PRAXIS Working Paper No 29

The Estonian Information Society Developments Since the1990s

Tarmo Kalvet

August 2007

Since the 1990s Estonia has made remarkable successes in information society development. The current article describes achievements in key fields and discusses the main factors that have made such developments possible. It asserts that the major factors that have affected as well as contributed to the evolution of information society in Estonia include the economic factors, active role of the public sector, technological competency, and socio-cultural factors. It is argued that telecommunications and banking sectors are the cornerstones of Estonian information society developments; they are also behind major initiatives dedicated to computer training and awareness raising. Activities of the public sector have been also crucial in providing favourable legislative environment, but also in launching infrastructural projects and in implementing innovative e-services. Public sector developments have been strongly influenced by some non-governmental organisations. ICT skills and R&D competencies, a lot of which is Soviet inheritance, have been also crucial.

The report has been prepared within the project "Network for Teaching Information Society" (NETIS, 2006-2008). The objectiuve of the network is to increase knowledge and competence of students on information society and also to broaden and deepen their understanding on the topic by introducing a course on information society in tertiary education institutions.

PRAXIS Center for Policy Studies
Estonia pst. 5a, 10143, Tallinn, Estonia
tel (+372) 640 9000
fax (+372) 640 9001
e-mail praxis@praxis.ee

The Estonian Information Society Developments Since the1990s

Tarmo Kalvet,

PRAXIS Center for Policy Studies and Tallinn University of Technology

Tallinn, 2007

Content

Introduction **5**

1. General ICT usage indicators **7**

2. Information society politics, policy and regulations **10**

3. E-Government **13**

4. Information society and the economy **16**

5. Education, research and development **20**

6. Digital divide **23**

7. Trust, network and information security **24**

8. Discussion: Towards the explanatory framework **26**

9. Recommendations for future information society research **29**

References **31**

Introduction

The objective of the *Network for Teaching Information Society* (NETIS, 2006-2008[1]) is to increase knowledge and competence of students on information society and also to broaden and deepen their understanding on the topic by introducing a course on information society in tertiary education institutions. According to the mission statement:

> *Europe depends on competent and aware people to manage and progress the information society as it develops. NETIS aims to improve the skills and competences of students, teachers, researchers, experts and wider public by developing widely accessible, relevant, innovative and sustainable e-learning course on information society. Through a constructivist approach we use a modular course-design and take advantage of international synergies to produce adaptable, reliable content. By these means NETIS expects to increase the participants' awareness and reflections on the impact of information society on everyday life.*

The current chapter in the electronic text book has the objective of familiarizing students and wider audience on Estonian developments and is meant to complement the course book. Next to covering almost all topics introduced in the course book, eGovernment[2] is studied in more detail considering that Estonia has been very successful in implementing it. There are two additional themes introduced. The first of them is related to digital divide and the information environment (section 6). Information and network security have been on prominent place in Estonia along with cyberwar issues that have risen recently and are thus addressed in section 7.

It is almost impossible to cover the developments of the more than 15 years within one relatively short article, but in order to understand success factors, drivers and barriers as well as future challenges such longer perspective must be considered.

The point of departure of the rent article is that Estonian success in information society ments is widely recognized.[3] deed, over the years Estonia has ranked in high positions in international comparisons measuring e-readiness[4] not only among the Central and Eastern European countries, but also among the old EU member states and leading

Box 1. Estonia's rank in some international comparisons

The *Global Information Technology Report 2006-2007*, which uses a comprehensive tool for measuring the progress of and identifying the obstacles to ICT development worldwide, has ranked Estonia on the 20th position among the observed 122 countries.

Economist Intelligence Unit has ranked Estonia 27th among the served 68 countries, while considering it the leader in Central and Eastern Europe.[6]

[1] See http://www.ittk.hu/netis/ for details.

[2] eGovernment (European Commission COM (2003)567) could be defined as the use of information and communication technologies in public administrations combined with organisational change and new skills in order to improve public services and democratic processes and strengthen support to public policies. It encompasses thus the dimensions of public administration, democracy, governance and policy making.

[3] This is supported by the fact that based on understanding that other countries can learn from Estonia's experience (especially in the field of e-governance), Estonian E-governance Academy, a joint initiative between the Republic of Estonia, United Nations Development Program (UNDP) and Information Program of the Open Society Institute (OSI) was set up in 2002.

[4] Defined, for example, by the Economist Intelligence Unit as "the 'state of play' of a country's ICT infrastructure and the ability of its consumers, businesses and governments to use ICT to their benefit." Similar approaches are applied elsewhere.

ICT-countries.[5]

The UN Global E-government Readiness Report ranks Estonia as among the top 22 countries in its 2005 Web Measure Index.[7]

The current article is in part based on an extensive research project undertaken by Tallinn University of Technology and PRAXIS Center for Policy Studies on the analysis eGovernment and eHealth in Estonia.[8] The project *Next Steps in Developing Information Society Services in the New Member States: The Cases of eGovernment and eHealth* (2005-2007) was part of the international research commissioned by the Institute of Prospective Technological Studies (IPTS) of the Directorate General Joint Research Centre, European Commission. That study is complemented with the results of other research undertaken by PRAXIS or other research where the author has been involved since 1997. Thus, it is mainly based on desk research, although dozens of experts have been interviewed throughout those previously mentioned projects. The author is grateful to all of interviewees. Of course, the author is fully responsible for all remaining insufficiencies and errors.

[6] Economist Intelligence Unit 2006.

[5] For a detailed snapshot of a situation in 2002, see Krull 2003. The picture remains similar in latest overviews; see, for example, *Accompanying Document to the i2010...* 2007; *Information Society Benchmarking Report...* 2005.

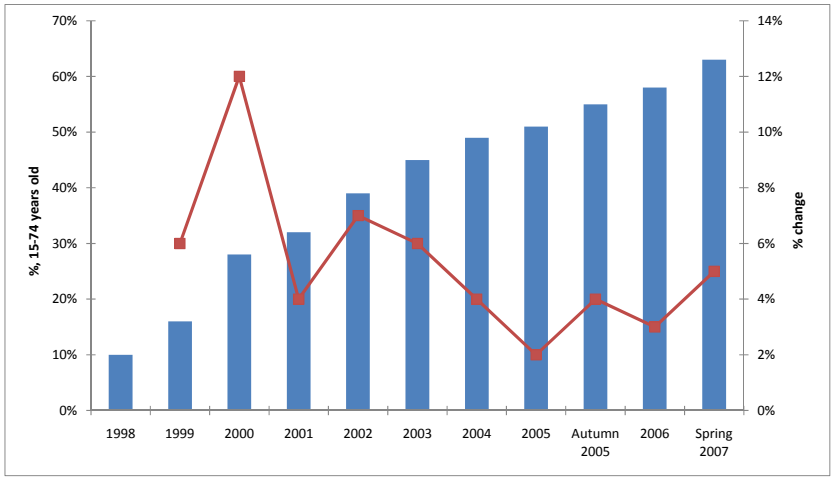
[7] *UN Global E-government Readiness Report* 2005, p. 88.

[8] Estonian case stuy published Kalvet and Aaviksoo 2007.

1. General ICT usage indicators

Internet usage, which most characterises information society development, has been growing rapidly over the years. Surveys by TNS Emor indicate that 63% of people aged 15-74, or 65% of those aged 6-74, are Internet users as of 2007 (Figure 1).

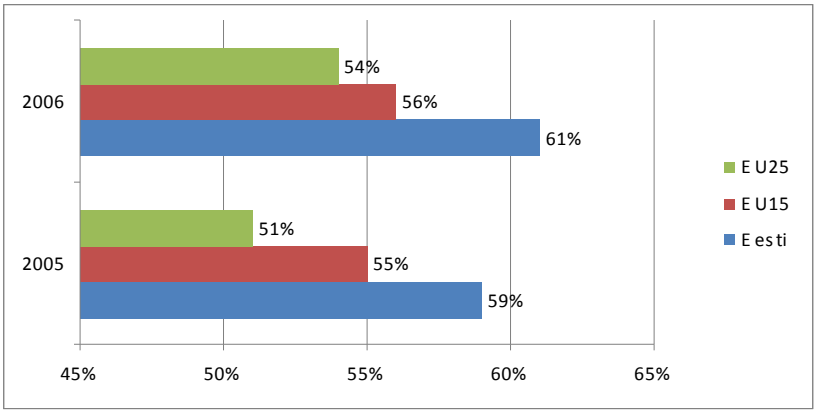
Figure 1. Internet users in Estonia, 1998-2007



Source: TNS Emor 1998-2007

Estonia is performing better then the European Union (EU) average according to Eurostat: the share of individuals using the Internet was slightly higher in Estonia than in the EU in average (Figure 2).

