



ERAWATCH Country Report 2008

An assessment of research system and policies

Estonia

Rurik Holmberg, Katrin Männik, Ruta Rannala and Alasdair Reid



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ERAWATCH COUNTRY REPORT 2008

An assessment of research system and policies Estonia

ERAWATCH Network -
Technopolis Group Estonia

Rurik Holmberg, Katrin Männik, Ruta Rannala and Alasdair Reid

Joint Research Centre
Directorate-General for Research

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Executive Summary

Research policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the European Union (EU) economy are at the heart of the Lisbon Strategy. In particular, guideline No. 7 of the Integrated Guidelines for Growth and Jobs which aims to increase and improve investment in research and development, in particular in the private sector. In this context, this report aims at supporting the mutual learning process and the monitoring of Member States efforts. The main objective is to characterise and assess the performance of the national research system of Estonia and related policies in a structured manner that is comparable across countries. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. This report is based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

Estonia has performed well in recent years in terms of meeting its commitment to improving investment in research and development. It has achieved one of the fastest growth in R&D expenditure in the EU27. However, it faces a range of challenges due to the small size of the research system, the fragmented structure and still largely outdated research infrastructure as even fresh investment since 2004 cover only a small part of actual needs. In addition, one major concern is the insufficient rate of PhD graduates in science and engineering. The national objectives related to improving the investment into research are at risk due to limited public finances and an economic structure which is increasingly uncompetitive.

The tables below summarise the main elements of discussion and analysis for each of the domains and challenges addressed in this report and the policy opportunities and related risks.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	<ul style="list-style-type: none"> There is a relatively clear political consensus on the importance of working towards a “knowledge based Estonia”
	Securing long term investment in research	<ul style="list-style-type: none"> Structural Fund programming approach has provided longer-term commitment, balancing the short-term vagaries of annual budgeting rounds The private sector is expected to contribute a significant share of the increased R&D spending by 2014, but given current trends this is unlikely to be achieved.
	Dealing with barriers to private R&D investment	<ul style="list-style-type: none"> The value added in Estonian industry production is often low and consequently also domestic demand for industrial R&D is low. Lack of attention to FDI as a source for increased investment in research Launch of Estonian Development Fund should help to structure public-private financial resources for knowledge intensive firms
	Providing qualified human resources	<ul style="list-style-type: none"> Action is being taken (graduate schools, etc.) to improve the attractiveness of science as a career, faced by insufficient levels of (doctoral) students in S&T

Domain	Challenge	Assessment of strengths and weaknesses
Knowledge demand	Identifying the drivers of knowledge demand	<ul style="list-style-type: none"> Tradition of transparent public consultation on policies; Despite recent foresight, actions, strategic planning of scientific and industrial research priorities requires greater efforts. Few mechanisms for technology assessment or identification of broader societal needs for knowledge.
	Co-ordination and channelling knowledge demands	<ul style="list-style-type: none"> The launch of national technology programmes should improve co-ordination of knowledge demand and production
	Monitoring of demand fulfilment	<ul style="list-style-type: none"> Little is done aside from programme level evaluations to monitor impact of policy initiatives
Knowledge production	Ensuring quality and excellence of knowledge production	<ul style="list-style-type: none"> Research assessment and peer review mechanisms are in place but remain based largely on scientific criteria and less on their relevance for the economy or society. Initial steps towards concentrating funding in science excellence centres with sufficient critical mass to compete in the ERA.
	Ensuring exploitability of knowledge	<ul style="list-style-type: none"> Management processes and capacities in R&D institutions remain weak (despite support) and incentives to undertake applied research are low for academics. Programmes such as SPINNO aimed at improving management of IPR in universities.
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	<ul style="list-style-type: none"> Instruments such as the competence centres have begun to create synergies between academic and business interests. Circulation of knowledge could be dramatically ramped up and cover a much wider range of companies.
	Profiting from international knowledge	<ul style="list-style-type: none"> Estonian research teams have been strongly involved in EU programmes and research mobility and internationalisation of the research base is a clear priority.
	Enhancing absorptive capacity of knowledge users	<ul style="list-style-type: none"> Limited number of S&T graduates working in industry able to act as 'gatekeepers' for co-operation with knowledge institutions; There is a developing but relatively standard and limited range of support services for enterprises seeking to transfer technology, etc.

Estonia clearly stands at the crossroads. On the one hand there is wide-spread understanding of and concordant political commitment to a general overhaul of the entire R&D system, but on the other hand shortage of both financial and human resources put the process at risk. In brief, the willingness to change may exceed the financial and human capacities.

R&D intensity has been rising but this rise is unlikely to continue since the government budget is under pressure and business expenditure is concentrated in a limited number of firms (most of the 2007 increase was attributable to Skype), making the Estonian system vulnerable to developments in a few companies. Investment in R&D infrastructure is dependent on EU Structural Fund support and even with current investment levels only a fraction of the accumulated under-spend of the previous decade will be made up. One solution for Estonia could be to develop its research strategy as part of a Nordic-Baltic research system, with sharing of infrastructures and increased inter-country mobility of researchers. This approach could allow for maintaining present strengths without being forced to dilute financing across a wide range of scientific specialisations. This would also reduce the sense of being at a disadvantage in demographic terms.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	<ul style="list-style-type: none"> Elements of medium-term horizontal strategic planning implemented and continuous efforts to link national investment and implementations plans with the strategic framework documents Political commitment of virtually all policy parties to the Lisbon goals including on R&D. 	<ul style="list-style-type: none"> Worsening budgetary and macro-economic situation for both business and public funding. Prioritisation of annual state budget process and needs and the objectives of the Coalition Agreements instead of medium/long-term strategy planning Reliance on business sector to reach investment goals.
Knowledge demand	<ul style="list-style-type: none"> Nation-wide technology- and cluster related foresight activities were started by the EDF in mid-2008. EDF has a sufficiently narrow approach to focus on 5-6 key (technology) areas. Inclusion of business demands in education plans. 	<ul style="list-style-type: none"> No common approach and implementation means to monitor or evaluate the knowledge demand systematically and comprehensively No coherent consistent articulation between RDI, education, labour market, industrial foresight and social policies in terms of knowledge demand and supply.
Knowledge production	<ul style="list-style-type: none"> Measures such as the competence centres have begun to improve academic-industry linkages. 	<ul style="list-style-type: none"> Propensity to research commercialisation not supported by academic inventive system still based on publications. Limited financial means of enterprise sector and lack of specific (financial) measures to promote improved IPR management and protection.
Knowledge circulation	<ul style="list-style-type: none"> Further improvements to the articulation between higher education, science, technology and enterprise policies. To increase the knowledge and practice in R&D and innovation management, to develop partnerships between industrial clusters and the public sector and to increase the international R&D cooperation of SMEs. Need to create more attractive motivation package (funding, competences, infrastructure) for foreign researchers and engineers in the Estonian business or research sector 	<ul style="list-style-type: none"> Absence of business R&D engines in the economy, which may not produce the expected outcomes from public policy on R&D and innovation. Shortage of human resources for creating a critical mass of R&D competence in specific fields of technology.

Scientific specialisations seem to be only loosely connected to future economic-society needs, but on the other hand, in the absence until recently of foresight type activities, it is difficult to ascertain which scientific specialisations are most crucial for future development needs. In recent years, Estonia has performed well in sectors focused on the short-to medium term (such as financing, real estate etc.), while finding long-term paths have been paid less attention to. In general, knowledge demand in Estonia is insufficiently articulated and so far based on some very sporadic interactions between companies and universities.

Human resources in S&T are improving thanks to improved infrastructure, graduate schools, funding, etc. but salaries and PhD stipends are non-competitive (nationally

and versus international competition - e.g. Finland) and the number of PhDs per year is far below what it should be.

The rapid growth of R&D funding in Estonia makes it appropriate to study the effects in detail, especially against the assumption that the knowledge production systems is still suffering from inefficiencies and, at times, sub-optimal performance. Even if the rate of increase of R&D funding of the last years would not be maintained the boosting of and inflow of funds has been big enough to motivate an evaluation of the effect on the system.

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1 - Introduction and overview of analytical framework

1.1 Scope and methodology of the report in the context of the renewed Lisbon Strategy and the European Research Area

As highlighted by the Lisbon Strategy, knowledge accumulated through investment in R&D, innovation and education is a key driver of long-term growth. Research policies aimed at increasing investment in knowledge and strengthening the innovation capacity of the EU economy are at the heart of the Lisbon Strategy. Guideline No. 7 of the Integrated Guidelines for Growth and Jobs aims to increase and improve investment in research and development (R&D), with a particular focus on the private sector. The ERAWATCH network has been requested to produce analytical country reports to support the mutual learning process and the monitoring of Member States' efforts.

