ICT, Innovations and Innovation policy: The Case of Estonia

Working Paper

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1. ICT as techno-economic paradigm leader and the key role of the state[2]

1.1. The importance of innovation

The 1980s and 1990s have been the era of rapid developments in information and communications technology (hereafter ICT), leading to different theories of information society and arguments about the emergence of a 'new economy'. Statements like "knowledge and information is being produced today like cars and steel were produced a hundred years ago… just as the importance of land in production changed dramatically as the economy moved from agriculture to industry, so too does the movement to a knowledge economy necessitates a rethinking of economic fundamentals" (Stiglitz 1999, p. 1) are rather widely spread. Whether economic fundamentals really have changed or such transformations have similarities in history, remains debated, although the authors of the paper are sympathetic to the historical approach and support the theory of economic waves.

The rapid increase of ICT industries has also caused major changes on the international economic arena. For example, at the end of World War II Britain had a comparative advantage in the computer industry, surpassed only by that of the United States. However, at the beginning of the 1990s, the last major British computer company was purchased by a Japanese company (Evans 1995, p. 99). Korea, which notably started its efforts to build the computer industry only after India and Brazil (Evans 1995, p. 109), made together with other newly industrialised states its successful emergence into the group of industrialized countries.

Such major changes in contemporary economics and society have lead to a question about the role of the State in economic transformation. While many agree, that guaranteeing security and internal order are the classic tasks of the State, the argument that "in the contemporary world, fostering economic transformation and guaranteeing minimal levels of welfare are not far behind" (Evans 1995, p. 5) is somehow questioned by dominating neo-liberal view. Actually, "there is virtually no country, except Hong Kong, which achieved the

[2] This working paper does not attempt to provide detailed information about Estonian transition. Instead, it provides the reader with relevant background information for understanding the developments of the Estonian ICT cluster in the light of transition to market economy and to the new techno-economic paradigm.

status of an industrialised country without at least some periods of heavy state involvement in the developmental effort" (Chang 2001, p. 21).

This way the success of all modern developed countries lies in industrial innovation and the role of state policies is crucial here. As reported, among others, by Dosi (1982): "The strict relationship between economic growth and change, on the one hand, and technical progress on the other is rather evident and well recognized "fact" in economic thought" (p. 147). The importance of technological innovation was for the first time clearly expressed by Schumpeter in the beginning of the 20th century, although the concept of innovation has been present from the beginning of the emergence of the discipline of economics.

1.2. Changes in the techno-economic paradigm in the 1990's

The work on fluctuations in the general price level has been studied already since the late 18th century and the existence of long wave-like price movements in industrial economic development has been noted by the Dutch economist Van Gelderen (alias J. Fedder) with an article published already in 1913.

By 1926 a Russian economist Nikolai Kondratjev (1892 – 1938) had advanced to propose long wave as phenomenon inherent in the capitalist mode of production with characteristics of upswing and downswing phases. Kondratjev (1935) proposed the existence of cycles that represent long-term movement of prices between poles of inflation and depression that last 47 to 60 years (pp. 106-107). He did not, however, propose any causation mechanism nor any explicit commitment to the role of innovation (Perez 1983, p. 358). Schumpeter, although approaching long waves differently than Kondratjev himself (Freeman and Soete 1997, p. 18), formulated less a theory of long waves, but rather method for understanding cycles in general (Perez 1983, p. 358-359) and developed a coherent theory using economic theory, history and statistics.

Schumpeter (1939) did extensive work to describe and analyse the first three waves and followers of Schumpeter, notably Freeman and Perez, have developed theories of the Fourth and the Fifth Kondratjev wave. However, their approach differs from Schumpeter's own account as the emphasis is moved from Schumpeter's first introduction to the diffusion of new technologies, as "what matters for a major upswing and transformation of the economy in terms of new investment and employment is the widespread diffusion of numerous innovations based on a new infrastructure" (Freeman and Soete 1997, p. 20). For this reason several technologies are attributed to various Kondratjev waves differently. According to the

theory of long waves (table 1) the Fourth Kondratjev, the age of mass production of automobiles and synthetic materials, is from the beginning of the 1990s being substituted with the Fifth Kondratjev (table 2).

To conclude, the general understanding of scholars is fully supported: ICT is one of the key technologies that are currently leading the paradigm that started in the beginning of the 1990s. Similarly to other key factors (like cotton, coal and iron, steel, oil and plastics) that had all-pervasive influence in the productive sphere, and a capacity, based on a set of interwoven technical and organisational innovations, to reduce costs and change the quality of capital equipment, labour, and products, it is believed that the ICT also carries enormous potential.

Table 1. Successive waves of technical change

Approx. Timing	Kondratjev waves	Science, technology, education and training	Transport, communication	Energy systems	Universal and cheap key factors
First 1780s-1840s	Industrial revolution: factory production for textiles	Apprenticeship, learning by doing, dissenting academies, scientific societies	Canals, carriage roads	Water power	Cotton
Second 1840s-1890s	Age of steam power and railways	Professional mechanical and civil engineers, institutes of technology, mass primary education	Railways (iron), telegraph	Steam power	Coal, iron
Third 1890s-1940s	Age of electricity and steel	Industrial R&D labs, chemicals and electrical, national laboratories, standards laboratories	Railways (steel), telephone	Electricity	Steel
Fourth 1940s-1990s	Age of mass production (´Fordism´) of automobiles and synthetic materials	Large-scale industrial and government R&D, mass higher education	Motor highways, radio and TV, airlines	Oil	Oil, plastics
Fifth 1990s-?	Age of microelectronics and computer networks	Data networks, R&D global networks, lifetime education and training	Information highways, digital networks	Gas/oil	Micro-electronics

Source: Freeman and Soete 1997, p. 19

Table 2. A tentative sketch of some of the main characteristics of the Fifth Kondratjev[3]

Approximate periodization: Upswing	1980s and 1990s
Description	Information and communication Kondratjev
Main 'carrier branches' and induced growth sectors, infrastructure	Computers Electronic capital goods Software Telecommunications equipment Optical fibres Robotics FMS Ceramics Data banks Information services Digital telecommunication network Satellites
Key factor industries offering abundant supply at descending price	' Chips' (microelectronics)
Other sectors growing rapidly from small base	'Third generation' biotechnology products and processes Space activities Fine chemicals SDI
Technological leaders	USA, Japan, Germany, Sweden Other EEC, EFTA Russia and other Eastern European Taiwan, Korea Canada, Australia Chile
Other industrial and newly industrialising countries	Brazil, Mexico Argentina, Venezuela China, India Indonesia, Turkey Egypt, Pakistan Nigeria, Algeria Tunisia, Other Latin American
Main features of the national system of innovation	Horizontal integration of R&D design, production and process engineering and marketing. Integration of process design with multi-skill training. Computer networking and collaborative research. State support for generic technologies and university-industry collaboration. New types of proprietary regime for software and biotechnology. ´Factor as laboratory´.

Source: Freeman and Soete 1997, p. 65

[3] All columns are necessarily speculative.

1.3. National innovation system and innovation policy

Freeman (1987) treats national innovation system (NIS) as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies” (p. 1). Another classical approach considers the system of innovation as “elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and that a national system encompasses elements and relationships, either located within or rooted inside the borders of a nation state” (Lundvall 1995, p. 2). Narrow definition includes “organisations and institutions involved in searching and exploring – such as R&D departments, technological institutes and universities”, but for the current discourse the wider approach that includes “all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as sub-systems in which learning takes place” (Lundvall 1995 p. 12) is applied.

This way relevant institutions are understood as rules, norms, habits, and shared expectations that pattern economic behaviour. Such an approach is quite non-exclusive, but due to the dynamic and overwhelming nature of the innovation process, as argued previously, it is the most appropriate.

