Analysis of Estonian IT Sector Innovation System: Introduction and Methodology

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1. Foreword and acknowledgements

On the outskirts of European Union, though right at the heart of European Research Area, Estonia envisages its clear role as a full-fledged member of modern Information Society. Surrounded by neighbouring Scandinavian information technology forerunners, Estonia has succeeded in reaping valuable experience from large scaled regional cohesion. The acquisition of ICT competence is being as overwhelmingly intensive as never before, public awareness is gradually improving, Information Society priorities are declared on highest political levels. Every aspect of the broad picture seems to follow the scenario we all wish to witness. Still, does it give a reason to be that optimistic?

In contrast, in its communication to European Council the Commission, when speaking about European knowledge-based Information Society concludes: "Without concerted action to rectify this the current trend may lead to a loss of growth and competitiveness in an increasingly global economy. The leeway to be made up on the other technological powers in the world will grow still further. And Europe might not successfully achieve the transition to the knowledge based economy." The alarming statement is made on the basis of latest European studies, which indicate the relatively low level of total R&D expenditures and increasing rates of brain drain from Europe to the USA. These surveys pave the way for elaborating new strategies, which would address the core problems more vigorously and define proper approaches for solving these. In the present situation it is important to get the right insight to the character of the impediments surrounding the accession to knowledge-based society, as properly determined problems help to tackle them more effectively.

Until now, there have been various statements regarding Estonia's readiness for digital uptake. Yet, the clear picture is still missing. One can have an imagination about processes commonplace to Estonian IT sector, but any subsequent analysis requires definitely somewhat more precise data than currently available. Availability of adequate information is imperative for facilitating the subsequent developments in the sector, on one hand serving as a basis for adequate political decisions, on the other hand for restructuring present innovation system.

As a result, the report is a natural response to the present situation and needs of Estonian society, aiming to solve partly the problems related to the lack of relevant information, but also positioning the role of ICT in Estonian economic and scientific landscape.

The performer of the study is the Innovation Centre of Foundation Archimedes, Estonia, whose aim is to enhance the participation of Estonian research, commercial and other organisations in EU research and technological development programmes. The tasks of the Innovation Centre include acting as a National Contact Point for the Fifth Framework Programme of EU Research and Technological Development and implementation of other activities so as to enhance the innovation capacity of Estonian industry and society as a whole.

Closer attention to ICT field and high public expectations have lead to the project "Establishment of the Virtual Centre of Excellence for IST RTD in Estonia" (acronym: Estonian *e*Vikings; Contract No IST-2000-26452), which is financed by the EU's 5th Framework Programme.

This project is being implemented in co-operation with several experts from other organisations and countries. The first working seminar in Tallinn (August 24, 2001) gave us the opportunity to present the preliminary results of the study to some of the leading experts of the field in Estonia. We, the authors, are especially grateful to Professor Jaan Penjam from the Tallinn Technical University, Prof. Ülo Jaaksoo, Ms. Kitty Kubo from the Ministy of

Economic Affairs, Mr. Arvo Ott from the Ministry of Transport and Communications and Mr. Jaak Anton for their intelligent feedback, suggestions for additional elements, and corrections.

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2. Terminology

2.1. Basic terminology

RTD – Research and Technological Development **(RTD)** covers the following three activities:

- Basic research is experimental or theoretical work undertaken to acquire new knowledge without any particular application or use in view.
- Applied research is directed towards a specific practical aim in order to acquire new knowledge of it.
- Experimental development aims at producing new materials, products or devices; at installing new processes, systems or services; or at improving substantially existing ones.

R&D –Research and development (R&D) is a more widely used concept than RTD. According to Hernesniemi research is used to define that part of scientific research, which makes the necessary ground for technology or other developments and improvements in firms or directly serves it. An important part of R&D is becoming acquainted with the results of research work and their active use for development in firms. Development can be defined as a group of activities aiming to in-crease absolute or relative (compared to the costs) value added of the company. Activities can include technological development but also other activities such as better organisation of production, marketing research and creating brands etc.

National Innovation System – 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).

Productivity - ratio of volume measure of output to a volume measure of input use in producing goods or services. The present assessment focuses on evaluating productivity based upon output value measures and general value based growth rates.