Figure 2. Percentage of individuals (16-74 years old) who used the Internet in the last three months



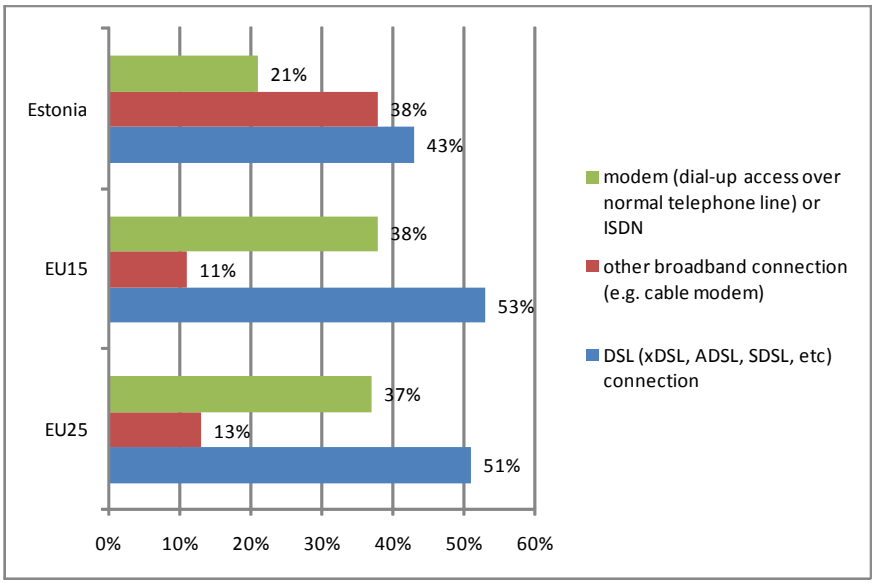
Source: Eurostat 2007

As of 2006 46% of individuals could use Internet at home and the share has been constantly growing in Estonia (40% in 2005; 32% in 2004). For the EU15 the respective indicator was 45% and for EU25 43% in 2006. The second popular usage place in Estonia is work, followed by place of education. Public Internet Access points have been used by 2% of individuals in 2005 and 2006, while in 2004 the share was 6%.[9]

[9] Eurostat 2007.

Mostly the Internet connection at households is broadband connection (80% in 2006; compared to 62% in EU15 and EU25), ADSL connections dominate (Figure 3). The early and wide dissemination of the broadband connections is rather remarkable and has caused appearance of titles like "True or False: U.S.'s Broadband Penetration Is Lower Than Even Estonia's?"

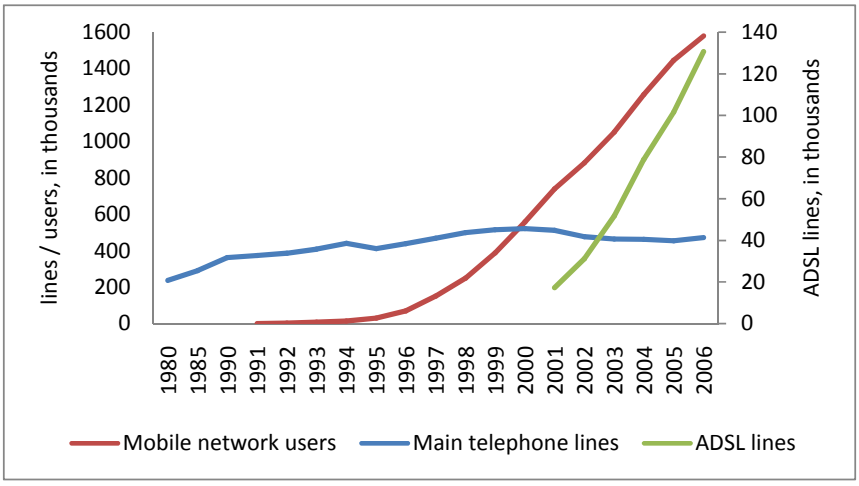
Figure 3. Most popular types of Internet connections at households (2006)



Source: Eurostat 2007

There has also been rapid spread of mobile telephones and their use has substituted the need for fixed telephone lines, a tendency observable since 2000. Since 2001 there has been an impressive growth of the ADSL lines (Figure 4).

Figure 4. Main telephone lines, ADSL lines and mobile network users



Source: Statistical office of Estonia 2007

Similar to users from EU25 and EU15, Internet is largely used for e-mail communication and for finding information about goods and services. Estonian Internet usage, though, is different from "EU average" by the following: financial services (mainly Internet banking) and reading/downloading online newspapers/news magazines are relatively more popular. eGovernment services are also widely used. At the same time, Internet is relatively less used for educational courses (and for e-learning in general) and for e-business (Table 1).

The percentage of individuals who accessed Internet, on average, at least once a week has increased from 45% (2004) to 56% in 2006; this is slightly above from the EU15 (49%) and EU25 (47%). The share of those using Internet every day or almost every day has been 40% both is 2005 as well as in 2006.[10]

Tabel 1. Internet activities (%) by individuals 2006

	EU25	EU15	Estonia
Communication	46	48	52
Formalised educational activities (school, university, etc)	9	9	6
Other educational courses related specifically to employment opportunities	8	9	2
Post educational courses	9	10	2
Downloading official forms	14	n/a	17
Obtaining information from public authorities web sites	23	n/a	27
Sending filled forms	9	n/a	17
Seeking health information on injury, disease or nutrition	20	21	18
Financial services (Internet banking, share purchasing)	22	24	48
Training and education	20	22	8
For sending / receiving e-mails	44	46	49
Playing / downloading games and music	18	18	28
Interaction with public authorities	26	n/a	29
Using services related to travel and accommodation	27	29	20
Finding information about goods and services	43	46	44
Looking for a job or sending a job application	11	12	17
Reading / downloading online newspapers / news magazines	19	19	50
Other communication uses (chat sites, etc.)	18	18	21
Telephoning over the Internet, for videoconferencing	7	7	14
Selling goods and services (e.g. via auctions)	9	10	3
Downloading software	16	17	21
Listening to Web radios / for watching Web television	12	12	17

Source: Eurostat 2007

92% of companies have access to the Internet (EU25 92%) as well, mainly via broadband access (76%).[11] 79% of the companies connected to the Internet also maintain a homepage on a web site.[12]

Table 2. Internet activities (%) by enterprises[13] (2006)

	EU25	EU15	Estonia
Obtaining after sales services	33	36	36
Banking and financial services	74	74	90
Receiving digital goods and services	41	44	30
Use the Internet for market monitoring (e.g. prices)	54	53	45

Source: Eurostat 2007

[10] Eurostat 2007.

[11] Eurostat 2007

[12] TNS EMOR 2006.

[13] All, without financial sector (10 employed persons or more).

2. Information society politics, policy and regulations

Attempts to build up an information society as well as knowledge-based economy in Estonia can be traced way back in Estonian politics and policy. The first information society strategy – *The Estonian Way to the Information Society* – was prepared already in 1994. The document was much inspired by respective developments in the EU (*'Bangemann Report'* of 1994 and *White Paper on Growth, Competitiveness, and Employment,* 1993) and of the USA (e.g., *Information Infrastructure Task Force*, 1994) and focused largely on market failures associated with infrastructure development.[14]

The main policy document on Estonian information society policy – *Principles of Estonian Information Policy* – was approved by the Parliament in 1998. The following were seen as main instruments: modernisation of legislation, supporting the development of the private sector, development of interaction between the state and citizens, and awareness raising on problems concerning the information society. An important link between policies and action plans was also established since then. On the basis of the *Principles*, an *Information Policy Action Plan* which is updated annually was developed where all Government agencies made specific proposals with schedules, sources of finance, and responsibilities for implementation of information policy.

An updated version of the strategy – *Principles of the Estonian Information Policy 2004-2006* – was approved by the Government in 2004. It reiterated the priority given to the development of eGovernment services, stressing the main objectives including: the introduction of eServices in all state agencies together with respective training and awareness-raising activities for the whole society; keeping the level of ICT use in Estonia at no less than the average level of the EU, and hence ensuring the efficiency of the Estonian economy and society in general; and increasing the export capacity of the IT sector. Other key elements of the 2004-2006 strategy include provisions for: the developing IT solutions for extending e-democracy; increasing efficiency of the public sector; increasing digital literacy through e-learning; increasing ICT-related research and development to promote private sector activities; establishing a national IT security centre as a contact point for all EU institutions; enhancing the reputation of Estonia as an e-State; and facilitating access to ICT for the socially disadvantaged. In main principles, the documents are rather similar, although the recent is more concrete in terms of targets and instruments and it connects information society with education, R&D, culture, business, etc. Likewise, the position on the role of state in information society has become clearer all over the world. EU policy developments such as *eEurope* and *eEurope+* have also been considered.

The new *Estonian Information Society Development Plan 2013* sets out objectives covering social, economic and institutional dimensions. It acknowledges that no additional disparities or divides are to be created in developing an information society, and that an information society should enable the reduction of current gaps. The economic pillar is strongly present and aims to contribute to the continuous growth of the Estonian economy as a result of wide take-up of ICT and the generation of more added value and exports of the Estonian IT sector. Under the institutional pillar, the development plan seeks to ensure that public sector will be citizen-centered, transparent and efficient.

There is another very important policy field that has relevance on the information society development; namely, research, development and innovation (R&D&I) policies have potentially very direct influence on the societal development. The main strategy directing R&D&I in Estonia has been the *Estonian Research and Devel-*

[14] Kalvet 1997.

opment Strategy 2002-2006 and its successor *Estonian Research, Development and Innovation Strategy 2007-2013*. For the implementation of the stated objectives and the vision for the future – knowledge-based Estonia – the key areas in both strategies have been said to be user-friendly information technologies (ICT in newer strategy), biomedicine (biotechnologies in the newer version), and materials` technologies.