Understanding the national innovation system is essential for policy planning as innovation policy can be equated with targeting different elements of the national innovation system, elements being organisations (e.g. SMEs, MNEs, research institutes) and institutions (e.g. relationships between organisations, public attitude towards new technologies). Although some elements of innovation systems tend to be mostly universal between countries, the systems differ remarkably in the institutional sense. For this reason, innovation policies, targeted at strengthening the national system of innovation, are also different. This also explains why pure copying does not work.

OECD manual, frequently referred to as the “Oslo Manual” (1997), is offering guidelines for collecting and interpreting technological innovation data on firm level. Accordingly ‘technological product and process innovations’ (hereafter innovations) comprise of

implemented (i.e. introduced on the market or used within a production process) technologically new products (means both goods and services) and processes as well as significant technological improvements in products and processes (p. 31). Dosi (1988) also states that "in an essential sense, innovation concerns the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organisational set-ups" (p. 222) and similar approach is common in innovation literature.

Schumpeter (1939) distinguishes between economic growth and development. Economic growth, on the one hand, denotes the slow, gradual and cumulative change of an economic system, resulting from factors such as population growth, for instance, that is said to originate from sources that are exogenous to the economic system (p. 58). Economic evolution, on the other hand, comprises the process of innovation and its economic effects: "The changes in the economic process brought about by innovation, together with all their effects, and the response to them by the economic system, we shall designate by the term 'Economic Evolution' " (ibid, p. 61).

This way the given framework differentiates between static and dynamic elements of the economic system. Innovation policy, a sub-field of industrial policy[5], is targeting at dynamic elements. To keep the framework reasonable the following definition for innovation policy that seems to be implicitly or explicitly widely applied, is used: innovation policy aims at elements of science, technology and industrial policy that "explicitly aim at promoting the development, spread and efficient use of new products, services and processes in markets or inside private and public organisations" (Lundvall and Borrás 1999, p. 37). By such definition innovation policy is a horizontal policy, in addition organisational, financial and commercial steps which actually, or are intended to lead to the implementation of technologically new or improved products or processes are subjects to innovation policy.

As development levels of economic systems are different, there is no unique set of tools or specific objectives of innovation policy, although as previously argued, ICT is a technology "superior" over others. This way ICT-related developments should be definitely targets of innovation policy. However, policy objectives (e.g. promotion of first worldwide introduction or

[5] Industrial policy "is aimed at particular industries (and firms as their components) to achieve the outcomes that are perceived by the state to be efficient for the economy as a whole" (Chang 1994, p. 60).

diffusion), targets (e.g. SME's or MNE's or universities), and innovation modes differ remarkably between countries and technologies.

2. Estonian transition to market economy

2.1. General developments

Estonia re-established its political and economic independence from the Soviet Union in August 1991, and since the end of the 1980s and the beginning of 1990s there have been several simultaneous transitions going on. The first one is transition from planned economy to market economy, and the second one is related to the transition to the new techno-economic paradigm. All developed countries are experiencing the latter transition as well and in the course of the transition old industries, traditional employment, financing, and related structures are destroyed. In the countries of Central and Eastern Europe (CEE)[6] the transformation presents additional, specific problems that are different than those in the other parts of Europe and indeed of the world[7].

Estonia's transfer to market economy could be used as a standard economics textbook example of the neo-liberal, *laissez faire* approach to economics. Estonian economic policy is described as having a heavy reliance on market mechanisms, 'getting the state out of the economy', rapid and large-scale privatisation, free trade and liberal investment laws. Much of the focus was on establishing a stable currency and the approval of balanced state budgets. This way the major concern of Estonian policy-makers was market failure in the sense that the main concern, and thus the objective of state intervention was to create 'enough markets' with demand and an appropriate price mechanism.

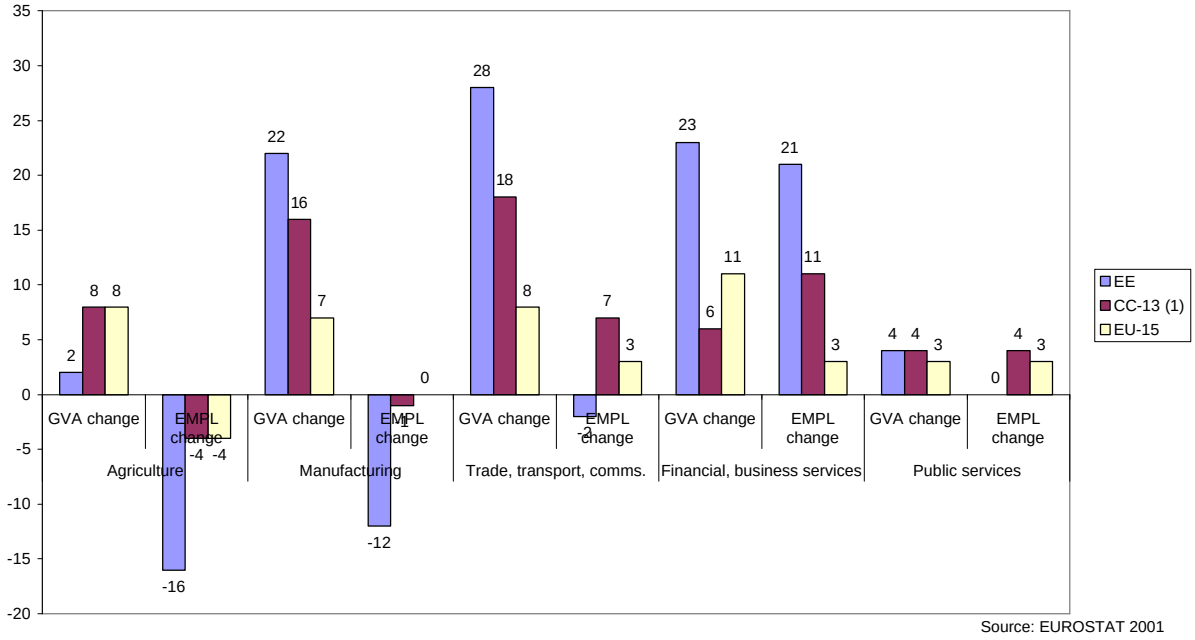
The CEE countries have had different experiences with privatisation, price liberalisation, liberalisation of trade and the foreign exchange system, but in this respect Estonia has been successful. Estonian economy has been restructured (Figure 1) – e.g. the size of the agricultural sector has decreased, but services sector has at the same time increased

[6] CEE includes the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, FYR Macedonia, Hungary, Poland, Romania, Slovak Republic and Slovenia (EBRD 2001). In the current chapter most comparisons are made within the group of Central Eastern Europe and the Baltic States: Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia.

[7] For more information on changing techno-economic paradigm in the countries of Central and Eastern Europe, see PRAXIS Centre for Policy Studies' project (2000-2002) Creative Destruction Management in Central and Eastern Europe: Meeting the Challenges of the Techno-Economic Paradigm Shift.

(Eurostat 2001). According to judgement of the European Bank for Reconstruction and Development (EBRD) Estonia has succeeded (Table 3) with privatisation, made substantial progress with (large-scale) privatisation and trade and foreign exchange system liberalisation when compared to other CEE countries (EBRD 2000). Still, all transition countries are experiencing sharp social problems and problems with the adoption to the new techno-economic paradigm.