The main objective of this report is to analyse the performance of national research systems and related policies in a comparable manner. The expected result is an evidence-based and horizontally comparable assessment of strength and weaknesses and policy-related opportunities and risks. A particular consideration in the analysis is given to elements of "Europeanisation" in the governance of national research systems in the framework of the European Research Area, re-launched by the ERA Green Paper of the Commission in April 2007.

To ensure comparability across countries, a dual level analytical framework has been developed. On the *first level*, the analysis focuses on key processes relevant to system performance in four policy-relevant domains of the research system:

1. Resource mobilisation: the actors and institutions of the research system have to ensure and justify that adequate public and private financial and human resources are most appropriately mobilised for the operation of the system.
2. Knowledge demand: needs for knowledge have to be identified and governance mechanisms have to determine how these requirements can be met, setting priorities for the use of resources.
3. Knowledge production: the creation and development of scientific and technological knowledge is clearly the fundamental role of a research system.
4. Knowledge circulation: ensuring appropriate flows and distribution of knowledge between actors is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production.

These four domains differ in terms of the scope they offer for governance and policy intervention. Governance issues are therefore treated not as a separate domain but as an integral part of each domain analysis.

Figure 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
<ul style="list-style-type: none"> • Justifying resource provision • Long term research investment • Barriers to private R&D funding • Qualified human resources 	<ul style="list-style-type: none"> • Identification of knowledge demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment 	<ul style="list-style-type: none"> • Quality and excellence of knowledge production • Exploitability of knowledge production 	<ul style="list-style-type: none"> • Knowledge circulation between university, PRO and business sectors • International knowledge access • Absorptive capacity

On the second level, the analysis within each domain is guided by a set of generic "challenges" common to all research systems that reflect conceptions of possible bottlenecks, system failures and market failures (see figure 1). The way in which a specific research system responds to these generic challenges is an important guide for government action. The analytical focus on processes instead of structures is conducive to a dynamic perspective, helps to deal with the considerable institutional diversity observed, and eases the transition from analysis to assessment. Actors, institutions and the interplay between them enter the analysis in terms of how they contribute to system performance in the four domains.

Based on this framework, analysis in each domain proceeds in the following four steps. The first step is to analyse the current situation of the research system with regard to the challenges. The second step in the analysis aims at an evidence-based assessment of the strengths and weaknesses with regard to the challenges. The third step is to analyse recent changes in policy and governance in perspective of the results of the strengths and weaknesses part of the analysis; and finally the fourth step focuses on an evidence-based assessment of policy-related risks and opportunities with respect to the analysis under 3) and in the light of Integrated Guideline 7.

This report is based on a synthesis of information from the European Commission's ERAWATCH Research Inventory¹ and other important publicly available information sources. In order to enable a proper understanding of the research system, the approach taken is mainly qualitative. Quantitative information and indicators are used, where appropriate, to support the analysis.

After an introductory overview of the structure of the national research system and its governance, chapter 2 analyses resource mobilisation for R&D. Chapter 3 looks at knowledge demand. Chapter 4 focuses on knowledge production and chapter 5 deals with knowledge circulation. Each of these chapters contains four main subsections in correspondence with the four steps of the analysis. The report concludes in chapter 6 with an overall assessment of strengths and weaknesses of the research system and governance and policy dynamics, opportunities and risks across all four domains in the light of the Lisbon Strategy's goals.

¹ ERAWATCH is a cooperative undertaking between DG Research and DG Joint Research Centre and is implemented by the IPTS with the support of the ERAWATCH Network (www.erawatch-network.eu). The ERAWATCH Research Inventory is accessible at <http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home>

1.2 Overview of the structure of the national research system and its governance

One of the smallest European countries in terms of population (1.3 million inhabitants in 2007, Statistics Estonia), Estonia has a relatively successful history of economic and structural reforms over the last 15 years. By 2007, gross domestic product (GDP) per capita in purchasing power standards (PPS) stood at 72% of the EU27 average. High rates of economic growth have been maintained in recent years (real growth rate per capita was 10 % in 2005, 11% in 2006)². Yet, during 2008, the foundations for further improving competitiveness were questioned and the need for a more significant shift to knowledge intensive activities underlined (Varblane, 2008).

Administratively, the country is divided into 15 counties, with about 70% of the population living in towns. Tallinn is the capital and also the largest city with 403,500 inhabitants, followed by a handful of other larger towns (Tartu, 101,169, Narva 68,680, Kohtla-Järve 47,679, Pärnu, 45,500)³. Higher education and research activities are essentially concentrated in Tallinn and in the historic university town of Tartu. Given the scale of the country and the centralised governance structure, research policy elaboration, governance and implementation are done only at the nationwide level. Local governments have neither the devolved responsibility nor the financial capacity to develop their own research policies.

From 1998 to 2007 expenditure on R&D has grown by 10% per annum, the second highest growth rate in the EU27 (just behind Cyprus), causing the GERD/GDP ratio to rise from 0.57% in 1998 to 1.14% in 2006 (Table 1). Although still far behind the EU27 average of 1.84%, it is the third highest rate amongst the 2004 intake of EU Member States (after respectively the Czech Republic and Slovenia). This trend is based partly on a political commitment of successive governments to increase competitiveness via investments in and innovation (see also 2.1.1); allied to the positive impact of EU funding since 2004 (notably the Structural Funds).

Table 1: R&D Expenditures, by performers/ sectors, in 2005- 2007

Expenditure by performer	Total	HEI	State	NPO	Business
In current prices, 1000 EEK					
2005	1,627,585	674,339	183,684	35,727	733,835
2006	2,362,537	959,609	310,169	42,933	1,049,826
2007	2,716,988	1,135,636	235,336	64,916	1,281,100
In % of GDP					
2005	0.94	0.39	0.11	0.02	0.42
2006	1.14	0.46	0.15	0.02	0.51
2007	1.14	0.47	0.10	0.03	0.54
In % of total expenditure (with corresponding figures for EU-27 in brackets)					
2005	100.0	41.4 (22.0)	11.3 (13.6)	2.2 (0.9)	45.1(63.4)
2006	100.0	40.6 (21.8)	13.1 (13.4)	1.8(0.9)	44.5(62.7)
2007	100.0	41.8	8.7	2.4	47.2

Sources: Eurostat (<http://epp.eurostat.ec.europa.eu>), Estonian Statistics, Ministry of Education and Research

² If not referred otherwise, all statistics used are sourced from Eurostat.

³ Figures from 2008 census

In terms of R&D **expenditures**, Estonia shares characteristics common with many of the other 'Convergence'⁴ Member States, in that the government sector provide the largest share while the business sector is well below the average EU level (44.5% in 2006, compared to 62.7% in EU27). Recent trends suggest however that the role of the business sector in R&D is increasing, both as a source of financing (38% in 2005 and 2006) and as a performer (45% in 2006), thus overtaking the until recently dominant higher education sector (41% in 2006).

Table 2: R&D financing, by sources and performer, 2005- 2007 (000 EEK)

Performed by Source	Total	HEI	State	NPO	Business	% of GDP	% of Total
State budget							
2005	708,039	495,257	146,548	15,297	50,937	0.41	43.5
2006	1,052,660	765,836	194,846	11,976	80,002	0.51	44.6
2007	1,240,200	869,900	217,400	33,500	119,400	0.52	45.6
Business							
2005	624,000	35,162	27	1,803	587,000	0.36	38.3
2006	900,900	47,763	111	2,012	851,000	0.44	38.1
2007	1,131,000	63 400	100	9,900	1,057,000	0.47	41.6
NPOs							
2005	3,000	1,846	104	1,074	0	0.002	0.2
2006	3,300	1,089	21	2,171	0	0.002	0.1
2007	5,000	600	100	2,000		0.002	0.0
HEIs							
2005	12,300	11,871	167	279	0	0.007	0.8
2006	21,100	15,889	1,879	2,979	400	0.010	0.9
2007	23,500	19,300	500	2,000	2,700	0.010	0.9
Foreign							
2005	280,300	130,203	36,838	17,274	96,000	0.16	17.2
2006	384,500	129,032	113,312	23,795	118,400	0.19	16.3
2007	317,200	182,500	17,200	18,500	99,000	0.13	11.7

Sources: Eurostat (<http://epp.eurostat.ec.europa.eu>), Estonian Statistics, Ministry of Education and Research

Considering the orientation of R&D expenditure (GOVERD and HERD), in 2004 Estonia invested more than the EU27 average in agriculture (12.9% compared to 6%), engineering and technology (21.4% compared to 20.6%) and humanities (14% compared to 8.8%); and less than the EU27 average on medical sciences (11% versus 18.7%), natural sciences (30.7% compared to 34.9%) and marginally for social sciences (10.1% versus 11%). The public sector continues to play a dominant role in R&D **funding** accounting in 2006 it for 46 % of total financing (especially through higher education) compared to 38% by business. Estonia is amongst a small group of EU countries that receive a significant proportion (16% in 2006) of R&D financing from abroad (due to the significant foreign investment in the economy as well as EU funding).