While there has been a general consensus by all political parties on the goal to transform Estonia into a successful information and knowledge-based society, linkages between political rhetoric and policies/action plans are almost non-existent or remain unclear at its best. The political backing has still been crucial as respective regulative environment is needed or the implementation of some technologies (e.g., Public Key Infrastructure and ID Card) and applications (e.g., e-voting), although hot political debates have occasionally taken place.[15] Although ICT and knowledge-based Estonia are in prominent place of the programs of all political parties, this is not backed up with strongly implemented policy instruments. For example, on the basis of the 2002-2006 R&D&I Strategy, annual national programmes in key areas were to be compiled which had to define specific programmes and measures for promoting R&D&I according to the objectives of the strategy. However, so far more specific priorities nor implementation plans have been prepared.

All in all, Estonia has implemented a lot of innovative solutions in the public sphere (described in detail in section 3), although sometimes it is difficult to understand if these projects resulted from approved policies and action plans, or would have emerged anyway and these policies have been adopted *post factum*. In Estonian eGovernment development a very pragmatic approach can be observed and relations between strategies and actual developments can be rather described rather as 'development driven strategies' than 'strategy driven development'.

Estonia has been often reported as a country with favourable legislative environment towards ICT and the most important legislative acts have been approved without external pressure (e.g. compliance to *acquis*). Indeed, in some instances, the regulatory framework has been crucial. For example, the Public Information Act took effect in January 2001. The Act also includes significant provisions on electronic access and disclosure (e.g., the duty to maintain websites, obligation to ensure that the information is not 'outdated, inaccurate or misleading', e-mail requests must be treated as official requests for information, etc.). Information disclosed via a website is very extensive and has changes routines how information is handled within public sphere contributing to the emergence of 'good governance' in Estonia.

Approved on 8 March 2000, the Digital Signatures Act, provides the necessary conditions for using digital signatures and the procedure for exercising supervision over the provision of certification services and time-stamping services. Digital signature has the same legal consequences as a hand-written signature..

According to the Riigikogu Electoral Law, voters who hold a digital signatures certificate can vote on the website of the National Electoral Committee, but only on advance polling days (from the sixth to fourth day before the actual election day).

Perhaps the most profound steps by the State guaranteeing strong kick-off for Estonian information society developments are related to the early involvement of strategic foreign partners for the development of Estonian fixed communications network[16] and later the liberalisation of the Estonian telecommunications market. Although the Concession Agreement was signed between the Government of Estonia and the Estonian Telephone Company in 1992 that granted exclusive rights to the Company until 2001 for the provision of fixed voice telephony services[17], non-basic telecommunication services (e.g. mobile and data communication,

[15] See Drechsler and Madise 2004 for overview.

[16] For detailed overview see Högselius 2005, pp. 79-92.

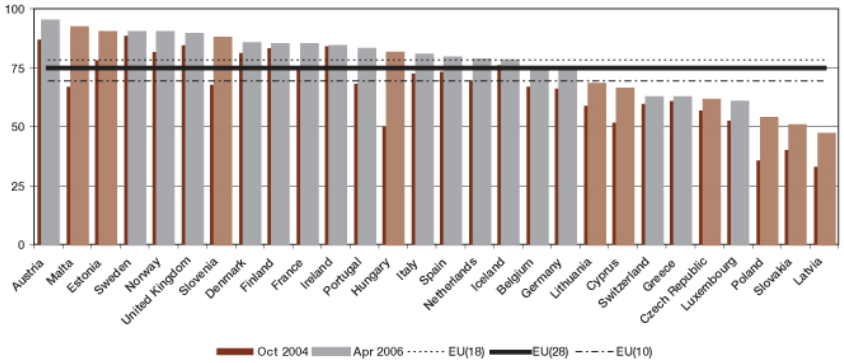
[17] The Concession Agreement was limited with national and international switched fixed voice telephony services, telex and telegraphic services, their installation and interconnection to them

paging services, satellite communication or value-added services) have been offered freely. Although a licence is needed for building and operating networks, the general liberalisation taken place has placed Estonia among the first Central and Eastern European countries to open all segments of their telecommunications market.

3. E-Government

In terms of online public services available, Estonia is considered advanced and highly sophisticated. The country is not only ahead of all other New Member States, but also scores better than the majority of EU15 countries (Figure 5). When compared to results from 2004, a remarkable progress can be observed.[18]

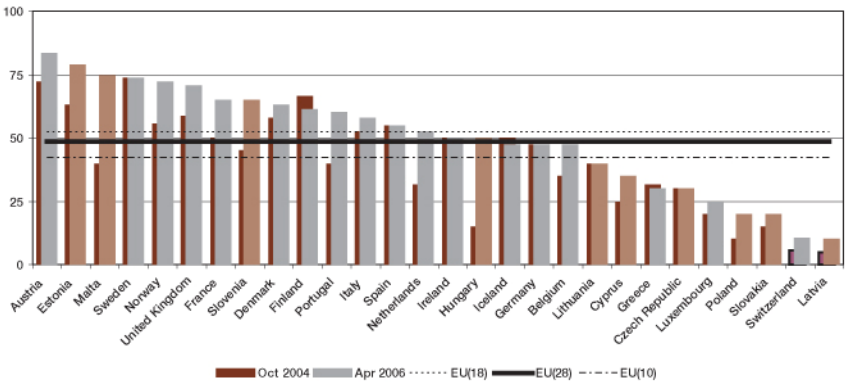
Figure 5. Online sophistication of public services, 2006



Source: *Online Availability of Public Services...* 2006, p. 8

The percentage of services that offer a complete electronic case handling is also very high, more than 75% of the services can be handled fully electronically which is considerably above EU25 average (Figure 6). Basically, all public services in Estonia include an eService component. In particular, all State and local government agencies, legal persons in public law, and persons in private law performing public law functions have to accept digitally signed documents. Digital signatures have been used (for signing contracts, applications, transaction orders, etc.) more than 2.6 million times by more than 60,000 users since 2002.[19]

Figure 6. Public services fully available online (%), 2006



Source: *Online Availability of Public Services...* 2006, p. 9

Estonia is the first country in the world to enable its citizens worldwide to vote over the Internet for political elections – i.e., at the local elections of 16 October 2005. ID-card based system allowed citizens to sign their ballots electronically via the Internet, the number of e-votes cast during the local elections amounted to 9,287,

[18] Estonia occupied the 8th position as of October 2004 compared to the 3rd position in 2006.

[19] Certification Centre 2007.

representing 1.85% of total votes.[20] The efforts continued and for the first time in the word e-voting was used for parliamentary elections. Overall, 30,275 voters have used the possibility of e-voting in March 2007 elections, which corresponds to 5.4% of the participating voters.[21] Next to such extremely innovative services there are also some more standard services that stand out due to extremely widespread usage. For example, Estonia is one of the leading countries in the world when it comes to the popularity of submitting tax returns and customs declarations electronically. A total of 532,000 income tax returns were submitted to the tax authority by private individuals in 2006; 82% of these came in through the electronic Tax Board system, compared to 75% in 2005 and 59% in 2004.[22]

The architecture of eGovernment in Estonia was developed in the framework of the X-Road project. X-Road is the implementation of unified interfaces for different databases and a data exchange layer which allows officials as well as legal and natural citizens to process data from national databases over the Internet within the limits of their authority. The Estonian commercial banks and some other private companies are also linked to X-Road as data users.[23]

The Estonian ID card and the opportunities provided by it for electronic authentication and authorization are central to Estonian eServices. Without the existence of this infrastructure several innovative public services in Estonia would not be possible (e.g. e-voting). In addition to being a physical identification document, the card has advanced electronic functions facilitating secure authentication and legally binding digital signature. An electronic processor chip (a respective smart card reader is needed for operation) contains a personal data file as well as a certificate for authentication and a certificate for digital signature.[24]

The following additional projects have contributed to the advanced situation regarding Internet connections in public organisations: The backbone network PeaTee (EEBone) that is the broadband network of data communications between government institutions[25]; a target programme KülaTee (Village Road) as a follow-up project to PeaTee to provide data communication services for local government agencies, schools and libraries[26]; the Estonian Educational and Research Network (EENet) to manage, coordinate and develop the computer network of science, education and culture.[27]

According to the survey *Information Society in Estonian Local Governments* on 2006 (in which 115 local governments responded to questionnaire-based data collection out of 227 municipalities and cities), the situation regarding both hardware and software in local governments is good as well. However, the mapping among local governments in Estonia (based on 59 respondents) according to BEGIX[28] showed varying levels of development among local governments. There are some cases which showed good standing, but there were laggards existing as well. According to local governments, ICT contributes a great deal to effectiveness and transparency, while other important dimensions such as benefits, participation, and change management are not so well considered.

In addition to the popularity of Internet based public services, Estonia is also well known in the field of mobile value-added services (mServices). Estonia was the first country in the world to have mobile positioning in commercial use and one of the first to have 112-emergency calls linked with mobile positioning system that can determine origins of each call.[29] In fact, clients of all Estonian mobile operators can already pay for car

[20] For complete overview see The National Election Committee 2006.

[21] For complete overview see Trechsel 2007.

[22] Estonian Tax and Customs Board 2007, p. 41.

[23] See http://www.ria.ee/27309.

[24] See http://www.id.ee.

[25] See http://www.ria.ee/27315.

[26] See http://www.ria.ee/27426.

[27] See http://www.eenet.ee.

[28] 'Balanced E-Government Index' is a self-evaluation tool for eGovernment service. See www.begix.net.