Figure 1. Growth index of gross value added at constant prices and employment, 1998 (1995=100)



Source: EUROSTAT 2001

Table 3. Progress in transition in of Central Eastern Europe and the Baltic states[8]

Countries	Population (millions, mid-2000)	Private sector share of GDP in %, mid-2000 (EBRD estimate)	Enterprises: Large-scale privatisation	Enterprises: Small-scale privatisation	Enterprises: Governance & enterprise restructuring	Markets and trade: Price liberalisation	Markets and trade: Trade & foreign exchange system	Markets and trade: Competition policy	Financial institutions: Banking reform & interest rate liberalisation	Financial institutions: Securities markets & non-bank financial institutions
Czech republic	10,3	80	4	4+	3+	3	4+	3	3+	3
Estonia	1,4	75	4	4+	3	3	4+	3-	4-	3
Hungary	10,0	80	4	4+	3+	3+	4+	3	4	4-
Latvia	2,4	65	3	4+	3-	3	4+	2+	3	2+
Lithuania	3,7	70	3	4+	3-	3	4	3-	3	3
Poland	38,7	70	3+	4+	3	3+	4+	3	3+	4-
Slovak Republic	5,4	75	4	4+	3	3	4+	3	3	2+
Slovenia	2,0	55	3	4+	3-	3+	4+	3-	3+	3-

Source: EBRD Transition Report 2000, pp. 14-15

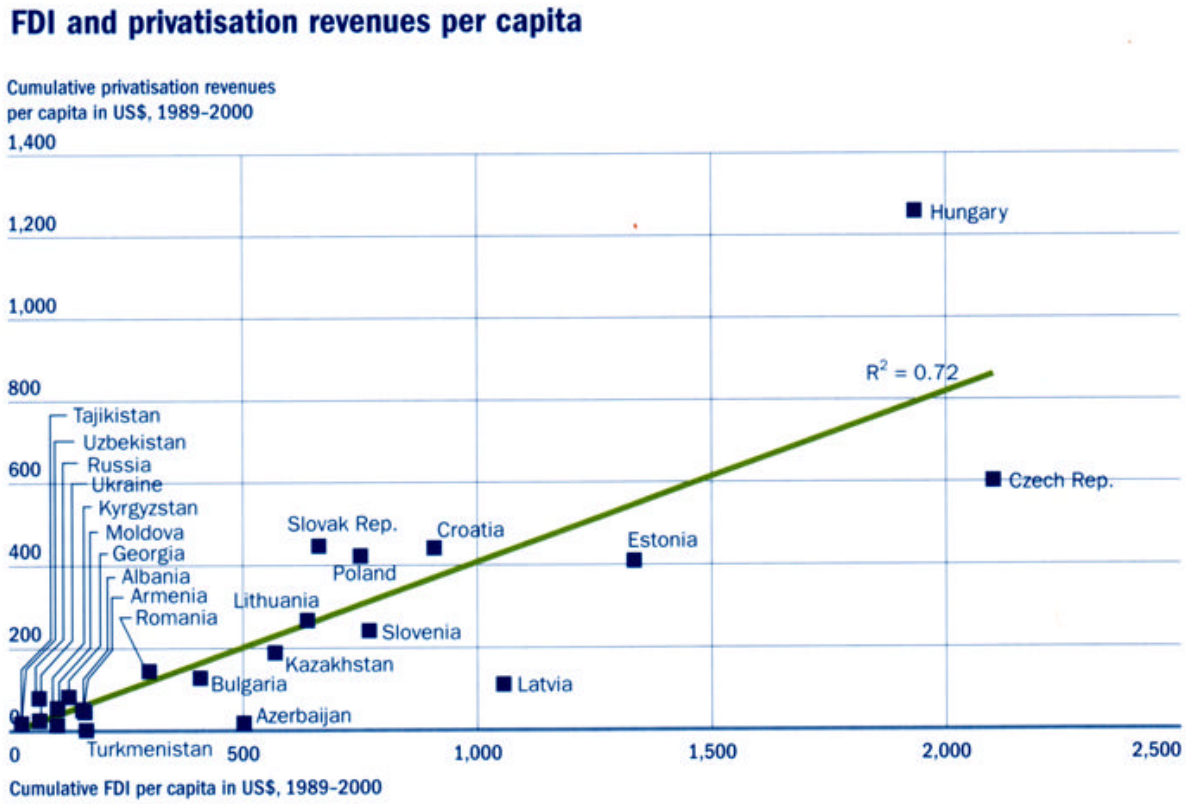
[8] Classification runs from 1 (weakest performance) to 4+ (best performance).

2.2. Foreign direct investments

Transition into investment-driven economy has been outstanding, as Estonia has been remarkably successful in attracting foreign direct investments (Table 4). In cumulative FDI-inflows per capita terms (1989–2000) Estonia lags only behind the Czech Republic and Hungary among the Central and Eastern European Countries and the Commonwealth of Independent States (EBRD 2001, p. 22).

With the end of the Estonian privatisation process, it is foreseeable that the amount of FDI is about to decrease and to go into the structurally different sector in the years to come. As Estonia has advanced further with privatisation compared to other transition countries, this also has had an impact on the future FDI – according to the European Bank for Reconstruction and Development (2000, p. 84), a strong positive relationship exists between cumulative privatisation revenues and cumulative FDI (Figure 2).

Figure 2. FDI and privatisation revenues per capita



Though Estonian overall RTD funding is only 0.8% of GDP, it is referred that innovations, alongside with overall economic growth emanate to a large extent from foreign direct investments (FDI) made into Estonian economy together with inward technology transfer

(technology imports). FDIs are frequently seen as a means for know-how and competence spill-over and technology transfer. The positive factor derived by relatively high FDI inflow is the fast learning opportunities, which are necessary basis for generating own technological solutions. High level of FDI inflows to Estonia in turn has generated much optimism about the future perspectives of the Estonian industry. Hernesniemi (2000) argues, “Knowing the low R&D intensity of Estonia and its focus on basic research, there is full reason to argue that FDI and technology transfer through it has been the most remarkable source of technology development during the last decade. Good examples, which became familiar during the evaluation process, are Elcoteq …” (p.8)

However, literature that analyses FDI and developing countries distinguishes several types of technology transfers. James (1996) concludes in his literature review based study on microelectronics technology transfer to the Third World that export-oriented direct foreign investments does not engender a significant increase of local learning capabilities in contrast to the loss of effective proprietary rights of technology owners and cooperation with local industry.

Consequently, although FDI bring along changes in the economic structure of a country, they do not necessarily contribute to the innovative capabilities of the local industry, and thus changes in technological trajectories. Considering Estonia’s current competitive advantage and the problems with the decreasing attractiveness for FDI, the problem of specialisation in low-tech, labour-intensive low-wage industries leading to lock-in in low and medium technology sectors remains to be tackled. Currently there are also signs of locking-in in Estonian manufacturing sector (specialisation in low-tech, labour-intensive low-wage industries).

Table 4. Foreign direct investment (net inflows recorded in the balance of payments)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Estimate 2000	Projection 2001	Cumulative FDI-inflows 1989-2000	Cumulative FDI-inflows 1989-2000 per capita	FDI-inflows per capita 1999	FDI-inflows per capita 2000	FDI-inflows 1999	FDI-inflows 2000
	(US$ million)											(US$ million)	(US$)	(US$)		(in per cent of GDP)	
Czech Republic	na	983	563	749	2,526	1,276	1,275	3,591	6,234	4,477	6,000	21,673	2,102	605	434	11.7	9.1
Estonia	**na**	**80**	**156**	**212**	**199**	**111**	**130**	**574**	**222**	**241**	**300**	**1,926**	**1,337**	**154**	**168**	**4.3**	**4.9**
Hungary	1,459	1,471	2,328	1,097	4,410	1,987	1,653	1,453	1,414	1,650	1,650	19,42	1,935	140	164	2.9	3.5
Latvia	na	na	50	279	245	379	515	303	331	330	350	2,43	1,027	139	139	5.0	4.6
Lithuania	na	na	30	31	72	152	328	921	478	355	300	2,367	642	129	96	4.5	3.2
Poland	117	284	580	542	1,134	2,741	3,041	4,966	6,348	9,299	8,000	29,052	751	164	240	4.1	5.9
Slovak Republic	82	100	107	236	194	199	84	374	701	1,500	2,000	3,611	669	130	278	3.6	7.4
Slovenia	-41	113	111	131	183	188	340	250	144	133	100	1,534	768	72	67	0.7	0.7
Central eastern Europe and the Baltic states	1,617	3,031	3,925	3,278	8,961	7,032	7,365	12,431	15,872	17,986	18,700	82,012	1,154	192	198	4.6	4.9
South-eastern Europe[9]	93	148	274	646	726	1,143	2,917	3,850	3,530	3,153	3,874	16,465	312	73	68	3.1	3.6
Commonwealth of Independent States[10]	0	135	642	1,579	3,600	4,419	7,963	5,654	4,054	4,921	6,899	32,967	167	25	24	4.1	4.3
Total	1,710	3,314	4,84	5,502	13,288	12,594	18,245	21,934	23,456	26,059	29,473	131,444	505	88	89	4	4