Value Chain – sequential order of the activities contributing to gradual elaboration and development of product or service. Complete value chain starts with inbound logistics and ends with final services or product maintenance.

Cluster - network of production of strongly interdependent firms linked to each other in a value adding production chain. Clusters play significant role as geographically concentrated competition domains, where shared infrastructure, complementary expertise and business activities alongside with sophisticated competition relationships generate synergy in the form of higher productivity, know-how spill-over and innovative incentives.

SME – ***Small and Medium Enterprise*** is defined as a business unit with less than 250 employees, annual turnover not exceeding 625 mln kroons or assests less than 420 mln kroons, and the enterprise fulfils independency criterion (the share of other companies should not exceed 25%). According to the number of employees enterprises are further divided as follows:

up to 9 employees – microenterprise;
10-49 employees – small enterprise;
50-250 employees – medium enterprise;
over 250 – large enterprise.

2.2. Defining ICT sector

Within the present study the concept of ICT sector is based on the definition outlined in OECD's (2000) prominent report "Measuring the ICT Sector". According to the report the following principles are used in defining ICT sector:

"*For manufacturing industries, the products of a candidate industry:*

- *Must be intended to fulfil the function of information processing and communication including transmission and display;*
- *Must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process.*

For services industries, the products of a candidate industry:

- *Must be intended to enable the function of information processing and communication by electronic means.*" (p. 7).

In line with the criterions set above, the definition of the ICT sector is presented in Annex I.

3. Objectives of the study

The main objectives of the report proceed from the prominent and recent study of the Estonian Innovation System, performed by the Finnish expert Hannu Hernesniemi in 2000. According to the the study the major weaknesses of the Estonian NIS are:

1) "*low awareness, which can be seen as a lack of realised technology development needs in firms and an unwillingness among politicians to invest in technology development,*
2) *the low RTD funding level and serious deficiencies in practical funding,*
3) *over allocation towards basic research and sciences not related to technology and unsubstantial contact between research units and firms, and*
4) *poor functioning of technology policy management and non existing contacts to firms.)*" (Hernesniemi 2000, p. 28)

The current study therefore takes a closer look at the all mentioned aspects in the context of Estonian ICT sector and in order to target low awareness issues it also focuses on more general issues. More specifically, the following questions are addressed within this project:

- What are the general growth perspective and innovation level of the Estonian manufacturing industry?
- How advanced is Estonian IT infrastructure? What is the level of implementation of various technological (ICT) applications? How can Estonian success in implementing various ICT solutions be explained?
- Which sectors compose Estonian IT cluster? Do cluster and national borders overlap?
- What is the competitive position of IT cluster within Estonian economy? Does it have more potential to become dominating force with respect to other clusters? The assessment of productivity levels is crucial here.
- Besides, even broader approach for assessing Estonian IT cluster competitiveness should be applied, as we need to conduct the evaluation also on the basis of international comparison. Therefore, the question remains to be answered - what is the position of Estonian IT cluster within international context?
- What is the scientific level of R&D in IT sector? Is there any urgent necessity for R&D at present economic stage? What is the state of IT related education in Estonia? Problems and possibilities of IT education: can it cope with technology change?

The target group of the present report is to provide decision-making support for all involved organisations, including:

- Parliament, that should be committed to developing the innovation capacity of Estonia and the technological level of its industries,

- Government that is in key position in systematic development of innovation system and technology development,
- Research and Development Council, that should strengthen preparatory work for policy planning and provide systematic overviews,
- Ministry of Economic Affairs that should anticipate technology development, plan and prepare the technology policy (Hernesniemi 2000, pp. 54-59),
- International organisations, which can utise the knowledge in their country reports and analyses,
- ICT and related businesses that are able to use the information presented in the report for improving awareness,
- International ICT business community to gain insights to the current state of Estonian ICT industry and innovation system on the whole.