[29] For an overview of m-services development and related factors, including case studies on mobile parking, mobile transport ticketing, and mobile commerce, see Rannu 2003.

parking via their mobile phones since 2000. Tartu City, in particular, has paid remarkable attention to the development of mServices.[30]

The general excellence in the provision of eServices is a result of many years of development work and has certainly benefited from the following. At first, there was stable funding provided for the state IT expenditures in 1993-2005; excluding personnel-related costs it has been ca 1% of the total state budget.[31] Secondly, the development of the public sector ICT infrastructure started very early in Estonia and has been very successful. Most of the civil servants who need computers for their daily activities have them.[32] As of 2005, 99% of the computers of central government organisations were connected (mostly via broadband) to the Internet. Most importantly, there have been enthusiastic and visionary civil servants behind the development of public sector information systems. External experts have been widely used as well, especially in the development of the following key projects that have created excellent bases for eServices in Estonia.

It is also important to notice that some central information systems and applications have been developed by technocrats without existence of respective policies (e.g., establishment of state portals). Also, some services were initiated as a results of the activities of the NGO Open Estonia Foundation. For example, full and publicly available on-line database of Estonian legislative acts was opened already in 1996 by a NGO Institute of Baltic Studies and almost all official forms were put on the Internet within a pilot project within Phare Public Administration Programme. Both initiatives were (co-)funded by the Open Estonia Foundation and later taken over by the public sector.

[30] Rannu and Semevsky 2005

[31] *IT in Public Administration of Estonia* 1994-2005, authors' calculations.

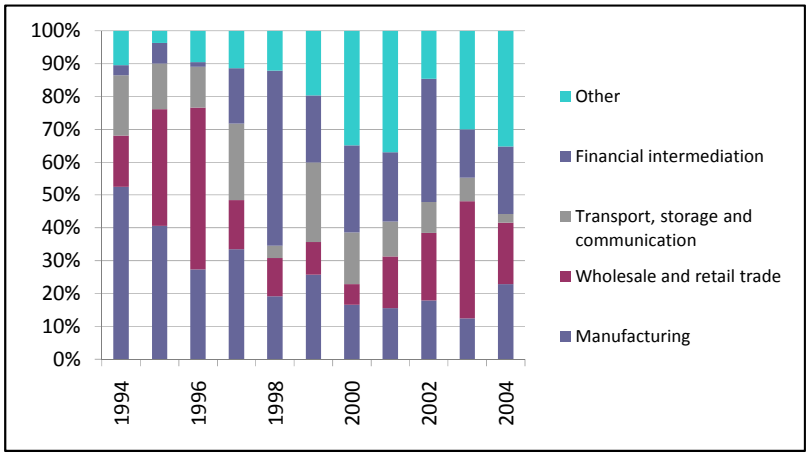
[32] 34.8 % of the administrative staff of central apparatuses were already equipped with computer workplaces in 1995, 89% of needs for computer workplaces were satisfied in 1998. See *Information Technology Means…* 2005.

4. Information society and the economy

Although Estonia suffered from over-industrialisation during the Soviet period, its economic structure was relatively favourable to the more modern economic structure – that is to say, large share of the industry was oriented towards higher value-added production which took advantage of skilled labour and the portion of large-scale outdated industries was smaller especially when compared to other Soviet Republics.[33] Since the restoration of its independence in 1991, the country has aggressively pursued integration with the West as well as a free market economy.

In order to allow technology transfer, the improvement of managerial skills and more effective market competition, large-scale privatisation was undertaken in Estonia and already by 1995 most companies were privatised. Privatisation has been one of the main factors influencing the inflow of foreign investment to Estonia. The role of FDI in Estonian private sector developments has been crucial (see Figure 7 for the direct investment inflow). The share of FDI in gross fixed capital formation[34], for example, although fluctuating in the 1990s, reached levels as high as 40.8 per cent in 1993 and 37.9 per cent in 1998.[35] FDI have mostly originated from the neighbouring technology up-front countries of Finland and Sweden.

Figure 7. Direct investment inflow by fields of activity



Source: Bank of Estonia 2007

The telecommunications sector is one of the cornerstones of Estonian information society development. Crucial decisions regarding the involvement of strategic partners have resulted with considerable investments into the telecommunications sector and upgrading of the telecommunication networks (Figure 7).[36] There has been strong competition in the data communications market. The technologies introduced include ADSL and cable modems, WiMax, CDMA as well as WiFi that is available in 1,109 hot spots all over Estonia.[37]

[33] See, for example, Hansen and Sorsa 1994.

[34] A measure of the net new investment by enterprises in the domestic economy in fixed capital assets.

[35] OECD 2001, p. 10.

[36] Although data for telecommunications sector is not available on detailed level, there is evidence about the large share of investments from company annual reports. For example, Eesti Telekom did invest 88 mln EUR to the fixed and mobile telecommunications in 2000 (Eesti Telekom 2001, p. 16).

[37] www.wifi.ee.

The Estonian ICT market is dominated by telecommunication network services. EMT as the biggest mobile communications operator occupies the 7th position in largest Estonian companies ranked by turnover, Elion (the former ETC) the 11th position. The other two main operators are on the 31st and the 32nd position (all data for 2005).[38] The profit margins for those companies are around 20%, although EMT stand out with its profit margin above 30%[39] (2005 data) and give those companies plenty of financial resources for further investments and development project as well as for the involvement in various information society initiatives undertaken in Estonia.

The first banks were established in Estonia in 1988 and similar to telecommunications sector developments were boosted with the help of FDI (see Figure 7). By the end of 1995 foreign ownership amounted to 35 per cent of the share capital of Estonian banks. Two major Swedish banks, Swedbank and SEB, had acquired majority ownership both in Hansapank and Eesti Ühispank, respectively, by 1998.

It is somewhat extraordinary how quickly electronic banking and Internet banking has emerged in Estonia. Hansapank started its first electronic banking solution Telehansa in 1993. The first banks to introduce Internet banking services in Estonia were Eesti Forekspank and Eesti Hoiupank in 1996.[40] It is even more outstanding that as the world's first Internet banking services started in 1995, and by the end of 1996 there were only about 20 such services, of which three were from Estonia.[41]

A strong software industry that could develop and service large-scale banking information systems was missing in Estonia in the beginning of the 1990s. This gap had in turn challenged the banks in Estonia to build up their own in-house capacity. Still, a case study of one of the banks argues that the emergence of Internet banking in the company was rather a result of work of enthusiastic employees than systematic conduction of R&D or guidance given by top managers. Programmers developed the Internet bank days and nights on their own initiative.[42] The building up and development of own in-house capacity has led to the situation where the banks have been the 'informal' leaders in the software industry in Estonia. The Estonian banking system has actually set standards for e-services offered by other private and public sector companies. Banks have been also providing authentication mechanisms to access public and private sector e-services.

Some other Estonian software companies are world-wide known as well. These include Skype, where Estonian programmers did the main code writing for now internationally popular VOIP application, or Playtech, the world's largest publicly traded online gaming software supplier. Regio that started as the map publisher has developed into GIS software and mobile solutions developer. There is a stream of m-services developed in Estonia that have become very popular. Recently EMT-launched 'Mobile ID' for personal identification as well as digital signing is an additional unique service.

The Estonian ICT sector consists of about 500 active companies that generate 1.1 billion EUR turnover and employed 8,600 people.[43] The sector is rather consolidated; the largest 100 companies account for 90% of the market (Table 3).

[38] Äripäev 2006.

[39] Annual reports of companies, calculations by author.

[40] for the history of Internet banking, see Kerem 2003

[41] Alec 2004. See also Centeno 2004.

[42] Kalvet 2006, p. 81-83.

[43] Estimation according to annual report of 640 companies from 2005.

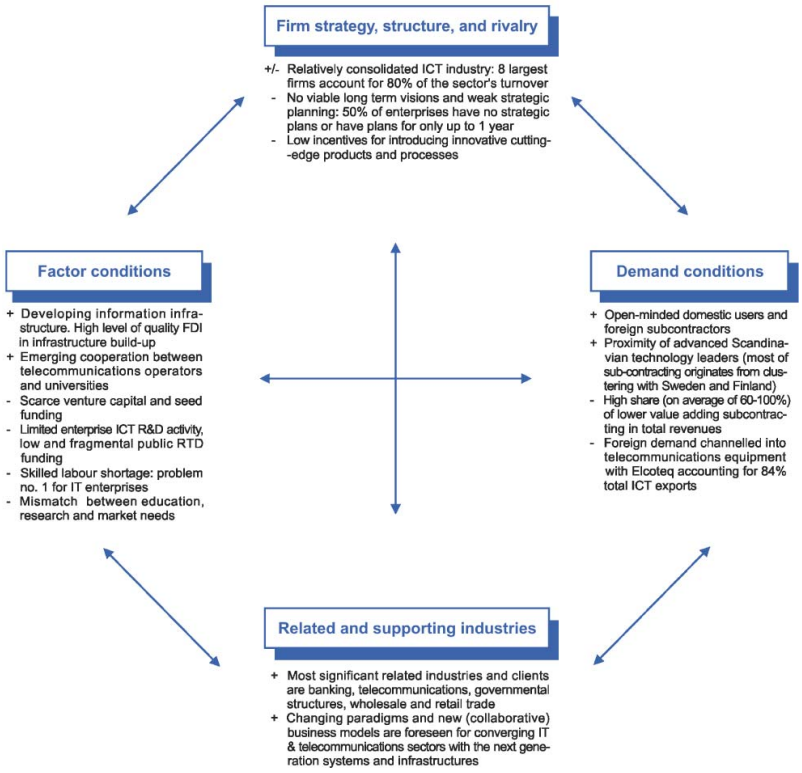
Table 3. Estonian ICT market, 2005

Annual turnover, mil EUR	Number of companies	Market share
above 6.4	24	72%
3.2-6.4	19	8%
1.3-3.2	47	8%
0.6-1.3	57	4%
0.06-0.6	325	7%
below 0.06	168	1%