Source: EBRD 2001, p. 22

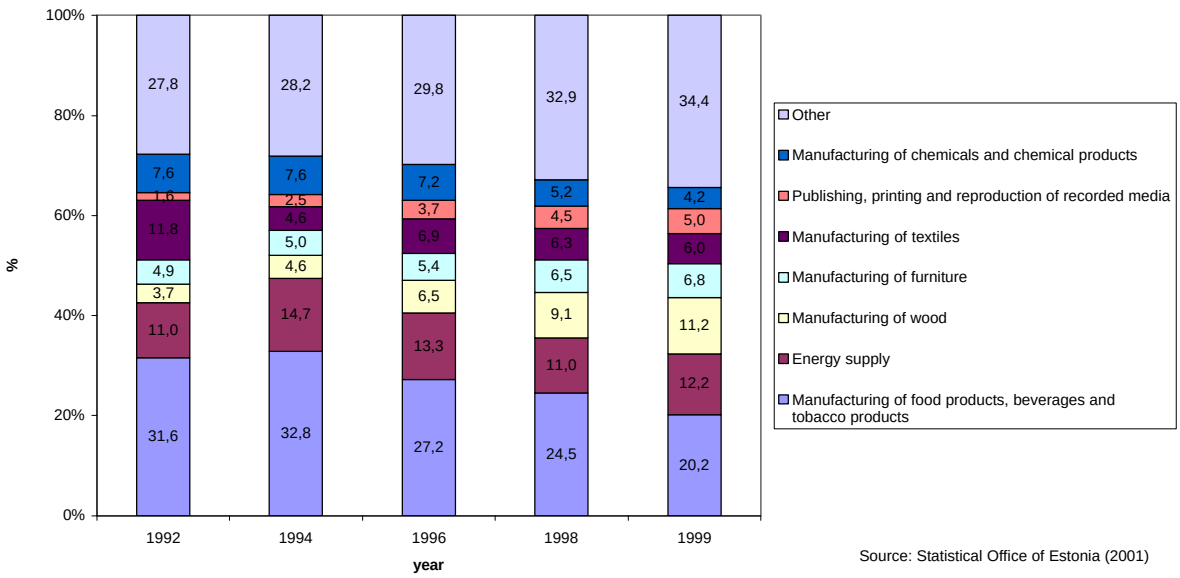
[9] Includes Albania, Bulgaria, Bosnia and Herzegovina, Croatia, FR Yugoslavia, FYR Macedonia, Romania

[10] Includes Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

2.3. Manufacturing sector

Estonian manufacturing sector employed 138,000 persons in 2000; that consists 22.6% of the total number of employed persons (Statistical Office of Estonia 2001). For the member states of the European Union the share of employment in manufacturing was on average 20.3% in 1999 (compared to 66.1% employment in services) (EC 2000, p. 11). Consequently, the overall size of the Estonian manufacturing sector corresponds to those in industrialized countries.

Figure 3. Proportion of industrial production by economic activity (percentages) years 1992, 1994, 1996, 1998, 1999



Source: Statistical Office of Estonia (2001)

The whole transition process seems to support the widely held position that neo-liberal approaches to economic policy help to revive the private sector, but that such a revival is invariably limited to small-scale, low technology, which does not require extensive state support. For example, Estonian manufacturing was dominated in 1999 by the manufacturing of food, beverages and tobacco products, energy supply and manufacturing of wood and furniture (Figure 3; Statistical Office of Estonia 2001). Analysing the Estonian trade pattern and comparing it with OECD exports in 1997, Hernesniemi (2000) concludes that 'the Estonian competitive edge in exports lies in very traditional industries like wood industries and furniture production, textile and clothing industries and foodstuff industries. In inorganic chemicals, there is also evidence of competitiveness in OECD exports. It is on these industries that Estonia currently has strength' (p. 10). A rather similar conclusion was also reached by Wergeland (1997) who, using data from 1989 reported that Estonian showed advantages in exports in foodstuff, agricultural products, textile and building materials. (p.

139). Although in comparing two sets of data some restructuring pattern can be noted, these changes have indeed happened within low-technology industry group.

Another interesting and highly relevant point follows from the Pavitt's sectoral taxonomy of innovations (1984), which is a well-established identification of some regularities in the way in which technological change unfolds and affects economic activity. According to this approach industries differ in their patterns of technical change.

In *supplier-dominated activities* (such as agriculture, textiles, clothing, building, mining, forestry, commerce, and traditional manufacturing) most innovations come from suppliers of equipment and materials. Firms that operate in these activities undertake generally little R&D[11] and request few patents. Main innovations are incremental cost-reducing process innovations embodied in intermediate and capital goods.

In *production-intensive activities* (such as scale-intensive industries including cement and glass manufacturing, metal refining, and transportation equipment, and specialized suppliers such as machinery production), R&D is conducted in the larger firms. It is centred on both product and process technologies. Firms tend towards vertical integration and appropriability is linked to tacit knowledge, secrecy, and patents.

Within *science-based industries* (e.g. electrical equipment manufacturing, fine chemicals including pharmaceuticals and biotechnology, aircraft and aerospace, electronics, optical and laser instruments, robotics, and advanced materials) the main source of technology is in the R&D activities of the firms. This R&D is based on the development of science, in universities and in public laboratories, with which these firms perform close collaboration. In the science-based industries there is more “technology push” innovation that could be directed towards the creation of new technological paradigms (see also 1.2).

Introduced empirical data shows, that majority of Estonian manufacturing enterprises belong to low-technology group. As the number of innovative acts in these sectors is everywhere relatively low, this explains why Estonian enterprises are generally investing very little resources to research and development.

[11] For more details on the research and development in Estonian ICT Sector, please see eVikings working paper by Marek Tiits (2001).

2.4. Productivity increase as catching-up

The situation in the European Union (EU) candidate countries is that both R&D expenditure and average productivity are still much lower than the average within the EU. According to 1998 figures, the EU economy as a whole was 2.5 times more productive than that of the candidate countries. Trade, transport and communication, financial and business services are the most productive sectors within the candidate countries' economies, where labour productivity has reached 66% of the EU level. The Estonian overall labour productivity is 37% of the EU, which is also very close to the candidate countries' average of 41%. Labour productivity is the highest in trade, transport and communications (55% of EU average), and in agriculture (46%). For manufacturing the figure is 26% for Estonia, 29% for Latvia and 30% for Lithuania (Eurostat 2001).

The productivity increase has emerged mainly from domestic entrepreneurs, foreign enterprises and through foreign direct investments (FDI) resulting in major productivity increase in new, small enterprises or those sectors where foreign enterprises were willing to act as restructuring agents (Radoševic 1998). Those restructured enterprises seem to outperform domestic firms that are based on local capital.

Estonia's rapid increase in productivity could be explained by the catching up model, according to which (Abramovitz 1986), relatively backward countries grow faster than advanced countries, because they are able to imitate technological knowledge, and hence converge to the frontier value of per-capita income more rapidly. The process is caused by the rapid increase in world trade and international investment flows, and the increasing trend towards international access to information and codified knowledge. Technological accumulation plays a crucial role here, but besides technological aspects, there are also issues of 'social capability' that mark a broad description of the set of institutions that facilitate the international diffusion of technological knowledge. Among the factors that are considered of prime importance for 'social capability' are the educational and the financial system.