Governance of research policy

The national governance system for research policy is set out in the special law *Research and Development Organisation Act* (1997, 2007), which provides the organisation, structure, functioning and financing principles of the Estonian R&D system. At the **political level**, the Government of the Republic adopts national R&D development plans (such as the two R&D and innovation strategies, called

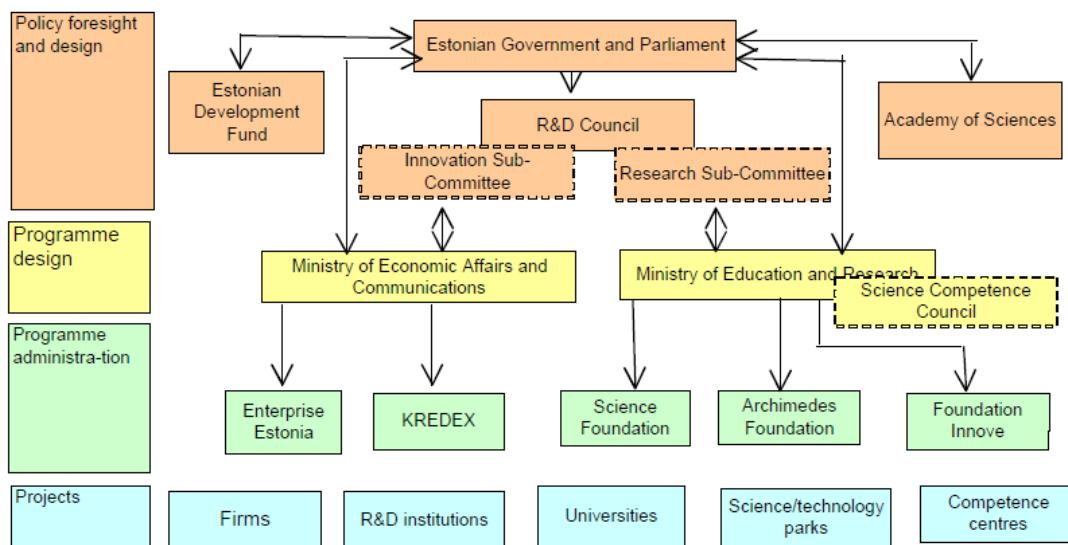
⁴ Member States or regions with less than 75% of the EU27 average GDP per capita

Knowledge-Based Estonia I for 2003-2006; and Knowledge-Based Estonia II for 2007-2013), submits them to the Parliament, approves national R&D programmes, ensures cooperation between the ministries and enacts legislation.

The Research and Development Council is an expert and consultative body that provides advice to the Government of the Republic in the fields of R&D and innovation. The Council is chaired by the Prime Minister, which links it directly to the Cabinet. It also includes the three other most relevant ministers for research and innovation policy: the Minister of Education and Research, the Minister of Economic Affairs and Communications and the Minister of Finance. Other members are, among others, the president of the Academy of Sciences and the president of the Estonian Chamber of Commerce and Industry. Despite the high profile of the members of the Council, the role of the Council is much less visible in the strategy setting or R&D-related strategic foresight (Tiits, 2007) and more focused on *ad hoc* expert advice to the Prime Minister.

At the policy design level, the two central organisations in Estonian RDI policy are the **Ministry of Economic Affairs and Communications** (MEAC), and the **Ministry of Education and Research** (MER). Support to and funding of industrial R&D, as well as planning, coordination and implementation of innovation policy are the competence of the MEAC. The MER implements national research policy, organises the financing and evaluation of universities research institutes and coordinates international cooperation of research.

Figure 2: Overview of the governance structure of the Estonian research system



Source: Authors' update based on Männik (2007)

Two permanently established **advisory bodies** (the **Research Policy Commission** and the **Scientific Competence Council**) provide advice to the Minister of Education and Research. In particular, the Scientific Competence Council provides expert advice and submits proposals to the Ministry on distributing targeted funding and is also involved in research evaluation, etc. The former system of research institutes of the **Estonian Science Academy** was fully restructured during the 1990s, and the majority of institutes were incorporated into the public universities. Under the *Estonian Science Academy Act*, the Academy has become purely a representative

body for scientists and acts neither as a research performer nor as an evaluation, monitoring or supervisory body for research activities.

Both the MEAC and the MER have special, but small units working on policy: a division under the Economic Development Department and the Department of Research, as well as their own advisory committees for policy development, the Science Policy Committee for the MER, and the Innovation Policy Committee for the MEAC. Via the respective Ministers, both policy committees are closely involved in the activities of the Research and Development Council.

Until recently, there has been a lack of balanced co-ordination of research policy, innovation, education and other related issues. However, during the development of the *RDI Strategy for 2007-2013*, a permanent **Coordination Commission** was established in 2007 by the MER. It includes representatives of the both core ministries in R&DI, the Ministry of Finance and the State Chancellery, implementation agencies, public universities and entrepreneur associations. The State Chancellery (Strategy Office) itself is active intermediary in the R&D related strategy and policy consultations, and acts as a secretariat of the Research and Development Council.

At the **operational level**, the two ministries (MER and MEAC) have their own implementing agencies/bodies and intermediaries. The main implementing body of the MEAC is the **Enterprise Estonia Foundation**, which is responsible for managing innovation and technology programmes, and notably the majority of ERDF programmes. The objective of the **Estonian Science Foundation** (ESF) is to support scientific research by allocating grants (financed via the budget of MER), to find non-state-budgetary means to support research, etc. The ESF also represents Estonian researchers on international level. The implementing agency of the MER is the **Archimedes Foundation**, which is responsible for national activities related to the European Research Area, international research programmes and academic mobility measures, and the Foundation for **Lifelong Learning Development INNOVE**. The latter manages a range of programmes and support measures in the fields of lifelong learning and active labour market policies.

Research performers

In 2008⁵, there were 31 higher education institutions in Estonia, six of them were public (state) universities and four were private universities. The remaining 21 institutions are professional higher education institutions and some vocational education schools (the latter offer mostly last not tertiary but secondary-level education). The four largest **public research universities** are the University of Tartu (approximately 19,000 students), followed by Tallinn University of Technology (approx. 12,000 students), Tallinn University (7,800) and the Estonian University of Life Sciences (4,500). Virtually all academic research and development in Estonia is performed at the public universities and, indeed, it is strongly concentrated in the University of Tartu and Tallinn University of Technology, which together account for some 70% of all R&D output of higher education institutions (publications, patents, PhDs and income from contract research).

There are, however, a few public research organisations in specific science field, for instance, the National Institute of Chemical Physics and Biophysics, and the Estonian Biocentre. Smaller institutions of higher education, including the majority of professional higher education institutions, vocational education schools and private

⁵ State Education Information System (www.ehis.ee)

institutions account for only a minor share of research performed (OECD report of Tertiary Education, 2006)

As will be explored in the following sections, Estonia's research system has gone through a major restructuring in the past 15 years and yet the process is far from being completed. The structural changes are continuing and focusing now on new collaborative mechanisms bringing together research actors to focus on specific tasks and consolidating competence and frontier research capacities (Centres of Scientific Excellence, Competence Centres), development of performance and financing mechanisms, and steps towards further consolidation of the university system, with the aim to increase the competitiveness of the national research system and to foster optimal use of limited resources.

2 - Resource mobilisation

The purpose of this chapter is to analyse and assess how challenges related to the provision of inputs for research activities are addressed by the national research system. Its actors have to ensure and justify that adequate financial and human resources are most appropriately mobilised for the operation of the system. A central issue in this domain is the long time horizon required until the effects of the mobilisation become visible. Increasing system performance in this domain is a focal point of the Lisbon Strategy, with the Barcelona EU overall objective of a R&D investment of 3% of GDP and an appropriate public/private split as orientation, but also highlighting the need for a sufficient supply of qualified researchers.