4. Methodology

4.1. Selected literature

The theoretical dimension of the paper is founded on the publications from different prominent Science, Technology and Innovation Economists, who all emphasise the underlying role of innovation as a prerequisite for economic growth. To name some of the authors belonging to the school: Archibugi, D., Chang, H.-J., Dosi, G., Evans, P., Freeman, C., Soete, L., Lundvall, B.-Å., Perez, C., Schumpeter, J. A., etc.

The current study fully acknowledges already existing materials concerning Estonian Innovation System and IT sector. Most outstanding ones are:
- the “Evaluation of Estonian Innovation System” by H. Hernesniemi,
- “Research and Development in Estonia 1996-1999” by R. Kaarli and T. Laasberg,
- earlier reports “Research and Development in Estonia” by R. Kaarli and T. Laasberg,
- Innovation Trendchart – Estonian Country Report,
- European Information Technology Observatory 2000 and 2001 Yearbook,
- Estonian education and science evaluation reports,
- Estonian ESIS materials.

These are synthesised into comprehensive analysis, while filling the gaps found.

Additional sources for information comprise of a number of foreign ICT-industry related reports, such as
- “Swedish Information Technology in Figures 2000” by NUTEK,
- “Boosting Innovation: The Cluster Approach” and “Measuring the ICT Sector” by OECD,
- “ICT Cluster – The Engine of Knowledge Driven Growth in Finland” by L. Paija, etc.

and other IT policy-oriented publications and benchmarking reports (such as Progress Report on Benchmarking of National Research Policies, Commission Staff Working Paper 2000, etc.).

In benchmarking the key figures of Estonian IT industry, the most recognized indicators are primarily used in order to maintain international comparability of the study results. In line with available data some additional, but also alternative descriptive measures have been introduced i.e. productivity measures.

The analysis conducted in the report is based on internationally recognized Estonian and foreign statistical data sources. More specifically, large amount of statistical data is extracted from the materials of Statistical Office of Estonia and Estonian Bank, while foreign data sources comprised mainly of OECD publications, Eurostat and other.

4.2. Survey of Estonian ICT enterprises

The wide scale survey of Estonian ICT companies was conducted in May 2001. The list of target companies (Annex 1) was compiled by the project team. The main company selection criteria were turnover and growth potential. It was also assumed that companies with strong

economic performance and established market share pursue R&D activities more likely, and thus embed higher potential for better performance in the future. Based on the Business Registry database, the included companies cover altogether 85..90% of the domestic ICT market by turnover. Also, several emerging companies that are dealing with innovative products or processes were included due to the economic potential.

In composing the questionnaire, Community Innovation Survey questionnaire was consulted and modified according to the purposes of the current study (data collection for cluster study). The questionnaire was elaborated in cooperation with Estonian leading ICT experts and consulted with the Association of Estonian Information Technology and Telecommunications Companies. Also, professional assistance from the public poll opinion company Saar Poll OÜ was used concerning the formulation of questions, codification (see annex 2 for the questionnaire) and the selection of data collection methodology.

With respect to data collection an interviewing method was used, whereas the series of interviews were conducted by 19 interviewers from Saar Poll OÜ during May 2-22, 2001. Altogether 133 companies where approached by the interviewers, 99 of them were ready to disclose information.

Despite the mostly positive results of the survey still some deficiencies with respect to understanding essence and definition of the research and development[1] work were identified, which means, that we are unable to rely fully on the enterprise IT R&D related findings of the survey conducted.

4.3. Structure of the report

Structurally, the report has been divided into three major parts to fulfil the objectives and outlined methodological preferences in the best possible way.

The first part of the present paper "ICT, Innovations and Innovation policy: The Case of Estonia" provides reader with relevant background information in understanding the developments of Estonian ICT cluster in light of transition to market economy and new techno-economic paradigm. It does not, however, provide detailed information about entire Estonian transition process, as this would exceed the scope of the present report. Instead, it covers some aspects of the essential theoretical foundations and in terms of these seeks for parallels from today's Estonian information society. Also, references to other existing materials are provided in order to facilitate better acquisition of the topic and the involvement of interested readers.