With catching-up and the resulting increase in productivity, two possible scenarios may follow. First, some labour is allocated into other sectors, or alternatively, additional demand (e.g. export) is created and the sector continues to employ the same number of people, or the number could even eventually increase. The empirical evidence concerning Estonia seems to support the argument that with increasing productivity, the number of employed persons decreases in the respective sector (see also Hernesniemi 2000, pp. 12–14). When

comparing data from 1997 and 1994 (Statistical Office of Estonia 2001), out of the 13 manufacturing sub-fields where productivity growth was more than 14% annually, the same level or an increase in employment emerged in only four of them. Manufacturing of wood, paper, paper products, rubber and plastic products contributed positively to the employment increase, while 'manufacturing of furniture and other manufactured goods' remained stable. This process demonstrates the deepening of the lock-in effect.

3. Estonian transition into information society

3.1. General trends

Societal inclination towards a fast acquisition of modern technologies, willingness to experiment with new solutions and internationally successful promotional campaigns have introduced Estonia on the international arena as a rapidly evolving information society. For example, the issue of technological developments and their impact on society has been analysed by different international analytical reports and Estonia has been ranked highly:

- McConnell International (2001), for example, indicates that in the fields of e-leadership, human capital and overall e-business climate the majority of conditions in Estonia are suitable to the conduct of e-business and e-government.
- The latest (2001) Human Development Report issued by the United Nations Development Programme (UNDP) also ranks countries next to human development index (where Estonia holds 44th position and belongs to the group of high human development countries) also according to the technology achievement index[12]. Although Estonia was not ranked by the UNDP, according to the provided formula Estonia would be on the 30th position belonging to the group of potential leaders (Viik 2001).

Indeed, the broad picture seems to confirm this concept, as figures and early growth rates are in some cases remarkable (particularly in the category of consumer goods and exports), and several initiatives that have been undertaken by either government or corporate agents are remarkable, inspiring other countries to imitate Estonian practices.

The early launch of the Estonian information society developments is frequently used as best practice for other countries. Without hesitation, the rapid development of the telecommunications market is a clear success story:

- A reasonable state policy has generated rapid catching-up both in the fields of fixed lines and mobile communications;

[12] The technology achievement index focuses on three dimensions at the country level: 'Creating new products and processes through research and development' (1), 'Using new technologies — and old — in production and consumption' (2) and 'Having the skills for technological learning and innovation' (3).

- Estonia has been one of the first countries amongst the CEE countries to open the telecommunications market for liberalisation, giving a good basis for further development;
- Public initiatives in the fields of eLearning (e.g. Estonian Tiger Leap) and eGovernment are also good examples that other (especially Central and Eastern European) countries attempt to imitate. Like other transition economies, Estonia is experiencing very rapid developments in the technical sphere with a number of problems arising at the same time on the social scale, such as the digital divide[13].

Recent developments in the Estonian telecommunication market are characterised by the fast development of both telecommunications market and Estonian information society as a whole:

- Rapid increase in the number of telephone lines;
- Like in developed countries, proportionally mobile communication usage compared to that of the fixed networks has grown faster;
- Accessibility to modern telecommunication services (GSM, ISDN, *DSL) and reduction of the prices;
- Total liberalisation of the telecommunications market (expiration of the exclusive rights granted to Estonian Telephone Company) since January 1, 2001;
- Promotion of technological development by the State through legislation (Cable Distribution Act, Telecommunications Act, Digital Signature Act).

In general, the proximity of advanced Scandinavian technology forerunners is a significant driver. The rapid uptake of novel technologies, enhanced wireless communication infrastructure, a high number of conventional telephone lines and Internet hosts has created a moderately favourable platform for building up appropriate forms of applications.

3.2. Telecommunications infrastructure

As a well functioning telecommunications sector is considered important for enhancing the competitiveness of an economy and the quality of life, Estonia has paid much attention to the information society developments and directing these after regaining its independence. Main issue in the beginning of 1990s was insufficient technological infrastructure and in order to

[13] For the reasons that the current report is focusing on Estonian ICT cluster (especially on innovations, R&D), the social problems are not dealt with. For more information on social problems of Estonian information society developments see for example the reports of the joint project of PRAXIS Center for Policy Studies and EMOR on digital divide.

support its development a Concession Agreement was signed. This helped to attract significant investments into extension and digitisation of the public telephone network. During the 1990s the state has adopted also several important legislative acts and established the necessary state structures and has in this way organised the telecommunications

The most influential enterprise in the Estonian telecommunications market AS Eesti Telekom was restructured already in 1991-93; in 1997 the state enterprise Eesti Telekom was re-established as AS Eesti Telekom and the decision was adopted to organise an initial public offering (IPO) to sell up to 49% of the shares. The IPO took place at the beginning of 1999, and institutional and private investors purchased 49% of the shares owned previously by the Republic of Estonia. At the moment AS Eesti Telekom has 100% ownerships in AS Eesti Telefon (Estonian Telephone Company) and in AS Eesti Mobiiltelefon (Estonian Mobile Telephone Company). The shares of AS Eesti Telekom are owned as follows: Telia AB (Sweden) and Sonera Holding B.V. (Finland) – 49%, the Government of Estonian Republic – 27.3%, other investors – 23.7%.

Exclusive rights granted to AS Eesti Telefon by the Concession Agreement signed by the Estonian Government and AS Eesti Telefon in 1992 expired on January 1, 2001. Exclusive rights concerned the provision of basic services (national and international switched fixed voice telephony services, telex and telegraphic services, their installation and interconnection to them). Since the beginning of 2001 the number of telecommunications companies increased remarkably and currently the most important companies in the market are AS Eesti Telefon, Levicom BroadBand OÜ (TELE2) and Uninet AS.

Estonian mobile telephone communications market has been liberalised from the very beginning and currently there are three operators on the market.

As for year 2000 there are 522 000 conventional main lines in Estonia and 557 000 mobile communication subscribers (Statistical Office of Estonia 2001) with the market turnover (in 2000) for carrier services being 259 million Euros (EITO 2000, p. 409). Since its early days telecom sector has shown a constant growth, though conditions for further expansion are somewhat more restrictive nowadays. On the one hand, the market is reaching saturation point, though it might be just a temporary situation in light of the launch of the next generation mobile services; on the other hand intensive competition in the sector pushes down the prices. The predicted growth rate of the total telecom market was about 10% for 2001 (EITO 2000, p. 409).

Access to the Internet is mainly realised through the use of dial-up services in Estonia, although *DSL services are available in major cities. There are 8 major Internet Service Providers (ISP) in Estonia.

3.3. Technology uptake and applications

When looking at the ICT manufacturing in Estonia[14], it follows, that foreign orders are very important for the Estonian ICT sector - 73% of the subcontracting activity originates from abroad (all data follows from the eVikings survey from May 2001 if not indicated otherwise). Typically, subcontracting involves assembly of various communication equipment and software outsourcing. As a result, subcontracting revenues constituted 60–100% of the Estonian turnover of telecommunications equipment production, industrial automation, consumer electronics and components, and about 15% of the computers and office machinery sub-sector in 2000. Due to high foreign demand, the export of the Estonian ICT industry has increased rapidly. On the downside, most of the rise can be assigned to a single company's activity – Elcoteq Ltd provides 83% of the total Estonian ICT exports and 96% of telecommunications equipment exports as the statistics for the year 2000 indicates[15]. Of domestic industries, manufacturing, the telecommunications sector, banking, wholesale and retail trade, and governmental structures are the important drivers of the emerging Estonian ICT cluster, as they demand most of the production generated by the ICT sector.

On the services side, the most popular application areas of Internet are banking services, but public administration's efforts in IT sphere have also generated new web-based services in public domain. As 32% of Estonians aged 15 to 74 are identified as Internet users (EMOR 2001), there seems to be challenge for both public and private sector organisations in introducing innovations in services fields, namely through the use of ICT.