Four different challenges in the domain of resource mobilisation for research that need to be addressed appropriately by the research system can be distinguished:

- Justifying resource provision for research activities;
- Securing long term investment in research;
- Dealing with uncertain returns and other barriers to private R&D investment; and
- Providing qualified human resources.

2.1 Analysis of system characteristics

2.1.1 Justifying resource provision for research activities

In Estonia financial appropriation is based on a hierarchical strategic planning process. The over-arching document is the annual State Budget Strategy (SBS), which set the main goals for the period 2009-12⁶. This budgetary plan is complemented by the Action Plan for Growth and Jobs 2005-2007⁷ (or National Development Plan, NDP)⁸ and the National Strategic Reference Framework 2007-2013 (NSRF) for the implementation of the Structural Funds⁹. All these plans identify R&D and innovation as key components for sustaining strong economic growth and

⁶ Government Decree, 29.05.2008.

⁷ A new plan for 2008- 2011 is expected to be adopted by end 2008

⁸ http://www.riigikantselei.ee/failid/1.October_2005_Estonian_Action_Plan_for_Growth_and_Jobs2.pdf

⁹ See: http://ec.europa.eu/regional_policy/atlas2007/fiche/et_en.pdf for a summary. In the previous period, the equivalent document was the Estonian National Development Plan 2004–2006.

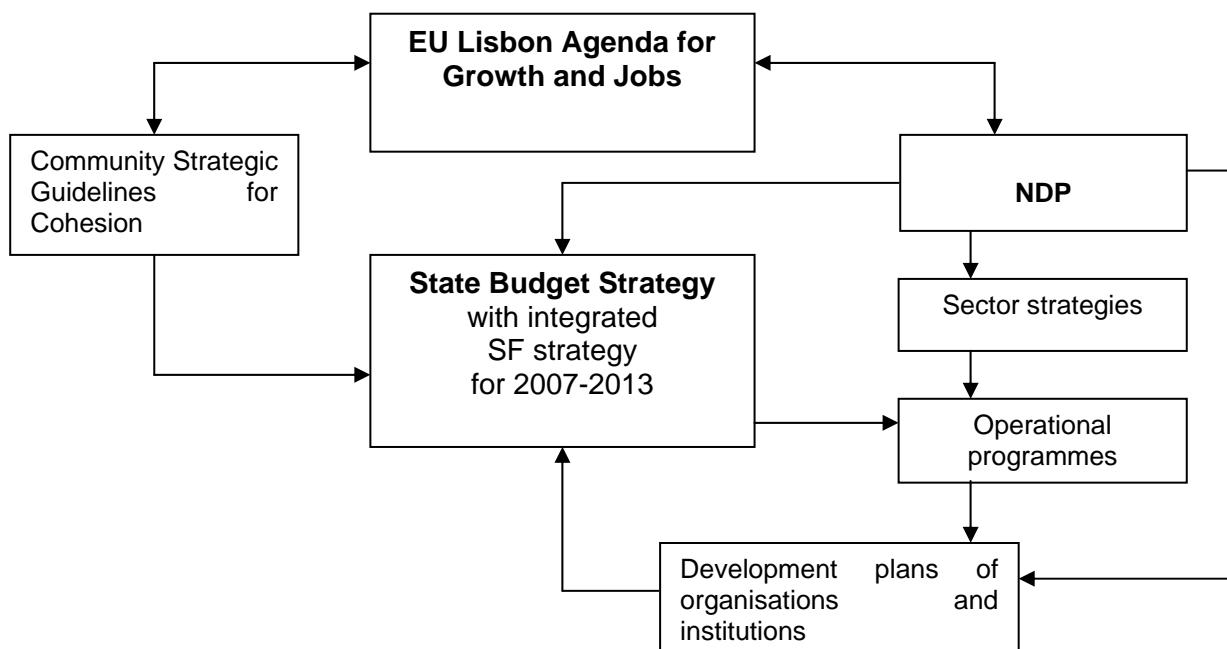
enhancing competitiveness.

The NDP is the national contribution to the EU's Lisbon objectives and summarises the Government's primary goals for increasing Estonia's competitiveness. It focuses on two key challenges: R&D and innovation; and employment. In particular, the fourth objective of the NDP is "Increasing the quality of research and development, as well as the capacity for innovation, growth, and long-term international competitiveness". In terms of research policy, the NDP argues

"Taking into account, apart from rapid economic growth, the real absorption capacity of the R&D sector and the low base level of R&D investments, it seems quite unrealistic to achieve a 3%-level by 2010. So the government's goal will be to raise the public sector's R&D expenditures to reach 1.05% of the GDP by the year 2010, and continues to increase it in the following years. A steady rise in public investment will allow the government's goal for 2010 to be that the total R&D expenditures should make up 1.9% of the GDP".

The general strategic framework justifying the resource allocations in R&D is complemented by the sector strategies (RDI Strategy and HE Strategy). Estonia's commitment to the 3% GERD/GDP target was initially stated in the Knowledge-Based Estonia Strategy 2003-2006 and confirmed again in the Research, Development and Innovation Strategy 2007-2013¹⁰. According to the latter, Estonia should attain the 3% target by 2014, a deadline that can be considered over-optimistic. This target is not included in the NSRF 2007-2013, but rather a commitment to "increase the R&D capacity and the innovativeness and productivity of enterprises"; with the target being to the increase of the share of BERD/GDP from 0.4% in 2004 to 1.6% in 2013.

Figure 3: Linkage between different level strategies and development plans



Source: Authors

As can be seen from Figure 4, from 2007, the various strategic plans are linked to ensure the complementary use of national budgetary resources and EU Structural

¹⁰ See: <http://www.hm.ee/index.php?0&popup=download&id=6175>

Funds in favour of the social and economic development of Estonia. Indeed, the NSRF¹¹ can be considered a permanent “implementation” strategy of the SBS and NDP objectives. Due to the strict and systematic EU financing rules, it is the most stable, detailed and coherent strategic framework in place, endorsed by a special law (the *Structural Assistance Act*). Prior to 2004 and the first round of Structural Fund support, public funding for R&D and innovation was minimal with the universities suffering from chronic under-investment in basic research infrastructure. The situation has certainly evolved positively since 2004 and the increased allocations of State and Structural Fund resources in the NSRF for research are “guaranteed” for the period up to 2013¹².

Concerning the extent of a public debate on research priorities, the consultations on the broader NDP, including the research related objectives, were substantial. The Prime Minister's office coordinates the drafting and monitors its implementation and the draft NDP was published on the Government website for public consultation before being approved. Currently, the elaboration of the NDP for 2008-2011 is underway and is following a similar consultative process. Discussions about the specific sectoral for research and innovation strategies tend to be confined to a more limited group of experts and politicians even if the strategies received Parliamentary scrutiny. Indeed, a public debate on the role of science per se and public understanding of science has not been given major strategic importance by the Estonian Government or agencies. More recently, initiatives have been launched to promote ‘innovation awareness’ (Enterprise Estonia with ERDF co-financing) or sectoral foresight (funded via the newly established Estonian Development Fund¹³). Moreover, the universities are increasingly trying to promote science education faced by limited interest from young people.

2.1.2 Securing long term investment in research

As noted above, the sectoral strategic framework for medium-term investment in research is the national R&D and innovation strategy, **Knowledge-Based Estonia 2007-2013**. A second policy framework of importance is the **Higher Education Strategy, 2006–2015**.¹⁴ The latter document proposes further reforms including the modernisation of the funding system for Estonian higher education and better alignment between educational and research functions of institutions of higher education. In practical implementation, both of these sector strategies could easily be compromised by the lack of explicit budgetary commitments in the higher-level strategies (Estonian Ministry of Education and Research 2006). An evaluation of Estonian RTDI Policy (Reid & Walendowski 2006) expressed the same opinion about the first R&D Strategy 2003-2006, pointing to the negative impact of annual variation of invested funds and the need to agree on stable financing principles for research and innovation.

The most stable, guaranteed **sources of R&D funding** are those from the state budget, which take two main forms:

¹¹ The drafting of the NSRF was coordinated by the Ministry of Finance and all the relevant ministries and the State Chancellery participated therein based on their areas of activity.