Source: Klaamann 2007

Although the mapping of the Estonian ICT cluster and the analysis of respective innovation system was carried out few years ago (Figure 8), the main conclusions from 2002 seem to be valid also today. The reestablishment of governmental structures, the emergence of a modern telecommunications and private sector banking system as well as rapid development in wholesale/retail trade and other knowledge-intensive business services have all contributed to the Estonian ICT cluster. Evidence from other countries seems to support this. A study on 42 US industries concludes that wholesale trade, the finance sector, and business services are the sectors with the largest IT investment and positive externalities.[44] Although innovative uses of ICT can be found throughout the Estonian manufacturing industry, the share of companies generally that has integrated ICT with internal and/or external business processes is lower in Estonia then in the EU in average.[45]

Figure 8. Estonian ICT cluster - Porter´s diamond



Source: Kalvet et al. 2002, p. 15

[44] Mun and Nadiri 2002.

[45] *Accompanying document to* … 2007, p. 26.

When looking at the ICT and electronics manufacturing in general, a close linkage between Estonia and Finland can be noticed; this applies to export markets, ownership, etc leading to conclusions that the Estonian ICT manufacturing sector is actually part of the larger Nordic ICT manufacturing cluster where lower value-added activities take place.[46] The major flourishing of ICT manufacturing in a neighbouring country that is one of the main ICT and electronic production powerhouses in Europe[47], has certainly provided spill-overs, allowing Estonia to enter global production networks. However, when looking at the value-added structure of the Estonian economy and the value-added structure of exports[48], it becomes clear that the role of ICT manufacturing in comparison with other branches of manufacturing is relatively small. And, there is no convincing empirical evidence for the widely held view that Estonian ICT manufacturing has been moving from low value-added manufacturing towards higher value-added production.

[46] Kalvet 2002.

[47] Koski et al. 2002.

[48] Kaasik 2003.

5. Education, research and development

The main providers of ICT education 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. 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.[49]

The number of students in computer sciences in professional higher education, applied higher education and diploma studies was 1,336 in 2006. 1,905 were involved in bachelor courses, 683 in master courses and 128 in doctor courses.[50] The low number of graduates (e.g., 5 PhD's in 2006, 60 Master's and 285 Bachelor courses graduates) has raised some discussions in Estonia about the lack of ICT professionals for further development. Also, the decreasing population will have a considerable impact on the Estonian educational system as a whole – the number of potential students at educational institutions will start to fall after 2007.

Although ICT education provided so far has backed up private sector developments, the need to develop curricula is also currently clear: 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.[51]

Estonia is well known for its ICT initiative on the general education level, namely the Tiger Leap Foundation established in 1997 to offer support in procuring ICT equipment for general educational schools. While the Foundation enjoyed strong political support and resulted with increasing the penetration of ICT in schools, there are profound problems unresolved. For example, Quangos, quasi-autonomous non-governmental organizations, have been given considerable role in the advancement of ICT education and e-learning in Estonia, but has resulted with a situation where government has given up responsibilities in guiding the developments, and is not providing legal and financial support as needed.[52] There are, still, successful initiatives in management of administrative information. An example is the first in the EU central enrolment information system called SAIS (SissAstumise InfoSüsteem) that has been developed for participating universities to consolidate the whole enrolment information, process and decision-making in one site. The system uses national ID-card as authentication tool aside from bank authentication. Currently Estonian Information Technology Foundation that is administering the National Support Programme for ICT in Higher Education Tiger University, Estonian E-university and Estonian E-Vocational School is key player in this respect.[53]

When looking at scientific excellence and R&D, the following must be considered: Compared to other former Soviet Republics, Estonia was in a rather advantageous position because there were some ICT-manufacturing industry that existed in the country. Almost all formerly state-owned organisations had their computing centre; and the Tallinn University of Technology and the University of Tartu provided good ICT-education.

[49] For detailed overview, see chapter 4 (Estonian ICT Sector Education and Research System) and Chapter 5 (Vocational ICT Education System) in Kattel and Kalvet 2006.

[50] Statistical Office of Estonia

[51] See Kalvet and Kattel 2006, pp. 56-60 and pp. 76-84.

[52] Suurna 2007.

[53] See Suurna 2007 for complete overview.

The first computers in Estonia were manufactured and installed already at the end of 1950s and in the beginning of the 1960s. The first computer centres were established in the University of Tartu (1959), Institute of Cybernetics (1960), and Tallinn University of Technology (Tallinn Polytechnical Institute). And the first- and second-generation Soviet-made Ural and Minsk computers were used both in scientific research and IT education at universities. In the 1980s, specialists from Estonia participated in the development of standard software engineering, CASE tools, among others, for different ministries of the Soviet Union. For example, the Institute of Cybernetics (established in 1960 as an institute of the Estonian Academy of Sciences) had competencies in elaborating problem-oriented software systems. Today, the Institute of Cybernetics of Tallinn University of Technology is an interdisciplinary research institution that specialises in control theory, selected areas of applied mathematics and theoretical mechanics, and selected areas of computer science and information technology, namely, programming language theory, specification and verification of timed and hybrid systems, databases and information systems research. The Institute has also been the motor of nearly all nationwide collaborative initiatives in the field of ICT.

The other important research and development competence centre has been Cybernetica AS, established in 1997 as a spin-off of the Institute of Cybernetics. It deals with information security (communications security products, digital signature technology), development of mission-critical systems and navigation systems development company. They were also involved in the development of the Estonian e-voting software.

In general, empirical data shows that the Estonian research system is not strong in an international comparison. In 2005 total spending on R&D reached 0.9% of GDP; EU15 average was 1.9% and EU27 1.8%. Spending of business enterprise sector on R&D was 0.42% of GDP in Estonia, both in EU15 and EU27 it was 1.2%.[54] The branches of Estonian industry whose sectoral value added as % of national GDP is the highest, are not R&D intensive. For example, when transport, storage and communication have a contribution of 10.6% to GDP (2005), its R&D intensity[55] is only 0.1; in the wholesale and retail trade and repair of motor vehicles the respective figures are 13.2 and 0.08. The most R&D intensive sectors in Estonia are computer and related activities, manufacture of electrical and optical equipment, chemical industry, and manufacture of transport equipment. According to various experts there are some 50 world class research intensive companies in Estonia, about 10-15 of them might belong to ICT sector.[56]

When we take a closer look at the publications of and references to Estonian ICT scientists in the databases of *ISI Web of Science*[57], we can bring out the following generalisations:

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). 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.[58]

[54] Eurostat 2007.

[55] Share of sectoral R&D in sectoral value added.

[56] See Gabrielsson et al. 2007, Chapter 3.

[57] For detailed results see Hakkaja 2005.

[58] Kalvet and Kattel 2006, 52.

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

Institution	No of scientists	Total no of articles	References	References/articles	Total for Institution	Average per person
Cybernetica	13	11	10	0.9	21	1.6
TTÜ, Küberneetika Instituut	27	143	268	1.9	411	15.2
TTÜ	91	149	168	1.1	317	3.5
TÜ	19	41	778	19.0	819	43.1
TÜ[59]	18	27	44	1.6	71	3.9
Kokku[60]	155	326	1202			

Source: Kattel and Kalvet 2006, p 52

Secondly, more than 80% of all publications of and references to Estonian ICT scientists from 19 79-2004 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.[61]

[59] Without Dr Jaak Vilo.

[60] 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..

[61] Kalvet and Kattel 2006, 52.

6. Digital divide

The changes in and development of the new techno-economic paradigm results with both winners and losers. Namely, some countries, population groups, and persons adapt to changes more easily, and others are more passive or even work against the changes. The term 'digital divide' refers to one of the dangers brought about by the emergence of the ICT paradigm and is understood as the gap between individuals, households, businesses, and geographic areas at different socioeconomic levels with regard both to their opportunities to access information and communication technologies and to their use of the Internet. The digital divide reflects various differences among and within countries.[62] In the context of the ICT paradigm, it refers to a situation where part of the population (or countries) is being or about to be excluded, because of an existing or emerging digital divide, from further economic and social development and well-being that is brought about by ICTs.