The most popular electronic service in Estonia is Internet banking. Hansapank has indicated 350,000 Internet banking clients and Ühispank 118,000 (Estonian Informatics Center 2001). To some extent the clientele basis is overlapping, but is still reasonable to believe that total number of Internet banking users exceeds 200,000, covering more than 14% of total

[14] Due to the high importance of manufacturing industry in economy as general, closer look at the industry is taken in eVikings working paper by Tarmo Pihl (2001). This paper focuses mainly on general information society developments.

[15] This expert opinion by the research team based on Statistical Office of Estonia and publicly available data.

Estonian population. Factors that have put Estonia to the position of the leader concerning Internet banking among former Eastern block Countries and outdoes a lot of Western European countries, are simple-to-use software, free of charge transactions during the services' introducing time to the market and the impact of Nordic countries' IT culture on Estonia.

Other popular services offered via digital channels are digital taxation board portal and insurance payment systems. Digital taxation board is represented both in the system of Hansapanks Internet banking interface Hanza.net, Ühisbank's U-net as well as separately, via Tax Board's own portal. In the former case personal identification of Hansapank's and Ühispank's clients is used for electronic tax-related transactions, in the latter case special security codes are issued to clients upon request. The number of income tax declarations submitted through Internet banking portals exceeded 36,000 for the declaration period of year 2000 (Estonian Taxation Board 2001).

There are other interesting services provided by the private sector, e.g.

- Mobile parking is another recent innovative initiative launched by the Estonian Mobile Telephone (EMT) and parking surveillance authorities. In order to use the system, after parking a vehicle a SMS has to be sent to the parking centre, and finished upon further notification, also via SMS. The parking fee is subsequently added to telephone bill or deducted automatically from client's mobile bank-account.
- LocateGSM is a service offered in cooperation with EMT and GIS developer Regio Ltd. This is a web-based mobile positioning system (MPS) enabling to display the location of EMT mobile subscriber on a map. This way the system is offering good bases for further development of different location-based services.

In addition there are also other remarkable initiatives carried out in the public sector. These are mainly dealing with the modernisation of the communication within the government, or provision of services to companies and individuals on digital bases (e.g. e-Citizen project under planning, electronic ID card initiative). For example,

- Government portal www.riik.ee covering all government institutions was established already in 1998;
- In 2000 the first phase of the project of "Information Systems for Government Sessions" was developed and implemented, forming thus a solid basis for Government's work digitalisation, as well as making available Government protocols and information concerned to general public.

- From June 2001 a citizen portal “Today I Decide” was launched. The project aims at engaging citizens more actively into policy decision processes, as well as motivating public debates concerning nation-wide and important initiatives. The citizen portal encourages submitting ideas, visions, directions etc. as well as comment on bills released by ministries already during the process of bill drafting.
- Steps towards modernising the governmental information exchange system were taken starting year 2000, at the initiative of the pilot project X-road (cross-road). The objectives of X-road pilot project are to interconnect state databases, to enable requesting information to authorised user via Internet from any of the databases after authorised accession. This project is especially important as elements of the state information system were founded technologically independently, but also at different points in time, thus calling for operative modernisation and co-operation.
- Parallel to X-road project incentives on bringing several main registries (Business Registry, Real Estate Registry etc) on full-electronic Internet basis are being implemented. The access is guaranteed to all users, and the information obtained has full legal power.

For projects like these governmental structures are important users of telecommunications equipment and services, office machinery, computers and software, whereas the government’s affection for novel technological solutions has had a positive effect on a number of public sector initiatives.

Despite of the rapid spread of Internet connections, relatively high level of users and extensive investments into Internet stores, the turnover of electronic commerce is insignificant. According to Global eCommerce Survey (TNS Interactive 2000) e-commerce penetration is 6% in Estonia. For the USA the relevant figure is 33% and for Finland 17%. Factors impeding the development of e-commerce are sustainability of buying habits, limited product range in Internet stores, inconveniences in paying for goods and deliveries and security risks when using bankcards. Forming a new electronic commerce culture is a world-wide problem and in this light Estonian developments are comparable to the most successful European countries. One of the strongest Estonian advantages in these developments is the widespread Internet banking (favours the rise of positive attitude towards e-commerce); the most important discouraging factors are the smallness of the potential market and conventional shopping habits.

Consequently, bringing more services onto digital basis is substantially dependent on the potential demand for these services. Presently the demand is derived mainly by the clients of Internet banking, who have their personal banking accounts for conducting electronic

transactions via Internet based web portal. Evidently, the fast development of the Estonian banking sector and the high-tech solutions elaborated by the banks' own product development departments have reinforced the need for quality software, and trustworthy and secure products, thus having also positive effects on generating innovative solutions. Also, collaborative actions undertaken by the banks and telecommunications operators have established strong links between these two sectors, paving the way for future m-commerce related activities. However, in this context the relations with content providers are insufficient, meaning that these relations have to develop towards a more active involvement of external content service providers in order for a large-scale functioning m-business or m-leisure to appear.

4. Innovations and Estonian innovation policy

4.1. Transition to innovative economy

With privatisation and technological upgrading, the **Estonian industrial structure started to depart from the factor-driven stage in the early 1990s**. The factor-driven stage is described by Porter (1998) as an economic system whose performance is dependent on the availability of primary factors, such as land, labour and capital. Sophistication of goods is low, whilst the main economic activities consist of assembly, labour intensive manufacturing and resource extraction. Technology is assimilated through imports, FDI and imitation. Also, economy is sensitive to economic fluctuations and exchange rates.

However, higher quality FDI, venture capital and other factors move the economic system into **investment-driven economy**, where national competitive advantage is based on the willingness and ability of a nation and its firms to invest aggressively. Financial capital is invested into modern facilities and into complex foreign products as well as process technology; products incorporate typically more sophistication and the economy is concentrated on manufacturing. Competitive advantages are drawn from improving factor conditions as well as firm strategy, structure, and rivalry.

Transition into investment-driven economy has been outstanding, as Estonia has been remarkably successful in attracting **foreign direct investments**. In cumulative FDI-inflows per capita terms (1989–2000) Estonia lags only behind the Czech Republic and Hungary among the Central and Eastern European Countries and the Commonwealth of Independent States (EBRD 2001, p. 22). As Estonia has advanced further with privatisation compared to other transition countries, this also has had an impact on the future FDI – according to the European Bank for Reconstruction and Development (EBRD), a strong positive relationship exists between cumulative privatisation revenues and cumulative FDI (EBRD 2000, p. 84).

At the same time, FDI does not necessarily contribute to the innovative capabilities of the local industry and thus to the changes in technological trajectories. This way the quality of FDI is more important for growth and competitiveness than the quantity alone. Also, although with the opening of the trade and inflow of foreign direct investments the investment/driven stage was achieved in most of the sectors, with the ending large-scale privatisation process

firms have been technologically upgraded and new management techniques have been applied, thus these sources for competitive advantages are being exhausted.

At the current stage Estonian adoption to the new techno-economic paradigm is mainly associated with the use of the new technologies in society (especially Internet and mobile communications). However, Christopher Freeman has proposed widely used taxonomy of innovations (1995):

- "1) incremental innovations are gradual improvement of existing array of products, processes, organizations and systems of production, distribution and communication;
- 2) radical or basic innovations: a discontinuity in products, processes, organizations and systems of production, distribution and communication, i.e. a departure from incremental improvement, involving a new factory, new market or new organisation;
- 3) new technology systems ("constellations of innovations"): economically and technically inter-related clusters of innovations (radical and incremental);
- 4) technological revolution ("change of techno-economic Paradigm"): a pervasive combination of system innovations affecting the entire economy and the typical "common-sense" for designers and managers in most of all industries" (p. 199).