¹² http://www.eestipank.info/pub/en/press/Press/kommentaarid/Arhiiv/_2008/_213.pdf

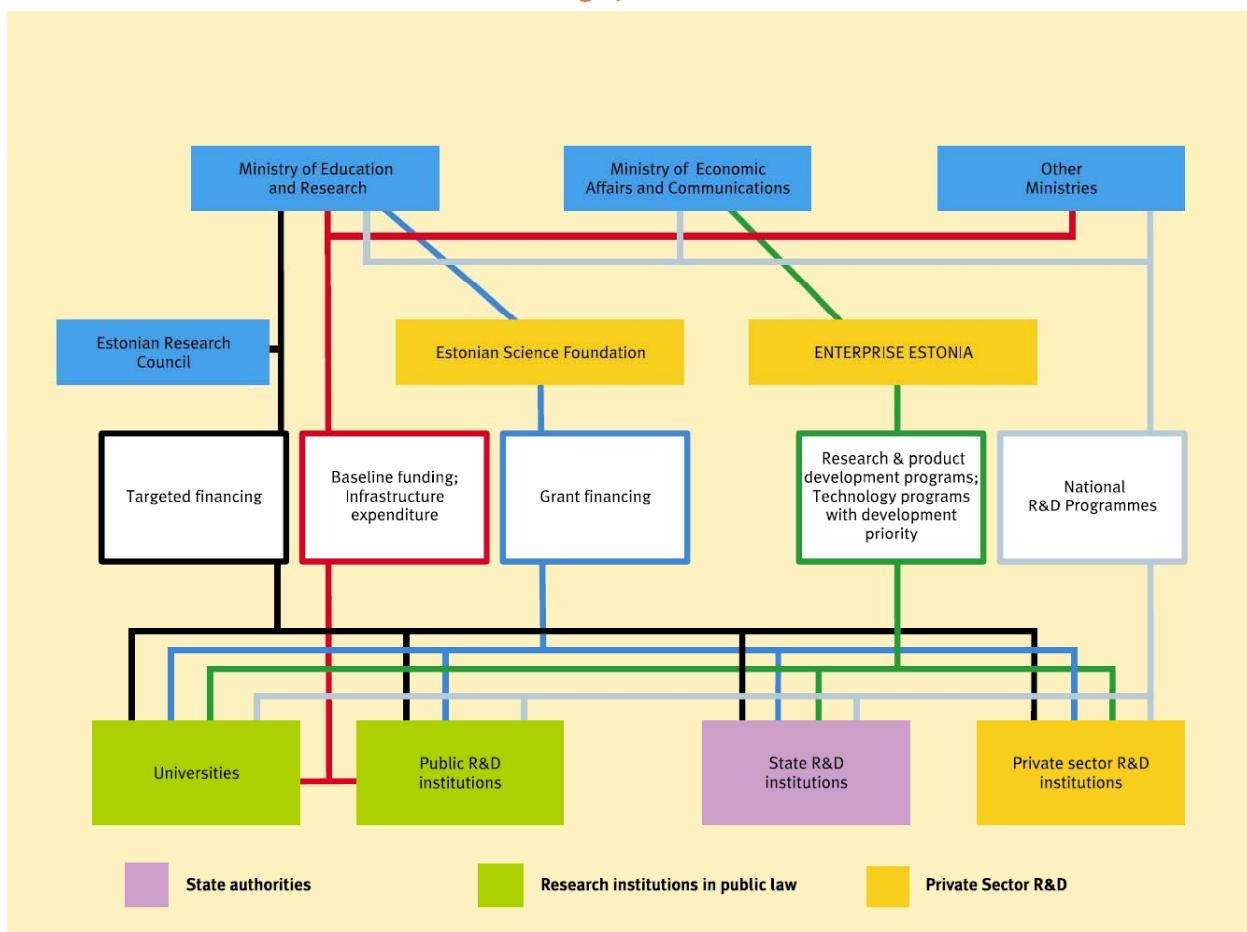
¹³ See: www.arengufond.ee

¹⁴ Available at www.hm.ee/index.php?popup=download&id=5908

- annual base-line funding and infrastructure expenses constitute non-competitive funding streams provided to specific organisations based on set criteria.
- targeted financing, grant funding, and national research and development programmes are fully or quasi-competitive and supplement the funding of the RD organisations in particular research fields or teams (individuals).

The principal funding stream for research in Estonia is the targeted financing scheme which disburses approximately €20m per year compared to €6-8m per year for the state infrastructure expenditures, Estonian Science Foundation grants or the new (since 2005) baseline funding mechanism. All types of funding mechanism have seen a growth in available finance but targeted financing has grown significantly in the last five years.

Figure 4: R&D funding system in Estonia



Source: Archimedes Foundation, Mobility Portal

Since 2004, the national funding streams are complemented by the instruments co-financed by the Structural Funds programmes. During 2004-2006, the R&D Infrastructure Programme (co-financed by the ERDF) constituted the first serious 'investment spurt' in Estonian research infrastructure in over a decade. However, this investment constitutes only a fraction of the estimated resources required to bring laboratories and other facilities back up to date¹⁵.

The 2007-13 NSRF provides for an indicative structural assistance expenditure of

¹⁵ Estimates of required investments are included in the OP development of economic environment 2007-13, see pages 86-87.

€656m for all activities falling under the heading research and technological development (R&TD), innovation and entrepreneurship, which amounts to 21.8% of ERDF resources¹⁶. Two out of three of the 2007-13 Structural Fund operational programmes (OPs) (Human Resource Development¹⁷; Development of Economic Environment¹⁸) make provisions for financing scientific research and the knowledge-based economy¹⁹.

In terms of specific research actions, the ERDF will continue to be used during 2007-13 to close the investment gap in research infrastructure (about 20-25% of research infrastructure is expected to be modernised). In addition, the Centres of Science Excellence programme budget for 2007-2013 (co-financed by the ERDF) will invest a further 700 MEEK (€44.74m).

Table 3: funding instruments for research (000€)

Instrument	2003	2004	2005	2006	2007	2008 (preliminary)
State Targeted financing	11 760.19	13 741.53	14 729.00	16 787.03	19 155.05	24 900.61
State Baseline funding*	-	-	4 116.45	5 120.16	6 219.48	8 084,95
State Infrastructure financing	3 872.55	4 258.92	4 946.95	5 857.72	5 857.72	7 495.81
ESF-grants, State budget	4 959.73	5 605.27	5 439.09	6 116.58	6 500.06	9 083.31
Science Excellence Centre*	-	-	588.00	1 712.90	1 712.90	2 142.00
R&D Infrastructure programme*	-	-	224.53	14 590.49	13 421.96	Not avail.
National Programmes (1)	-	1 999.95	4 282.24	4 950.14	5 461.45	5 752.26
<i>Total</i>	20 592.47	25 605.27	34 326.26	55 135.02	58 328.62	Not avail.

Source: Ministry of Education and Research, Ministry of Agriculture, Enterprise Estonia. NB: * co-financed by ERDF, (1) the national Programmes are: "Estonian Language and National Memory", "Files of the Arts and Natural Science", "Language Technological Support of the Estonian Language", "Applied Research in Agriculture"

The Government's past commitment to increasing R&D expenditure can be measured in part by GBAORD which stood at 1.5% of general government expenditure in 2007 (EU27, 1.62%); Estonia having achieved an increase of 7.3% over the period 2000-2007 compared to the EU27 average of 1.62%, placing it in 6th

¹⁶ As a point of comparison, Latvia is allocating 18% and Lithuania 19% to the same categories of expenditure

¹⁷ http://www.struktuurifondid.ee/public/OP1_21juuni2007_ENG.pdf

¹⁸ http://www.struktuurifondid.ee/public/maj.keskond_ENG.pdf

¹⁹ In particular, the OP Development of Economic Environment includes seven priority axes, the second of which is "Improving the competitiveness of Estonian R&D through the research programmes and modernisation of higher education and R&D institutions". The priority axis 2 is allocated €364 968 597 out of the total funding of €1.7 billion, or 21.4%. In the case of the OP Human Resource Development, the second priority axis (out of seven) is in favour of "developing human resources for R&D". The priority axis 2 is allocated €117 598 503 out of a total funding of €461 807 528 or 25.5% of the total OP budget, with EU funding being provided by the ESF.

position behind Luxembourg, Romania, Spain, Malta and Latvia (DG RTD, 2008). Indeed, the Estonian growth has been particularly rapid since 2002 with average annual growth rate of 10.6% between 2002-2005; with notably rapid increases in the following socio-economic fields: infrastructure and general planning of land-use (21.6%), protection and improvement of human health (18.5%), agricultural production and technology (15.9%) and social structures and relationships (69.6%). The structure of research expenditure and recent growth rates of GBAORD by socio-economic objective suggests that the Estonian publicly funded investment in research remains largely influenced by the current structure of the economy in terms of the importance of agricultural and land-use related research as well as on; while emerging fields such as medical sciences, although present in niches in the research system remain under-represented with respect to the EU27 average.