Based on the viewpoints of prominent Science, Technology and Innovation Economists the importance of innovation process and widely acknowledged approach to techno-economic paradigms are outlined. The first part also envisages the considerations of the authors regarding the national innovation system and innovation policy. It follows that due to the central position of ICT in the economic system it is not enough to focus solely on ICT sector as such. Cluster (part II of the paper) is much wider concept with higher economic impact potential, and therefore also more suitable approach in fulfilling the objectives of the report.

The methodology used in the report is an adapted version of the popular National Innovation System (NIS) assessment practice, whereas general ICT cluster analysis approach is integrated into the NIS framework for gaining better understanding about the existing interrelations between IT and supporting industrial sectors. The NIS methodology helps to indicate the role of different structures in generating sustained innovation in IT sector and assess the efficiency of their performance. The results enable to highlight the major obstacles confronted by the industry, and consistent with the results to define certain measures for adopting the necessary rearrangements. Cluster analysis represents an economic dimension

[1] Project team has identified, that the enterprise IT R&D indicated in the survey results should be still interpreted, as routine software development, etc. not falling under the definition provided in OECD Frascati Manual.

of the NIS approach, giving insight to the competitiveness and productivity issues, supply and demand side of IT products and services, competition driven innovation etc., while serving as a tool for determining ICT industry's place in Estonian economy on the whole. Such analytical approach is chosen due to its flexible and focused nature, as clusters represent relatively sophisticated interrelations between different sectors and sub-sectors in a more uniform and adequate manner than plain sectoral analysis would do.

As to methodological basis, M. Porter's renowned conditional model of cluster framework, also known as Porter's diamond, is used. Porter's diamond outlines basically four factor groups that serve as a precondition for emerging cluster relationships. These four groups embrace factor conditions, firm strategy, structure and rivalry, related and supporting industries, and finally demand conditions. All mentioned aspects are discussed in the context of present cluster evaluation, more specifically in "Estonian ICT cluster: Present State and Future Outlooks" part, where the economic structure and functional mechanisms of Estonian ICT cluster are presented. It is the common belief of the authors that analysis within such framework depicts relatively well the existing economic conditions, as well as preconditions for Estonian ICT cluster development today and help to assess its future outlooks. However, at the same time authors bare in mind the fact that not all methodological nuances are applicable and adaptable in Estonian context, as Estonian economy incorporates a number of differences compared to well established and stable western economies and it is important aspect to consider. A good argument for such statement is the research conducted by B.J. O'Toole, where the author looks for the relevance of Porter's Diamond in terms of Irish technology cluster and finds that majority of diamond conditions are not actually fulfilled in the context of Irish high-tech cluster. Therefore, the present research considers the peculiarities of Estonian economy and conducts analysis well in line with these conditions.

Another approach in determining the cluster relationships is based on Input-Output analysis. Input-Output (I/O) analysis is based on statistical input-output matrix (known also as Leontieff) tables, which indicate how much goods and services produced by one sector are used as input to production by another sector. It is a macroeconomic level approach, outlining the relationships between different sectors, though the identification of a cluster is still very much of a subjective matter. Still, this kind of analysis helps to see how deeply interrelated are the sectors and on the basis of the information to evaluate the extent of the convergence process. Input-output analysis is the most common practice in establishing the relations within a certain cluster. However, within the present evaluation it was not possible to use I/O tables, as such statistics is not available in Estonia. The I/O analysis conducted here is based on the individual questionnaires, which were validated on a sample of IT enterprises. More detailed information about the conducted survey is presented in chapter 4.2.

In addition to the analytical tools described above net export analysis as an indication of comparative competitive strength was applied, as well as productivity analysis, which is considered to be one of the core aspects within Estonian ICT cluster assessment. Productivity analysis is derived indirectly on the basis of OECD Productivity Manual, and harmonised with the purposes of the present evaluation. Productivity is measured on comparative basis and defined as the ability to generate value added per expense unit spent on personnel and capital.

The third paper, IST R&D and Innovation in Estonia provides in-depth analysis on the present state and shortcomings in the in Estonian IT related research and development activities. Alongside with the brief overview on the main Estonian IST RTD performers and RTD indicators insights to IST RTD national funding are provided. Based on IPPA methodology introduced by the European Commission, major strongholds and perspective fields of the Estonian ICT sector are outlined and some adequate RTD related recommendations posed.

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