A study from 2002 showed that there are 'Blue Collars' and 'Passive People' among the non-users of the Internet in Estonia. 'Passive People' are characterized by the following: most of the people in this group are 50 or older; they have relatively little interest in matters outside their daily life; their relation to the Internet or to computers is very weak, they neither see any benefits in the Internet nor do they have any need to use it; they prefer to use the traditional media (even if the Internet were cheaper and more convenient), as apart from their general display of a lack of interest, they are constrained by the language barrier and are unable to handle the user interfaces of computers; they are also relatively less capable of learning and memorizing new things, and unwilling to change their habits. 'Blue Collars' are mainly unskilled and skilled workers who do not need computers at their jobs; about half of the people in this group see no benefits in the Internet and are not willing to change their daily routines.[63]

The results regarding non-users, and most importantly about 'Passive People' are confirmed by a study from 2005: "… in 2005, people who were not using the Internet had a dominant home and garden-related lifestyle factor."[64] The study takes a detailed approach in relating Internet users and their Internet uses with actual lifestyles and comes up with a following typology: 'Versatile consumption oriented user', 'Communication and entertainment oriented user', 'Work and information oriented user', 'Entertainment and family information orientated user', 'Public and practical information user' and 'Small-scale user'. It also calls for further analysis on "aspects of what people do with the Internet."[65]

[62] OECD 2001, p. 5.
[63] Kalkun and Kalvet 2002.
[64] Pruulmann-Vengerfeldt 2006, p. 39.
[65] *Ibid,* p. 36.

7. Trust, network and information security

In terms of confidence in the security of e-services one of the relatively recent studies came up with a shocking result arguing that 64% of those using the Internet have distrust in the security of eServices.[66] This is in sharp contract with an EU-wide study according to which Estonia has been one of those with the lower level of concerns on data security and privacy/confidentiality after Bulgaria and Hungary. Only 9% of regular Internet users are very concerned about data security in Estonia, compared with 24% in CEE and 26% in EU countries on average (20% in Switzerland and 40% in the United States of America). Similar results were found on concerns about privacy and confidentiality.[67]

A lower level of concern has also been indicated in the recent pan-European comparisons: the share of individuals who have experienced fraudulent payment (credit or debit card use) or computer virus resulting in loss of information or time is lower compared to the EU average.[68] And, as far as one can say, there has been no major security accidents in Estonia over the last years that could have explained such major shifts.

No detailed studies are available investigating the reason why Estonian inhabitants generally trust online transactions more than people from the other regions. It may be plausible to presume however that the current situation has been caused by the existence of advanced and secure solutions, positive experiences with and tremendously positive image of on-line banking in Estonia. Even if there have been security incidents with on-line services, they have been handled in most appropriate ways, both in technical and public relations terms. This has also created a situation where people are not afraid of revealing very sensitive information (e.g., political preferences) over the Internet and created an exceptional base for the further development of e-voting solutions.

Avoidance of cybercrime[69] has been an important field in Estonia and has been promoted by all major information society stakeholders. This was the idea behind Estonian Public Key Infrastructure and ID cards and later eServices Interoperability Architecture; banks have been also very active in increasing awareness regarding cybercrimes. The most recent step in this respect is an initiative 'Computer Protection 2009'[70] with the objective, as it has been explicitly expressed, of becoming the country with the most secure information society.

Issues related to network and information security are much more global, of course. Cyberwar reflect a situation where warring nations or terrorist groups attack vulnerable computer networks. Estonian computer networks were subject to exactly such kind of attacks in April and May 2007 following the tensions with Russia over the removal of a Soviet-era war memorial. It is still unclear if the cyberattacks originated from the state-run computer networks from Russia or this attack was the work of tech-savvy activists, or 'hactivists,' but in any case swarms of computers hijacked by surreptitiously placed code swamped sites by deluging them with

[66] TNS Emor 2005.

[67] SIBIS 2003.

[68] Eurostat 2006.

[69] Cybercrime is a term used broadly to describe activity in which computers or networks are a tool, a target, or a place of criminal activity. See Council of Europe 2001.

[70] In May 2006 leaders of the largest banks (SEB Eesti Ühispank, Hansapank) and telecom operators (Elion, EMT) as well as the Ministry of Economic Affairs and Communications signed a co-operation agreement to launch a nationwide initiative to increase end-user PC protection and awareness in Estonia. A number of sub-projects will be launched (funded by these companies in the amount of EUR 3.7 million), the priority fields being the promotion of ID card-based authentication in the use of eServices. As of May 2, 2007 the banks did set a limit for financial transaction when logged in with a password card. In order to do transactions above EUR 640 limit, one has to use PIN calculator, password card where passwords are not reused, or, as recommended by banks, ID Cards.

bogus requests for information. Such "distributed denial of service" (DDOS) attack, this at its peak involved more than 1 million computers, created traffic equivalent to 5,000 clicks per second on some targets and blocked online access to banks and government offices. Also, to remain open to local users, Estonia has had to cut access to its Internet sites from abroad.[71]

[71] See Economist 2007a and 2007b.

8. Discussion: Towards the explanatory framework

Since the 1990s Estonia has achieved remarkable successes in information society development. Within a relatively short period Internet usage has skyrocketed, and e-services and m-services have found their place in the everyday life of the inhabitants and businesses of Estonia. What follows is a brief discussion of the main features of the transformation of Estonia into an information society.[72]

The major factors that have affected as well as contributed to the evolution of information society in Estonia include the economic factors, active role of the public sector, technological competency, and socio-cultural factors. The latter is closely related to demand for ICT and ICT-based services and is discussed in detail in other studies[73]. We will take a closer look at the factors leading to the supply of ICT infrastructure and e-services that have resulted in a synergetic and reinforcing interplay.

As a result of a series of market reforms and the relatively rapid achievement of macroeconomic stability, the Estonian economy has grown at an average of over 6% a year since 1995 with growth rates peaking at 10.5% in 2005 and 11.4 in 2006[74], making it a star performer in the EU. As a result, the Estonian GDP per capita, taking into account the purchasing power parity, has increased from 51% of the EU25 average in 2003 to 65% as of 2006.[75]

Such rapid economic growth and its direct impact (e.g., increases in tax revenues to cover State ICT-investments) or indirect impact (e.g., increases in living standards and thus more widespread home ICT-infrastructure) have had definite and positive impact on the Estonian information society development. Although countries can be found that have rapid economic growth, but slow progress in information society matters, these two are generally interlinked as there is probably no serious thinking when one has a 'bread or broadband' dilemma. The possible hypothesis that ICT is supporting the productivity explosion behind Estonian economic growth needs to be investigated further, but the existing evidence does give some basis for such claims.

Estonia's relative underdevelopment of the telecommunications infrastructure and ICT in general in the 1980s, might be also considered as an important factor in the end. There was not so much effort needed to "learn to destroy" and "creative processes" could be undertaken immediately.[76] Rapid switching from mainframe to PCs and skipping the "checks era" in banking certainly did contribute to Estonian rapid developments.

The telecommunications and banking sectors are cornerstones of the Estonian information society developments. Leading companies in these sectors have received considerable amounts of FDI and are currently among the most profitable and innovative companies in Estonia. As a result a very advanced but at the same time affordable telecom network has been established. A fully functional banking sector is crucial for capitalist economies; next to providing traditional financial services, the Estonian banking sector took a strong initiative in launching modern e-services creating expectations for similar kinds of e-services from other private as well as public sector organisations.

[72] Inspired by the work of Castells and Himanen (2002); for their analysis of the Finnish model of the information society see Chapter 7 in their book.

[73] For a detailed discussion of Internet users and uses, including the developments related to new media, see Pruulmann-Vengerfeldt 2006.

[74] Eurostat 2007.

[75] *Ibid.*

[76] See Högselius 2006 for a illustrative case studies.

The leading companies from both these sectors have gone beyond focusing just on their own business matters. Although characterising their activities as carried by 'Corporate Social Responsibility' might be too generous, they have launched several activities that are in the interests of society. They were, for example, behind Look@World initiative that provided basic ICT training to 100,000 people in Estonia and in the establishment of the Estonian IT College. Look@World has been also behind supporting the development of public internet access points all over Estonia. Currently the Foundation is involved in the initiative 'Computer Protection 2009'. A more classical example of Public Private Partnership is their activity in establishing public key infrastructure in Estonia via the Certification Centre.

In addition to the explosive growth of the banking and telecommunications sectors, growth has taken place in the wholesale/retail and other business services, i.e. in sectors where the empirical evidence from other countries shows largest IT investments and positive externalities.

The role of the public sector is very important in the societal development. The State has the role of going along with the ICT-paradigm, in providing the framework for all sectors to develop and avoiding the emergence of a digital divide as well as in modernising itself.

In the Estonian public sector there are two major horizontal projects that have both become very important for the modernisation of the public sector. First, government information systems and databases have been connected to the Internet through a service known as the 'X-Road'. Second, the Estonian ID-card, a compulsory identity document for all citizens includes electronic authentication and authorization which provides the foundation for several innovative e-services. These services have also provided a direct boost to the respective developments in the private sector.

Although the activities of the Estonian state can not be generally paralleled to 'developmental states' – i.e. to states that are actively promoting industrial transformation taking sometimes even leading roles[77] -, but can be rather characterised as 'autonomous', in the case of several public sector ICT-initiatives (including e-voting), a dynamic relationship between private and public sectors can be observed fuelling the arguments in support of public procurement as an important innovation policy instrument.[78]

The Open Estonia Foundation from the NGO sector has been instrumental in guiding Estonian information society; within its Internet program that was initiated in 1995 calls for proposals asking for innovative ICT-based services were organised and funding provided. Over the period 1992-1999 more then 190 projects were supported, including support to infrastructure development (including Public Internet Access Points) and applications (including www-sites and software in Estonian language). Although the total funding allocated was 1.7 mln EUR[79], this generated with many (pilot) projects that later became very popular and created demand for such services from the public sector.

