. In the tables where the area of activity of employers has not been analysed and the sum of income tax or the ratio of taxpayers has been considered in other terms, the total annual income tax per person was used, i.e. the income tax paid by a graduate or non-graduate in 2003 was aggregated independent of the number of different employers and local governments (occasionally, in the case of the graduates of 2000/01 the average income tax of 2001-2003, in the case

253 Classification of the Estonian Administrative and Population Division in 2003.

254 Classification of the Estonian economic areas of activity in 2003.

255 Classification of the Estonian economic areas of activity in 2003.

of the graduates of 2001/02 the income tax of 2002-2003 and in the case of the graduates of 2002/03 the income tax of 2003 was taken as a basis).

When analysing the average sums of income tax, the fact that income tax is paid only on the wages and salaries earned in excess of the tax-exempt minimum must be taken into account. Therefore, in relation to the average wages and salaries the sum of the average income tax is evidently a bit larger (upward shift).

7.8. Annex VIII. List of Participants of the Seminar, 27 November 2004

Table 7-8. Participants of the seminar on knowledge-based economy and ICT higher education organised by the Estonian Information Technology Foundation and PRAXIS Center for Policy Studies, 27 November 2004, Estonian IT College

1	Jaak	Anton	Ministry of Education and Research
2	Heli	Aru	Ministry of Education and Research
3	Kristi	Hakkaja	PRAXIS; State Chancellery
4	Olav	Harjo	Elion Ettevõtted AS
5	Dr. Diem	Ho	IBM EMEA (also Career-Space consortium)
6	Tarmo	Kalvet	PRAXIS
7	Prof. Dr. Rainer	Kattel	PRAXIS
8	Dr. Tarmo	Lemola	Advansis OY (Finland)
9	Jaan	Oruaas	Estonian Information Technology Foundation
10	Dr. Christopher	Palmberg	ETLA (Finland)
11	Prof. Dr. Jaan	Penjam	TUT
12	Tarmo	Pihl	Foundation Archimedes
13	Kristjan	Rebane	Estonian Information Technology Foundation
14	Dr. Indrek	Reimand	Ministry of Education and Research
15	Prof. Dr. Erik S.	Reinert	TUT, The Other Canon Foundation (Norra)
16	Dr. Tiit	Roosmaa	UT
17	Niilo	Saard	Estonian Association of Information Technology and Telecommunications
18	Toomas	Sõmera	Estonian Information Technology Foundation
19	Dr. Kalle	Tammemäe	IT College
20	Marek	Tiits	Foundation Archimedes
21	Gunnar	Valge	TUT
22	Tiit	Vapper	AS Reaalsüsteemid
23	Dr. Jaak	Vilo	eGeen Inc.
24	Prof. Dr. Enn	Õunapuu	TUT

Our (sometimes severe) attempts to establish knowledge-based economy in Estonia are without doubt related with education and with especially ICT-related education. The current study is a first attempt to examine our situation and relate it with innovation and educational policies in a comparative way in the context of increasingly globalising environment. The recommendations could and should be considered in designing further steps both by the State, public and private sectors, but most importantly – in co-operation.

Toomas Sõmara

Head of Board

Estonian Information Technology Foundation

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