The European Commission's 2006 annual progress report of the National Reform Plan Commission considered that the strategy is linked well with other existing policies. It also considered it to be integrated and coherent internally, across the macro-economic, micro-economic and the employment policy chapters. As for most measures a set of quantitative indicators is provided with the target values set for 2008, which allows progress to be measured. The Commission considered the intermediate objectives for R&D (1.5% of GDP by 2008, 1.9 % by 2010) as "ambitious but not unrealistic" but noted that "explicit budgetary commitments for achieving them still need to be made" and that the R&D and innovation strategy would benefit from clearer prioritisation. The central role of a policy direction supporting foreign direct investment (FDI) in financing R&D and fostering the transition from a relatively low-tech to a high-tech based industrial portfolio are not mentioned in the plan. The Commission calls for a stronger focus on increasing private R&D investment and on the role of FDI in this context.²⁰

An additional important source of research funds arises from the participation in **EU funded research programmes**. During the 6th Framework Programme (2002-2006), Estonian scientists participated in 325 successful applications (total funding - €33m), or about half the national targeted financing for the same period (see also section 5.1.2).

In general, since this assessment was made, further progress has been achieved in securing financial resources, notably through the ERDF/ESF co-financed operational programmes of the Structural Funds.

2.1.3 Dealing with uncertain returns and other barriers to business R&D investment

Following Estonia's re-independence in 1991 and the introduction of a market economy and liberal economic policy, the majority of manufacturing enterprises with in-house applied R&D collapsed. Massive privatisation and restructuring of key sectors transformed the structure of the national economy, this process and subsequent economic growth being stimulated by significant inward FDI, in per capita terms (UNCTAD 2007).

Until 2005, the leading sector contributing to GDP was manufacturing followed closely by various services, but from 2006 the order has been reversed. During 2002-2005, most added value was produced in manufacturing enterprises, followed by low-

²⁰ http://www.riigikantselei.ee/failid/2006_annual_report_estonia_en.pdf

technology sectors such as wholesale and retail. Enterprises in high-tech sectors, e.g. computer and related activities and telecommunications, accounted for only 1.2% of total value added, compared with 20-25 % in manufacturing and wholesale/retail sectors (in 2002-2006, Estonian Statistic Office Business Yearbook, 2008). Estonian labour productivity has only increased slowly and it is forecast to reach only 69% in 2008 of the EU27 average (Eurostat). Hence, economic growth has so far been much more investment-driven than knowledge-intensive.

A recent report (Varblane 2008) for the Estonian Development Fund is the most up-to-date and authoritative examination of recent trends and future prospects of Estonian competitiveness. The report concludes that the economy faces a series of challenges:

- The productivity of knowledge-intensive service and industry sectors is still several times lower than in highly developed countries²¹
- Estonian enterprises are largely engaged in those stages of the value chain where productivity in knowledge-intensive fields is comparatively low, and export orientation is low
- Estonia's economic structure by no means resembles a contemporary knowledge-based economy; it has rather an industrial structure still based on cheap labour and services

The report concludes, "Estonia needs to pay much more attention to developing knowledge-intensive and high-productivity services oriented towards external markets". It suggests changing the structure of industry towards increasing the relative importance of sub-branches with higher productivity (for example, production of precision instruments, medical equipment, sophisticated electronic components and equipment).

However, both intramural and extramural expenditures in secondary sectors which are often considered as the key sectors in terms of BERD, declined in 2002-2006, and especially noteworthy is the decrease shown in manufacture of chemicals and chemical products, and manufacture of electrical and optical instruments (Statistics Estonia). Hence, the total increase of BERD in Estonia stems from the service sectors (dominated by computer services, followed by the R&D sector *per se*), which accounted for 67 % of total intramural and 66 % extramural R&D expenditures in 2006. Indeed, in a September 2008 speech the President of Estonia noted that a single company, Skype, was responsible for a large share of the annual BERD currently being undertaken in the country. While pointing to Skype as an example he called on other enterprises to follow suit and increase investment.

This investment pattern is reflected in the fact that Estonia is widely recognised for innovative digital and mobile services implemented both by the public and private sectors (e.g. E-Health national project, e-and m-voting projects etc, see the *NDP Progress Report 2007*).

As noted above, there has been a positive trend in the R&D intensity and of the share of the business enterprise sector in GERD; which have risen from only 19.7% of the total R&D expenditure in 1998 to 47.2% in 2007 (still well below the EU27

²¹ For example, in the field of business services, productivity is only 21% of that in Ireland and Denmark, and 30% of the level of Finland, which overrides the view that Estonia has caught up with the developed EU countries in the business services sector.

average of 62.7%). However, the majority of companies in the secondary sectors perceive themselves as process innovators rather than product innovators. An analysis of CIS results (Kurik et al, 2002) points to a pattern of technology and knowledge transfer rather than industrial R&D or product development. Perhaps as a result, business funding of R&D activities at higher education institutions are marginal but there is an increasing trend, most likely due to new academia-business co-operation mechanisms (notably R&D financing schemes and the Competence Centres²² programme).

Government support for businesses to invest in R&D has been increasing since 2004 (from very low levels) with the arrival of the first phase of Structural Fund programming. The main mechanisms²³ are the R&D Financing scheme and to some extent the competence centre programme (aimed at inciting research-industry co-operation but also at raising R&D capabilities of the participating enterprises). Corporate taxation is low by Western European standards (reinvested profits are zero-rated) and no R&D tax credit type measure exists.

Despite a focus of policy on stimulating new 'high-tech start-ups/spin-offs', there remains only a limited number of biomedical spin-offs; and selected IT and software enterprises and a few advanced engineering firms. On-going development of facilities and services at the two science and technology parks (Tallinn and Tartu) and other specific investments by specialised Finnish intermediaries mean that research-intensive early-stage firms can expect to get more professional support. Yet, in reality, there is no real 'proof-of-concept' mechanism in place to provide a pipeline for early stage investors, universities despite support from the government under the SPINNO programme remain ill-equipped to manage IPR portfolios, and the market for local, or locally active foreign, venture capital firms, in early stage financing remains very small²⁴. As a response to the need to structure and develop a market and the competence locally for investing in knowledge intensive firms²⁵, the Estonian Development Fund was created in 2007 and has recently made its first two investments (the fund is a mixture of a co-investment scheme and a foresight and think-tank function on future trends and prospects for the knowledge economy in Estonia). Such initiatives while welcome are unlikely to change rapidly the prospect for further increased investments by the business sector in R&D.

2.1.4 Providing qualified human resources

Estonia is characterised by a high level of education and a growing importance of tertiary level education in the working-aging population. The share of persons (population group 25-64) with tertiary education was above the OECD average (31% vs 25%) but slightly below the leading R&D-oriented EU economies like Denmark (32%), Finland (34%) or Sweden (35%). The improvement of competitiveness by a

²² The Centres for Excellence are selected to support a number of particularly strong and internationally competitive Estonian research groups while the Centres of Competence are more innovation-oriented and are formed to link higher education institutions (i.e. their R&D capacity) with business companies. Both co-financed by EU SF, via national support programmes in Enterprise Estonia.

²³ Further more in-depth analysis of support to enterprises can be found in the InnoPolicy TrendChart annual reports for Estonia (2007, 2008)

²⁴ The draft NDP for 2008-2011 refers to the EVCA data, that VCI share (early stage) of GDP in 2006 was 0.031%, and sets a target to reach a level of 0.06% by 2011.

²⁵ Various studies and sector strategies such as, the Estonian Biotechnology Strategy, suggest that the weakness of local VC and low interest of foreign VC hinders the development of industrial R&D.

more effective use of skills and knowledge and a strengthening of ‘human resources’, notably for science and technology, is both a main objective of the Lisbon Strategy and outlined and adopted in Estonian national strategy documents in a comprehensive and consistent way²⁶

However, demographics are a key policy concern since the population has sharply decreased over the past fifteen years (from 1.57 million in 1989 to 1.35 million in 2004), in part a consequence of emigration in the early 1990s. In recent years the birth-rate has increased considerably, although it still remains below the exceptionally high birth-rates of the late 1980s. Hence, projections of the number of 16-18 year olds show a sharp decline culminating in 2016, when their numbers will increase again. The outcome is that the number of potential students in higher education is likely to decrease from 2009-10 onwards, with knock-on effects in subsequent years on the number of scientists and engineers in the workforce.