Without the existence of ICT skills and R&D competencies, a lot of which is a Soviet inheritance, the previously mentioned success in developing eGovernment or R&D-intensive products and services would not have been possible. Tallinn University of Technology, the Institute of Cybernetics and Cybernetica have been all actively involved in nearly all nationwide collaborative initiatives in the field of ICT. On the other hand, there have been initiatives aimed at increasing the level of ICT-education in schools (Tiger Leap) or among the general public (Look@World Internet Training).

Although foreign companies have been very active in the Estonian ICT market since the mid-1990s and they have been involved in the development of e-solutions, local companies still play the key role. In the case of e-

[77] See Evans 1995 and Wade 2003 for discussion.

[78] See Edler and Georghiou 2007.

[79] Open Estonia Foundation 2000.

banking, the solutions developed and put in place in Estonia are arguably being currently implemented in other countries after the Estonian biggest banks have become more integrated with the main headquarters (i.e. there is inverted technology transfer taking place).

Innovation culture has been crucial for the emergence of the most successful ICT-enabled applications and services. Himanen has called it 'hacker ethic' – a wish to realise creative passion, a wish to constantly surpass themselves, to produce creative work as a result of their actions.[80] And, those 'ethical hackers' have been provided with opportunities to implement their solutions, both in the public as well as private sectors.

Attempts to build up an information society as well as a knowledge-based economy in Estonia can be traced way back in Estonian politics and policy, although, the number of concrete policy instruments in support of such developments is surprisingly low. The exception is the beginning of the 1990s when 'good governance' can be observed: there was an Informatics Council established in 1989 that included representatives of the private sector and had real power in co-ordinating developments and implementing body.[81]

The steps regarding the involvement of strategic partners and liberalisation of the telecommunications market have been crucial; also, Parliamentary approval of regulative acts giving a green light to key horizontal projects such as ID-card equipped with electronic functions and e-voting, have had major impact.

The Estonian information society policy has been mainly oriented towards social issues and the modernisation of public administration. Estonian R&D&I policies on the other hand have been oriented to commercialisation of the knowledge from the public R&D facilities.[82] Recently, major changes can be observed in the nature of information society policy. It has become more discussed and implemented in synergy with other policies (e.g., enterprise support, education policy). This is attributable to the whole logic of the planning in the use of EU Structural Funds. Also, Estonian R&D&I policy is becoming more friendly towards existing enterprises; the R&D&I strategy for 2007-2013 foresees again preparation of national programmes in key fields and this time first steps have already been taken by respective ministries in 2007 that could give a further boost to private sector developments.

[80] Himanen 2001. This is similar to Schumpeter's famous approach to an enterpreneur, whose motives are more complex than profit maximisation and may include "the dream and the will to found a private kingdom, usually, though not necessarily, also a dynasty," and the "will to conquer: the impulse to fight, to prove oneself superior to others, to succeed for the sake, not of the fruits of success, but of success itself," and/or the "joy of creating, of getting things done, or simply of exercising one's energy and ingenuity" (Schumpeter 1934, p. 93).

[81] Although the Council has continued in advising the Government of the Republic, its role has diminished and since 2005 the Council has not actually held meetings.

[82] Kattel and Kalvet 2006, p. 11. See also Radosevic and Reid 2006.

9. Recommendations for future information society research

There are still several major technical and non-technical aspects related to information society research that need to be studied further. Based on Estonian experience the following can be emphasized.

Perhaps the most challenging issue is related to the potential of ICT to contribute directly to the economic development. Although it is generally agreed that the Estonian economy has been successful in catching-up with developed countries via the application of technologies, work organisation and know-how imported from the more advanced countries, there are streams of studies arguing that major challenges lie ahead as long as the commitment to bring about the economic, social and environmental renewal proposed in the EU's Lisbon Strategy, which will involve using innovation as the motor for economic change, and developing a learning economy, is concerned. According to some studies[83] the technological structure of Estonia's manufacturing industry has evolved since the mid 1990s towards less complexity, "This in turn highlights that, despite an enviable record of economic growth, Estonia's industrial structure in 1996 was in better shape than in 2000".[84]

One of the most controversial eServices implemented in Estonia is related to e-voting (as Internet-based voting). It appears that Estonia is the only country in the European Union with an e-voting law for national elections actually in place and Estonia was the first country in the world to enable its citizens worldwide to vote over the Internet for political elections. Several problems require further research. At first, security remains an issue. All reports dealing with e-voting solutions point to this issue, and there are reports that suggest cancelling any experiments related to Internet-based voting due to unsolved security issues. Estonian ID-card based public key infrastructure is certainly exceptional and several security risks are thus marginal, but further research might be needed. There remain also doubts whether such socially sensitive solutions should be implemented further, and whether the criticism on the implementation of e-voting in Estonia on the basis of its collision with the constitutional principles of secrecy, generality, and uniformity and possible technical problems and dangers is material and valid[85].

Another issue related to the public sector include co-ordination issues. The Estonian analysis shows that co-ordination of various ICT-related functions, levels and sectors remains an unsolved issue. More co-ordination can be achieved by hierarchy, network, or market. Next to the classical 'exercise of authority from the top' approach there is a network model that is based on solidarity, voluntary co-operation within a network, but assumes that objectives are widely shared among all network members. What could be the best model for the co-ordination of ICT development in Estonia should be further researched. But as objectives in the Estonian public administration are not really shared, network-based model would not work. Or, should one focus on building shared vision in the civil service and market players, instead of choosing between hierarchies and market? Shared vision has been central to the success of the Finnish model.[86]

Estonia is considered successful in the implementation of eGovernment solutions. Yet, the slowing down of developments in recent years urges for an analysis of the experiences of other countries and hence for lesson-drawing (which has already been done beneficially in the field of m-services). From another perspective, Es-

[83] See, for example, Tiits et al. 2003.

[84] *Ibid*, p. 27.

[85] See Drechsler and Madise 2004.

[86] Castells and Himanen 2002.

tonia's success in eGovernance has brought up discussions in many countries about the transferability of the Estonian model to them. Two research challenges are related.

Cost-benefit analysis and evaluation of Estonian public sector ICT solutions is severely limited. This is partially due to unavailability of cost data, but also due to lack of knowledge of methodologies and lack of respective tradition in Estonia. Hence, more research and policy analysis in the field of evaluation and cost-benefit analysis are needed to investigate the important questions, namely: if ICT is used in an efficient and effective manner, and if it brings about more transparency and accountability, among others.

Different issues emerge in the case of technology transfer. Theoretical literature suggests to move beyond widespread and simplistic 'best practice' dissemination. It is well know in the innovation research that institutions like norms, habits, and rules matter[87] and thus immediate policy transfer is impossible. "Borrowing a program that is effective elsewhere is no guarantee of success"[88], and one should instead use benchmarking, best practice, and lesson- drawing. Future research should identify what best practices are transferable to and from Estonia. For instance, the Estonian ID-card and PKI infrastructure for example could not be replicated in countries that do not issue mandatory ID cards, and whose citizens lack the trust required for their implementation. All these context-specific issues matter and should be researched further.

e-services have the potential to change many traditional practices in the society, thus social and ethical aspects must be researched further. This is especially true for the Health, for which some have speculated for the loss of trust between patient and doctor, fetishism of stored information. Additional problems may arise if privately shared individual health data will be simultaneously used for administrative purposes by policy-makers, who at the same time advocate for increased individual responsibility. Some more technical issues are also related to the integration and interoperability on international level and language technologies for *Ambient Intelligence*.

Digital divide continues to be a problem in Estonia. Also, Internet users seem to have different profiles, some preferring just entertainment-oriented uses and neglecting the wide array of public and private sector services available. The overcoming of digital divide and increasing awareness of existing e-services needs to be tackled, thus.

Also, cyber security has become an issue needing urgent addressing as well. Although there are many international organisations addressing the issue, the wide-spread approval of an international legal code regarding cybercrimes is missing.[89] How to regulate Internet and cyberactivities, including cyberwar, remains a partially researched issue.

[87] See, for example, Lundvall 1995.

[88] Rose 1993, p. ix.

[89] cf. the situation with the Council of Europe's *Treaty on Cybercrime*.

References

Accompanying document to the i2010 - Annual Information Society Report 2007, Commission of the European Communities, http://ec.europa.eu/information_society/eeurope/i2010/docs/annual_report/2007/sec_2007_395_en_documentdetravail3_p.pdf, 2007.

Alec, Charles. Estonia - the State of the e-state, *The Baltic Times*, 22 July, 2004, http://www.baltictimes.com/news/articles/10522/.

Äripäev. Estonia's Leading Enterprises, TOP 100, 1 December 2006.

Bank of Estonia, *On-line Database, 2007.*

Centeno, Clara. Adoption of Internet services in the Acceding and Candidate Countries, Lessons from the Internet Banking Case, *Telematics and Informatics*, 21, pp. 293–315, 2004.

Certification Centre (AS Sertifitseerimiskeskus), personal communication, August 2007.

Council of Europe, *Convention on Cybercrime*, http://conventions.coe.int/Treaty/EN/Treaties/HTML/185.htm, 2001.

Drechsler, Wolfang and Ülle Madise. Electronic Voting in Estonia, in: Norbert Kersting and Harald Baldersheim, eds., *Electronic Voting and Democracy. A Comparative Analysis*, Basingstoke: Palgrave Macmillan, 2004, pp. 97-108.