Following this typology, one can argue that services and goods developed in Estonia are mainly of incremental nature. Estonia's application of new technologies is therefore fully in line with the catching-up model. According to the model, however, all technologically less advanced countries have the potential for catching up with the advanced countries in the application of new technologies. This is especially true for consumer goods (mobile telephones, Internet), where relatively little skills are needed and the usage level depends on the supply. Due to the greater importance of tacit knowledge, however, the catching-up model is less well working for knowledge-intensive areas like ICT systems development or even modern manufacturing. However, in some services fields emergence of a few basic innovations can be noted (e.g. in the field of mobile telecommunications and related services).

However, the eVikings research project focuses mainly on manufacturing and innovations in manufacturing sector for reason - Estonian production of high-technology innovative goods is remarkably low (see chapter 2.3 for argumentation) and the export of ICT related services is also statistically marginal. Chang (1994) argues that the major reason for a structural shift towards service economy, debated largely recently, can be explained by the lagging productivity growth of service sector (compared with that of manufacturing). Many services, nevertheless, are non-tradable in their nature. His argument that "With a growing share of

services in national income, compensating productivity growth in manufacturing is needed – on the reasonable assumption that no dramatic increases in productivity in agriculture and services are likely in the foreseeable future – if a country wants to maintain its income level without running into balance-of-payments problems" sounds convincing (ibid, p. 58). On the other hand, one should also consider services that are close to manufacturing for the reason that borderlines between some services and manufacturing are blurring. Consider, for example, software innovations or other business services including research and development that could catalyse manufacturing innovations. Then again, not all areas even of the "knowledge intensive services"[16] (EC 2000) are considered, but only those with real potential impact on manufacturing productivity. Thus the emerging approach to relevant services as "technology-based knowledge-intensive services[17]" (Lundvall and Borrás 1999, pp. 115-122) is more applicable.

The next stage in Porter's scheme, **innovation-driven status**, realises itself through efficient and sophisticated technological solutions, extensive research and development that generates innovative products, continual training of the workforce in order to sustain intellectual capital and the capacity to maintain competitive advantages. Firms compete on low cost due to high productivity rather than on low factor costs. The whole economy becomes more advanced and less vulnerable to cost shocks and exchange rate movements as they compete on technology and differentiation;

Reaching the innovation-driven stage, however, needs strong support from the state in the form of proper industrial and innovation policies. Innovation policy focuses in those elements of science, technology and industrial policy that 'explicitly aim at promoting the development, spread and efficient use of new products, services and processes in markets or inside private and public organisations' (Lundvall and Borrás 1999, p. 37). Innovation policy is therefore

[16] Knowledge intensive services, being sub-part of services, include the following: communication services (post and telecommunications, software, media, Internet…), financing, insurance, real estate and business services (including consulting and R&D), community, social and personal services (including education and health) (EC 2000, p. 8).

[17] Potential technology-based knowledge-intensive services include: Technology-related publishing; Wholesale in machinery, equipment etc.; Logistics services and related transport services; T-KIBS in telecommunications; Patent bureaux; Technology-related market research; Technology-related economic and management consultancy services; Labour recruitment and provision of technical personnel; Technology-related training.

fundamentally oriented towards the establishment of a functioning National Innovation System, but such an active and influential policy is missing in Estonia so far.

For upgrading the Estonian economy to the next level – to the innovation-driven stage, where firms innovate – innovation policy measures that target manufacturing sector are needed. For increasing innovative capabilities the whole Estonian National Innovation System must be improved.

4.2. Estonian public policy

In the case of Estonian ICT sector, there are basically two fields of public policy that generally target this objective, although due to the encompassing nature of the use of ICT, all policies do shape the developments (e.g. education policy).

4.2.1. Information society policy

The first national informatics development program 'Estonian way to information society' was prepared in 1994 but since EU, OECD, G-7 and other organisations started to elaborate their action plans at the time, during the second half of 1990s new programs were compiled in Estonia considering recommendations from international organisations.

Estonian Riigikogu (1998) approved the updated strategy, Principles of the Estonian Information Policy, in 1998. The document determines the main principles of State actions in supporting the development of Estonian information society and it defines information policy as *'an integral part of public policy. It reflects the principles of the actions of the state in the creation of an information society – areas of interest and regulation mechanisms - in an era of rapid technological change. Government information policy takes into account the goals set up in regulating different spheres of social life and introduces opportunities for presenting innovative solutions'.* Modernisation of legislation, supporting the development of the private sector, shaping the interaction between the State and citizens, and raising awareness of problems concerning the information society are set as major goals.

In addition to this framework document, by end of year 2000 following key legislative measures have been adopted:

Act	Adopted	Entry into force
Public Information Act	16/11/00	1/1/1
Digital Signature Act	8/3/00	15/12/00

Telecommunications Act	9/2/00	19/3/00
Cable Distribution Act	10/2/99	1/6/99
Databases Act	12/03/97	19/4/97
Personal Data Protection Act	12/6/96	19/7/96

Estonian public policy for Estonian information society development has been realised mainly through these acts. Cable Distribution Act and Telecommunications Act have regulated the development of the telecommunications infrastructure, although several major modifications were implemented into the existing legislation (see "European Survey of Information Society", ESIS, reports on regulatory issues for further details). Other than these acts, they have had little direct impact on the private sector. For example, although the Digital Signature Act entered into force on December 15, 2000 and it enables wide use of electronic documents and digital signatures as well as several new electronic services, there are almost no services on the market.

Most of these acts have effectively targeted public sector leading to the emergence of eGovernment. For example, Public Information Act, approved in 2000, stipulates the conditions, order and ways to access public information, causes for refusing and restricting accessing public information as well as superintendence over access enabling. Mandatory information dissemination for all public bodies over the Internet and large-scale use of e-mail are also foreseen by the Act.

To conclude, although the development of the competitive economy was also foreseen as one of the major goals of the Estonian information policy documents, its action plans have not targeted this objective very directly.

4.2.2. Estonian innovation policy as 'no-policy policy'

As mentioned earlier, Estonia has indeed been successful in moving from the factor-driven stage to the investment-driven one. However, the initial conditions for catching-up were sufficiently advanced compared to other transition economies (e.g. infrastructure, human capital) and the successful transition was mainly a result of business opportunities exploited by foreign investors and domestic entrepreneurs.

The building blocks of the Estonian innovation policy are two documents: The Estonian State Innovation Programme (approved in June 1998) and the National Development Plan for the

years 2000–2002 (1999), but none of these were actually implemented (Hernesniemi 2000, p. 9). Although there are other economic policy documents, they propose neither explicitly nor implicitly industrial or innovation policy measures; they are mostly composed for international organisations or are written for specific reasons, but they do not propose a long-term vision, systematic approach and implementation mechanisms (see Kompus 2001 for details).

Nonetheless, Estonia has defined her research and development (R&D) strategy in a document entitled 'Knowledge-based Estonia. Estonian Research and Development Strategy 2002–2006' in which Estonia is seen as a place where research, orientated towards new knowledge, application of skills and knowledge and development of human resources, all combined in balance, are a source of economic and labour competitiveness and quality of life. The strategy also defines information society technologies (IST) as one of the three key areas for R&D in Estonia next to biomedicine and materials' technologies.

This way a proposed priority list of Estonian R&D strategy is a good response to the Fifth Kondratjev as both key technologies are included. Materials' technologies, characterised by more incremental innovations and consequently lower levels of economic uncertainty, help to reduce economic risks. Not surprisingly, however, the response of other countries is very similar. Camarero and Magnatti (2000, pp 99-100) report in their cross-country study of the technological sectors on which EU Member States are focusing their innovation policies that information society technologies appear as a focal sector in 27% of cases, and that almost every country has at least one measure targeted to this sector. New materials ranked the second, followed by biotechnology and environment.