In addition to these absolute trends, Estonia has a relatively small proportion of students in the areas of sciences, engineering, manufacturing and construction, i.e. areas contributing to the knowledge-based economy²⁷. In 2002-03²⁸, 9% of graduates originated from these study areas compared to an average of 14.2% for the OECD countries. By contrast, 39% of graduates were in the social sciences, business and law, considerably above the average of 30.6% for the OECD area (*Estonian Ministry of Education and Research, 2006*). This is despite the fact that Estonian education policy clearly favours R&D and technology education via the proportion of state commissioned student places (in 2005-06, around 40% of state-commissioned places were in the area of science and technology). As a result, both the higher education and business sectors are faced by a **lack of personnel** able to conduct R&D or assist in absorbing the results of R&D. As is mentioned in the RDI Strategy Progress Report 2007 “Despite the rapid growth of R&D intensity...the growth of number of scientists and engineers from 2000 stopped in 2005, and slow annual growth in 2006 was only 2.1%”.

The HEIs face a number of challenges in attracting and retaining high quality post-graduate students in more scientific fields. One important limitation is the student support system and salary levels in HEIs²⁹. Even if it were possible to boost the number of graduates, keeping them in the R&D sector is a further challenge. The average monthly salary in the R&D sector in 2005 was around 8242 EEK, which is slightly less than the average salary but much less than in comparable engineering, service and management jobs in private secondary or tertiary sectors. This is

²⁶ National Development Plan for Growth and Jobs 2005-2007, RDI Strategies for 2003-2006 and 2007-2013, strategies and laws on higher education and vocational education - Universities Act (1995), Institutions of Professional Higher Education Act (1998), Private Education Institutions Act (1998), Vocational Education Schools Act (1998), and the Standard of Higher Education (1996).

²⁷ Businesses (e.g. Chamber of Industry and Trade, Education Forum) stress the need for more specialists-technicians with good vocational skills. However, due to better employment and salary conditions, the most popular choice for young people is general secondary education then higher education rather than vocational courses.

²⁸ OECD data differs from EHIS. e.g., in 2006/2007 the proportion of graduates in these fields was 21.1%.

²⁹ As mentioned in the OECD report on Tertiary Education, the student support system in Estonia is extremely limited in its coverage with vast majority of students on bachelor or master level receiving no assistance with living expenses. The grant support that is available is very small and allocated on the basis of academic performance. The doctoral level is only where relatively good grant support mechanism is implemented (in sum 6000 eek/ approx. 380 EUR, compare with the official minimum wage, monthly 278 EUR).

amongst the lowest levels in the EU27 and it is one reason explaining the unattractive nature of a career in the local R&D system (RDI Strategy Progress Report 2007). The evaluation of the competence centre programme (Arnold et al 2008) pointed to the positive effect this initiative has had on stimulating postgraduate studies. Also, MER has assured the additional financing of research personnel by increase the financial instruments like baseline funding by 30% (from 2008).

A second limitation concerns the research infrastructure and the strategic interest of post-graduate students and researchers to pursue their studies in Estonia as opposed to in neighbouring countries with more generous State support (e.g. Finland) or better equipped and larger research teams (Nordic countries, Germany, etc.). As has been noted above, it is only in the last 3-4 years that HEIs have been able to access, notably Structural Fund co-financed, investment programmes for research infrastructure. Despite these limitations, the positive effect of some new support measures (proposed in the RDI and HE strategies and introduced through the Structural Fund support) is becoming visible: in particular, the activities of doctoral schools, support to centres of excellence and competence centres, financing for mobility programmes, etc. (see more Archimedes Foundation, Innove Foundation).

The RDI Strategy 2007-2013 Implementation Plan has as a target to achieve annual growth of 6% of scientists and engineers (full-time employed), leading to eight full-time employed scientists and engineers per 1000 employees in 2014; compared to 5.6 in 2007 (Statistics Estonia). Considering demographic trends and the remuneration levels of R&D specialists mentioned above, the provision of desired number of R&D and technology specialists needs extra policy attention, especially on Master and Doctoral levels.

Different aspects of internationalisation as a positive aspect of career planning are included in the Strategy for Internationalisation of Estonian higher education for 2006–2015 (approved in 2006 by the MER). The numbers of foreign students, including doctoral students, has increased by approximately 9 % between 2005-06 and 2006-07 academic years, which may be an indication of improved enrolment conditions³⁰. This issue is examined further in 5.1.2 below.

In terms of **adult education (lifelong learning)** and professional training, the share of adult students participating in self-educational activities (others than tertiary education) is relatively low (currently only 6% of persons in the age group 25–64, while the EU target for 2010 is 12.5%) (OECD Review of Tertiary Education of Estonia, 2006). Given the above-mentioned demographic trends, there will need to be an increasing role of lifelong learning education and continuous professional trainings in adult population groups (older than 25).

2.2 Assessment of strengths and weaknesses

Despite tense governmental negotiations on the state budget for 2009, the coalition partners have expressed their commitment to co-financing plans. However, as noted above, business expenditure on R&D, and innovation investment more generally, remains sub-optimal despite a rising trend. Policy efforts to raise business investment either directly (through grant support, etc.) or indirectly (through actions to improve

³⁰ See enrolment data on Estonian Education Information System portal: www.ehis.ee

awareness of innovation) are so far not radically changing the structure or nature of investments in R&D by the business sector.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • Improved co-ordination of R&D and innovation policy and resource allocation in recent years. • Increasing awareness in society about the role of RDTI in economic development, including the need for a sufficient number of scientists and engineers. • Significantly increased public funding for R&D since 2004; notably through Structural Fund co-financing of national development plans. • Long-term orientation of research plans is sustained by the updated strategy, and multi-year RDTI programmes/measures. • Well-established public universities are the core institutions of R&D system 	<ul style="list-style-type: none"> • Modest size of GDP and declining growth rates create government budgetary constraints limiting national resources for investment. • Public sector universities dominate research activity with weak links with other sectors (NPOs, business). • R&D investment capacity of private companies is modest, in particular due to an industry structure still based on low cost-productivity • Significant foreign investment but primarily in production and service activities rather than research intensive activities. • Slow growth in S&T students is a threat for future labour market in general, and particularly in scientific and engineering sectors

2.3 Analysis of recent policy changes

All Lisbon relevant strategies and development plans are supplemented with respective 3-5 years implementation plans, consisting of detailed objectives and performance targets, action plans, resource estimation, and sources. Hence, it can be considered positive that there has been an implementation of strategic planning and performance management principles in national and sectoral policy planning. At the same time, the effective commitment of funds is based on an annual budgeting process. Hence, in practical implementation, some contradictions between strategies at different levels (usually SBS vs. sector strategy) or weak operational linkages may arise. Assessing the NDP progress report in 2006, the European Commission mentioned that the justifications and budgeting of resource provision and the budgetary implications of the planned initiatives are only broadly defined, while the link between measures in the NDP and the Structural Funds was not sufficiently concrete.

Moreover, in order to attain the targets on overall GERD/GDP ratios, the Estonian RDI Strategy relies significantly on the future ability of the business sector to raise further the R&D investment intensity. It is not clear how this objective will be sustained with the current mix of policy instruments; in the absence of coherent industrial policies and enhanced administrative capacity to support structural reforms in Estonian economy.

The draft SBS for 2009-2012, proposed by the Ministry of Finance in May 2008, maintains the same priorities as the 2008-2011: growth of competitiveness, growth of social coherence and sustainable environment. The draft version lacks measurable concrete priorities and the objectives are mainly descriptive without any reference to the measures of or the sector strategies (only broad linkage to the governance/policy area). Also in May 2008, the Estonian Government approved the **draft version of NDP for Growth and Jobs 2008-2011**. The draft version incorporates and takes

notice of the EU Commission assessment of the existing NDP to make clear prioritisation of the national objectives of Lisbon Strategy, so it outlines clearly the key areas of the NDP for the next three years: productivity growth, R&D and Innovation, development and liberalisation of business environment, and the labour market.

In terms of the sectoral strategies, the RDI Strategy for 2007-2013 has been supplemented by an Implementation Plan for 2008-2012 (approved by the Government in December 2007) and the respective financial plans updated yearly. By the same legal act the Estonian Programme on Energy Technology was approved (the first of the long-mooted national technology programmes). Similarly, an *Implementation plan of the Higher Education Strategy* is being developed for the 2008-2010 period. Based on the national and sector strategies, the Government has recently approved two state investment in plans for 2008-2013:

- in May 2008, for modernisation of research and teaching facilities of R&D institutions³¹ and HEIs, respectively in amount of 1.581 billion EEK (€101m) and 637 million EEK (€40.73m);
- in June 2008, for modernisation of teaching environment of vocational education institutions, in amount of 3.63 billion EEK (€0.23b) co-financed by national budget and SF).