Dutta Soumitra and Irene Mia, *Global Information Technology Report 2006-2007: Connecting to the Networked Economy,* New York: Palgrave Macmillan, 2007.

Economist, Newly nasty, May 24th 2007.

Economist, A cyber-riot, May 10th 2007.

Economist Intelligence Unit, *The 2006 e-readiness rankings, A white paper from the Economist Intelligence Unit,* http://a330.g.akamai.net/7/330/25828/20060531184642/graphics.eiu.com/files/ad_pdfs/2006Ereadiness_Ranking_WP.pdf, 2006.

Edler, Jakob and Luke Georghiou, Public procurement and innovation – Resurrecting the demand side, *Research Policy*, forthcoming in 2007.

Estonian Information Society Development Strategy 2013, Ministry of Economic Affairs and Communications, http://www.riso.ee/en/files/IYA_ENGLISH_v1.pdf, 2006.

Estonian Research, Development and Innovation Strategy 2007-2013 (Eesti teadus- ja arendustegevuse ning innovatsiooni strateegia 2007–2013), Riigikogu (Parliament), http://web.riigikogu.ee/ems/saros-bin/mgetdoc?itemid=063390023&login=proov&password=&system=ems&server=ragne11, February 2007.

Estonian Research and Development Strategy 2002-2006, Research and Development Council, http://vana.hm.ee/uus/hm/client/index.php?1352671823229, 2002.

Estonian Tax and Customs Board, *Estonian Tax and Customs Board Yearbook 2006*, http://www.emta.ee/doc.php?21262, 2007.

Eurostat, *Eurostat On-line Database*, 2007.

Hakkaja, Kristi . *Estonian ICT Research and its Impacts – Bibliometric Analysis, PRAXIS Working Paper No 22*, PRAXIS Center for Policy Studies, 2005.

Hansen, John and Piritta Sorsa. Estonia: A Shining Star from the Baltics. In: Constantine Michalopoulos and David G. Tarr (Eds.), *Trade in the New Independent States*. Washington, DC: World Bank, 1994.

Högselius, Per. Learning to Destroy: Case Studies of Creative Destruction Management in the New Europe. In: Tarmo Kalvet and Rainer Kattel (eds), *Creative Destruction Management: Meeting the Challenges of the Techno-Economic Paradigm Shift*, Tallinn: PRAXIS Center for Policy Studies, 2006, pp. 73-83.

Högselius, Per. *The Dynamics of Innovation in Eastern Europe: Lessons from Estonia*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing, 2005.

Information Society Benchmarking Report, European Commission, http://europa.eu.int/information_society/eeurope/i2010/docs/benchmarking/051222%20Final%20Benchmarking%20Report.pdf, 2005.

Information Technology in Public Administration of Estonia, Annual Report 1994-2005, Tallinn: Estonian Informatics Centre, http://www.riso.ee/en/publications/natpublications.

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

Kalkun, Mari and Tarmo Kalvet (Eds.), *Digital Divide in Estonia and How To Bridge It*, Tallinn: PRAXIS Center for Policy Studies, 2002.

Kalvet, Tarmo. *Private Sector R&D in the New Member States: Case of Estonia,* Framework Service Contract 150083-2005-02-BE with the Institute for Prospective Technological Studies - Directorate General Joint Research Centre, European Commission, Brussels: European Techno-Economic Policy Support Network, 2006.

Kalvet, Tarmo. *The Estonian ICT Manufacturing and Software Industry: Current State and Future Outlook*, Seville: Institute for Prospective Technological Studies - Directorate General Joint Research Centre, European Commission, http://www.jrc.es/home/publications/publication.cfm?pub=1200, 2004.

Kalvet, Tarmo. *Theoretical Issues and Practical Plans of Information Policy in Developed Countries*, BA Thesis, Tartu: University of Tartu, 1997.

Kalvet, Tarmo and Ain Aaviksoo, Next Steps in Developing Information Society Services in the New Member States. The Cases of eGovernment and eHealth in Estonia, Seville: Institute for Prospective Technological Studies - Directorate General Joint Research Centre, European Commission, forthcoming in 2007.

Kalvet, Tarmo, Pihl, Tarmo and Marek Tiits, *Analysis of the Estonian ICT Sector Innovation System. Executive Summary*, Tartu: Archimedes Foundation, 2002.

Kattel, Rainer and Tarmo Kalvet, *Knowledge-based Economy and ICT-Related Education: Overview of the Current Situation and Challenges for the Education System*. Tallinn: PRAXIS Center for Policy Studies, 2006.

Kerem, Katri. *Internet Banking in Estonia*, PRAXIS Working Paper No 7/2003, http://www.praxis.ee/data/PRAXIS_Internet_Banking_in_Estonia0.pdf, 2003.

Klaamann, Vaho. *Eesti IKT sektori analüüs 2005 aasta andmete põhjal (Study of Estonian ICT sector based on 2005 data),* Tallinn: Estonian Association of Information Technology and Telecommunications, 2007.

Koski, Heli, Rouvinen, Petri and Pekka Ylä-Anttila, ICT Clusters in Europe. The great central banana and small Nordic potato. *Information Economics and Policy*, 14, 145-165, 2002.

Krull, Andre. *ICT Infrastructure and E-readiness Assessment Report: Estonia*, PRAXIS Working Paper No 5/2003, Tallinn: PRAXIS Center for Policy Studies, 2003.

Levy, Steven. True or False: U.S.'s Broadband Penetration Is Lower Than Even Estonia's, *Newsweek*, July 2-9, 2007.

Mun, Sung-Bae and Ishaq M. Nadiri, Information Technology Externalities: Empirical Evidence From 42 U.S. Industries, *NBER Working Paper No. 9272*, 2002.

OECD Reviews of Foreign Direct Investment, *Estonia*. Paris: OECD, 2001.

Online Availability of Public Services: How Is Europe Progressing? Web Based Survey on Electronic Public Services Report of the 6th Measurement, http://ec.europa.eu/information_society/eeurope/i2010/docs/benchmarking/online_availability_2006.pdf, 2006.

Online Availability of Public Services: How is Europe Progressing? Web Based Survey on Electronic Public Services. Report of the Fifht Measurement. October 2004. Capemini, http://ec.europa.eu/information_society/soccul/egov/egov_benchmarking_2005.pdf, 2005.

Open Estonia Foundation, *Overview of Internet Programme of Open Estonia Foundtion*, 2000.

Pruulmann-Vengerfeldt, Pille. Information Technology Users and Uses within the Different Layers of the Information Environment in Estonia, PhD Thesis, Tartu: University of Tartu Press, 2006.

Principles of the Estonian Information Policy 2004–2006. Estonian IT Policy: Towards a More Service-Centred and Citizen-Friendly State, http://www.riso.ee/en/Information_Policy_04.pdf, 2004.

Principles of Estonian Information Policy, RTI 1998, 47, 700.

Radosevic, Slavo and Alasdair Reid, Innovation Policy for a Knowledge-based Economy in Central and Eastern Europe: Driver of Growth or New Layer of Bureacracy? In: Piech, Krzysztof and Slavo Radosevic (Eds), *The Knowledge-based Economy in Central and Eastern Europe*, New York: Palgrave Macmillan, pp. 295-311, 2006.

Rannu, Rain. Mobile Services in Estonia, PRAXIS Working Paper no 8/2003. http://www.praxis.ee/data/PRAXIS_Mobile_Services_in_Estonia3.pdf.

Rannu, Rain and Maarja Semevsky, *Mobile Services in Tartu. Existing services, best practices, methodology and suggestions for future development*, Tartu: Mobi Solutions. http://www.ega.ee/public/Mobile_services_in_Tartu_FINAL1.pdf, 2005.

Schumpeter, Joseph A. *Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Cambridge, MA: Harvard University Press, 1934.

SIBIS, *Estonia. Country Report No.3,* 2003.

Statistical Office of Estonia, *On-line database*, www.stat.ee, 2007.

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

Suurna, Margit. *The Influence of Quangos on National Innovation Systems – Case Studies of the Estonian Genome Project and the e-Learning Initiatives*, Master Thesis. Tallinn: Tallinn University of Technology, 2007.

The National Election Committee, Municipal elections 2006, http://www.vvk.ee/english/report2006.pdf, 2006.

Tiits, Marek, Kattel, Rainer, Kalvet, Tarmo and Rein Kaarli, *Competitiveness and Future Outlooks of the Estonian Economy*, Tallinn: Research and Development Council, 2003.

Trechsel, Alexander, H. *Report for the Council of Europe. Internet voting in the Parliamentary Elections in Estonia.* http://www.vvk.ee/english/CoE%20and%20NEC_Report%20E-Voting%202007.pdf, 2007.

TNS EMOR, *Gallup e-Ratings, Estonia*, 1998-2007.

UN Global E-Governement Readiness Report Readiness Report 2005. From E-Governement to E-Inclusion, Department of Economic and Social Affairs Division for Public Administration and Development Management, New York: United Nations, http://unpan1.un.org/intradoc/groups/public/documents/un/unpan021888.pdf, 2005.

Wade, Robert. What strategies are viable for developing countries today? The World Trade Organization and the shrinking of 'development space'. *Review of International Political Economy*. 10, 4, pp. 621-644, 2003.