The new strategy 'Knowledge-based Estonia' (Riigikogu 2001), however, clearly emphasises other failures besides market failures as well, proposing that for remedying such failures, the state has to act as an investor, catalyst and regulator. On the other hand, due to its political nature, the document is full of value statements and does not present detailed action plan, although it also acutely emphasises the need to strengthen innovation policy implementation structures. The latter remains crucial, as without properly functioning public policy instruments, the document, although trying to create noteworthy public discussion and to increase general awareness, remains just a document, as the Estonian recent history track record on innovation policy evidently shows.

Consequently, it is clear that without a proper innovation policy and staying at the present knowledge-intensity level and R&D investments growth rate, Estonia would likely end up in

the EU, but would be forced to compete using extensively basic factor advantages, marginalised in terms of technology development and high value added production linkages, excessively dependant on budgetary transfers (Radoševic 1999). It is therefore essential that the mechanisms for co-ordination between the various national policies that affect RTD and innovation should be developed further. The rise of the public expenditure planned in Estonia and several other Candidate Countries should be actually forthcoming for the support of the national RTD strategies.

5. References

1. Camarero and Magnatti. 2000. Horizontal Theme 7: Sector-Specific Innovation Policies. Overview Report EIMS 98/181,98/182,98/183. European Commission, DG Enterprise.
2. Chang, H.-J. 1994. The Political Economy of Industrial Policy. New York: St. Martin´s Press.
3. Chang, H-J. 2000. An Institutionalist Perspective on the Role of the State - Towards an Institutionalist Political Economy. in Burlamaqui, L., A. Castro & H-J. Chang (eds.) (2001), Institutions and the Role of the State, Edward Elgar. http://www.econ.cam.ac.uk/faculty/chang/ipe-pdf.pdf.
4. Cooper, C. (Ed.). 1996. Technology and Innovation in the International Economy. Cheltenham: Edward Elgar.
5. Dosi, G. 1982. Technological Paradigms and Technological Trajectories: a Suggested Interpretation of the Determinants and Directions of Technical Change. Research Policy, Vol. 11, 147–162.
6. Dosi, G. 1988. The Nature of the Innovative Process. in Dosi, G. Freeman, C., Nelson, R.R., Silverberg, G., Soete, L. (Eds.), pp. 221-238.
7. Dosi, G. Freeman, C., Nelson, R.R., Silverberg, G., Soete, L. (Eds.). 1988. Technical Change and Economic Theory. London: Pinter.
8. EMOR. 2001. Press release from 03.05.2001. http://www.emor.ee/arhiiv.html?id=565. 18.10.2001.
9. Estonian Informatics Center. 2001. Information Society Indicators. http://www.eik.ee.
10. Estonian Taxation Board. 2001. Press release from 03.04.2001. http://www.ma.ee/pressiteated/pressiarhiiv/030401.shtml 18.10.2001.
11. European Bank for Reconstruction and Development. 2000. Transition Report 2000. London: Hyway Printing Group.
12. European Bank for Reconstruction and Development. 2001. Transition Report Update 2001. London: Alpine Press.
13. European Commision. 2000. Towards a European Research Area - Science, Technology and Innovation - Key Figures 2000. Luxembourg: Office for Publications of the European Communities.
14. European Commission. 2001. Key Figures 2001. Indicators for Benchmarking of National Research Policies. .
15. European Information Technology Observatory (EITO). 2000. European Information Technology Observatory 2000, Millennium Edition.. Mainz: Eggebrecht–Presse.

16. European Survey of Information Society, ESIS. 2000. European Commission's Survey "European Survey of Information Society" 1999-2000. http://www.ispo.cec.be/esis/.
17. Eurostat. 2001. News release. Candidate Countries. Labour productivity and remuneration levels just over 40% of EU average. No 55/2001 - 22 May 2001.
18. Evans, P. 1995. Embedded Autonomy: States and Industrial Transformation. Princeton, NJ: Princeton University Press.
19. Freeman, C. 1987. National Systems of Innovation: the Case of Japan Technology Policy and Economics Performance: Lessons from Japan. London: Pinter Publishers.
20. Freeman, C., Soete, L. 1997. The Economics of Industrial Innovation. Cambridge, Massachussetts: the MIT Press.
21. Haavisto, T. (Ed.). 1997. The Transition to a Market Economy: Transformation and Reform in the Baltic States. Cheltenham: Edward Elgar.
22. Hernesniemi, H. 2000. Evaluation of Estonian Innovation System. PHARE Support to European Integration Process in Estonia. .
23. James, J. 1996. Microelectronics and the Third World. in Cooper, C. Pp. 149-230.
24. Kompus, M. 2001. MA Thesis. Industrial Policy in Theory and Practise: The Case for Estonia. Tartu: University of Tartu.
25. Kondratieff, N.D. 1935. The long waves in economic life. The Review of Economic Statistics, Vol. 17 nov.35 105-115.
26. Lundvall, B.-Å. (Ed.). 1995. National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning.. London. Pinter..
27. Lundvall, B.-Å., Borrás, S. 1999. The Globalising Learning Economy: Implications for Innovation Policy. Luxembourg: Office for Official Publications of the European Communities.
28. McConnell International. 2001. Ready? Net. Go! Partnerships Leading the Global Economy. http://www.mcconnellinternational.com/ereadiness.
29. OECD. 1997. OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data – Oslo Manual. .
30. Pavitt, K. 1984. Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory. Research Policy, Vol. 13 (6), pp. 343-73.
31. Perez, C. 1983. Structural Change and the Assimilation of New Technologies in the Economic and Social System. Futures, Vol. 15 357-375.
32. Pihl, T. 2001. Working Paper. The Estonian ICT Cluster. Tartu: Archimedes Foundation.
33. Radoševic, S. 1998. S&T, Growth and Restructuring of Central and Eastern European Countries (The Report based on S&T Indicators). EU TSER Project: Restructuring and Reintegration of Science and Technology Systems in the European Economies in Transition. Brighton: University of Sussex, SPRU.

34. Radoševic, S. 1999. Restructuring and reintegration of science and technology systems in economies in transition. Final report of the TSER Project. Contract No: SOE1-CT95-1008. .
35. Riigikogu. 2000. Public Information Act. RTI 2000, 92, 597.
36. Riigikogu. 2000. Digital Signature Act. RTI 2000, 26, 150.
37. Riigikogu. 2000. Telecommunications Act. RTI 2000, 18, 116.
38. Riigikogu. 2001. Cable Distribution Act. RTI 2001, 53, 310.
39. Riigikogu. 1997. Databases Act. RTI 1997, 28, 423.
40. Riigikogu. 1996. Personal Data Protection Act. RT1 1996, 48, 944.
41. Riigikogu. 1998. Principles of Estonian Information Policy. RTI 1998, 47, 700.
42. Riigikogu. 2001. Knowledge-based Estonia. Estonian Research and Development Strategy 2002–2006. RTI 2001, 97, 606.
43. Schumpeter, J. A. 1939. Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process, Vol I and II. McGraw-Hill, New York. 1989 reprint (with an Introduction by Rendigs Fels). Philadelphia, PA: Porcupine Press.
44. Statistical Office of Estonia. 2001. CD-ROM. Statistical Yearbook of Estonia. .
45. Stiglitz, J. 1999. Public Policy for a Knowledge Economy. Speech delivered in Department for Trade and Industry and Center for Economic Policy Research. London, U.K. January 27.
46. Tiits, M. 2002. Working Paper. IST R&D and Innovation in Estonia. Tartu: Archimedes Foundation.
47. TNS Interactive. 2000. Global eCommerce Survey. http://www.tnsofres.com/ger2001/download/index.cfm.
48. United Nations Development Programme. 2001. Human Development Report 2001. Making New Technologies Work for Human Development. New York: Oxford University Press.
49. Viik, L. 2001. Eesti tehnoloogiatiigrite hulgas. Postimees 12/07/01.
50. Wergeland, T. 1997. The Future Trade Opportunities of the Baltic Republics. in Haavisto, T. (Ed.), pp. 119-149.