Finally, according to the work plan of the Government for 2007-2011, an amendment of the *Study Allowances and Study Loans Act* is planned (enforced in 2003, last amended in 2007) in 2008 with a view to increase the annual student loan amounts and expand them to vocational schools.

Challenges	Main policy changes
Justifying resource provision for research activities	<ul style="list-style-type: none"> • Structural Fund support for national RDI and Higher Education strategy implementation is an element of stability for budgetary allocations. • Drafting of SBS 2009-12 and NDP 2008-2011 is underway with a continuing commitment to increased investment in research.
Securing long term investments in research	<ul style="list-style-type: none"> • Adoption of several state investment plans related to research and higher education for 2008-2013 • On-going investment in research infrastructure with support of Structural Funds
Dealing with uncertain returns and other barriers to business R&D investments	<ul style="list-style-type: none"> • A range of programmes have been developed to incite enterprises to invest more in research, with most notably the R&D Financing programmes and the Competence Centre programme providing direct financing to enterprises. • A longer-term commitment to boost the number of knowledge intensive firms is also made through new institutions such as the Estonian Development Fund.

Challenges	Main policy changes
Providing qualified human resources	<ul style="list-style-type: none"> • Improvements in conditions for post-graduate studies through specific programmes like doctoral schools, competence centres, centres of excellence, etc. • Proposals to improve financial support for post-graduate studies; • Facilitating international mobility by alignment with EU legal framework for third-country scientific researchers

³¹ The majority of these R&D Institutions/beneficiaries are HEI-s

2.4 Assessment of policy opportunities and risks

A basically sound policy basis can be established in Estonia thanks to broad commitment. However, lack of coherence in planning and a worryingly high reliance on extrapolation of business performance may turn out to become a significant threat.

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> Political commitment of virtually all policy parties to the Lisbon goals and improved co-ordination of resource provision and R&D and Innovation policies at the Government level. Elements of medium-term horizontal strategic planning implemented (RDI strategy documents) and continuous efforts to link national investment and implementation plans with the strategic framework documents. 	<ul style="list-style-type: none"> Should further need for investment in research arise, it is unlikely that further national public funds will be available given the tightening budget situation. Lack of coherence between the SBS and RDI strategy, and prioritisation of annual state budget process and the objectives of the Coalition Agreements instead of medium/long-term strategy plans. Considerable reliance on increased share of business expenditure of research investment. Business behaviour often seems to be extrapolated instead of preparing for different scenarios.

2.5 Summary of the role of the ERA dimension

The adoption in Estonian policy of the EU's Lisbon goals related to boosting R&D as a factor supporting increased competitiveness and employment is coherent, comprehensive and linked with the respective national fiscal and other policies. Estonia is one of the most successful Member States in terms of the rate of growth of research expenditure in recent years even if the GERD/GDP ratio is still far from the 3% Barcelona Summit target. It is clear that the modernisation of infrastructure and measures to increase investment in the higher education sector are in line with the goals of the ERA Green Paper, notably if Estonian research structures are to co-operate effectively, attract temporary or permanent mobility of foreign researchers and compete in excellence based programmes (FP7, etc.). Moreover, the relatively small national research system remains fragmented and in need of clearer prioritisation of investment taking account both a) the specific strengths of Estonian research within the ERA b) the specific needs of the Estonian economy and society for knowledge generation and exploitation (academic-business links, etc.). Given the limited resources available, little movement has been made to overcome the small scale of the research system by seeking out opportunities for joint-programming or investment with neighbouring Baltic or Nordic countries.

3 - Knowledge demand

The purpose of this chapter is to analyse and assess how research related knowledge demand contributes to the performance of the national research system. It is concerned with the mechanisms to determine the most appropriate use of and targets for resource inputs.

The setting and implementation of priorities can lead to co-ordination problems. Monitoring processes identifying the extent to which demand requirements are met are necessary but difficult to effectively implement due to the characteristics of knowledge outputs. Main challenges in this domain are therefore:

- Identifying the drivers of knowledge demand;
- Co-ordinating and channelling knowledge demands; and
- Monitoring demand fulfilment

Responses to these challenges are of key importance for the more effective and efficient public expenditure on R&D targeted in IG7 of the Lisbon Strategy.

3.1 Analysis of system characteristics

3.1.1 Identifying the drivers of knowledge demand

Given the challenges of improving competitiveness and restructuring discussed in the previous chapter, demand for knowledge and improved capacity in the public (for policy development, prioritising of research investments, etc.) and private (identification of market opportunities requiring innovation investment, etc.) should be potentially very high. However, to date the structured analysis of and debate on knowledge demand in Estonia has been limited to a relatively restricted circle of specialists and policy makers. Technology road-mapping, technology assessment or foresight type activities have been only sporadically carried out since 2000. Indeed, Tiits (2007) highlighted the weakness of analytical capacity of Estonian political parties that affect their ability to assess the impact of the policy measures or make sound governance decisions. The administrative capacity and resources of public service are also very limited in this respect, hence forecasting activities are limited in scope (e.g. demographic surveys for education system, state health care and labour market prognosis). At the same time, some ministries (notably the MEAC) do commission assessment of the strategies, policies and programmes, and use them for the design of new initiatives or impact evaluation.

More specifically in the field R&D, it has been suggested that foresight activities of the R&D Council would increase the strategy planning capacity of the Government (Tiits 2007); but it is unlikely as long as the R&D Council remains in the position of *ad hoc* consultative body. Indeed, the introduction of systematic foresight focused on knowledge demand, needs and competitiveness and development, is only beginning with the full operation of the Estonian Development Fund (EDF)³². EDF was established in 2006 to analyse technological and field-specific development trends and provide forecasts of long-term developments of Estonia in order to help decision-makers (incl. entrepreneurs, politicians, and officials) make relevant decisions (*Estonian Development Fund Act*, enforced 2006). Institutions such as the R&D Council, the Bank of Estonia, the State Audit Office or governmental bodies (ministries) need also to establish some basic in-house competencies and absorption capacity for foresight studies developed by the EDF if this investment is to improve policy-making.

While the structural change in industry has radically changed the proportions of

³² <http://www.arengufond.ee/foresight/foresight>

secondary and tertiary sectors in local economy³³, the strong growth of the last decade has been achieved largely in sectors with low-wage and low productivity structures whose competitiveness is now under pressure. Moreover, recent economic forecasts show that several sources supporting the rapid growth of recent years are now exhausted – mainly the credit-driven domestic demand, and increased productivity or exports. The present economic situation calls for re-orientation of priorities and re-evaluation of over-optimistic socio-economic forecasts. The EDF commissioned study (Varblane, 2008) states that “as a whole, the favourable institutional basis of the market economy created in Estonia and its relatively good “marketing” to the international public is reflected in international rankings. Unfortunately, that may be sufficient for development in the stage of basic requirements and efficiency enhancers, but it is insufficient in the innovation factors’ stage of development to catch up with the world’s top countries”.

In terms of size and type of the enterprises able to carry out (or absorb) industrial R&D and generate knowledge demand, both foreign-owned large companies and research-intensive micro/SMEs are important. In terms of technology and innovation demand and knowledge transfer, the potential role of foreign-owned corporations (in 2004-2005, 45% of corporations were foreign-owned) should not be overlooked. There are also a number of highly innovative and ambitious local companies specialising in high-tech manufacturing/engineering and R&D. However, these companies are usually small - e.g., in biotechnology, in 2006, there were 55 local biotechnology companies employing 410 persons in total, with overall sales turnover of approximately €18m (statistics from Estonian Biotechnology Strategy). This type of company has increased its share in BERD during 2002-2006 (Estonian Statistics). However, as the 2007 OMC policy mix report (Polt W. et al 2007) argued:

“there is a need for a coherent discussion on the relationship between the future development of Estonian industry and the needs for R&D within industry and in the knowledge institutions. This discussion should not be misled by the dichotomy between high-tech and low-tech industries. /.../ Relevant Estonian business areas that could benefit from such incremental and knowledge-intensive innovation could for instance be food production, textile production, building materials, pulp and paper, furniture, manufacturing and electronics. The strong growth of the Estonian service sector indicates a need for a more systematic approach towards this heterogeneous part of the economy, including tourism (which is the only sector where there is an explicit sectoral policy), health and social work and financial services”.

At a broader **societal level**, demand for knowledge is expressed by a growing interest to acquire higher education, since it is a precondition for better employment and salary conditions³⁴. Responding to both individual and business needs (and faced to some extent by competition from neighbouring Nordic education systems), the HEIs (notably public) have been adapting the process of curricula development (in academic terms) and quality assurance, However, there remains a need to better

³³ According the Labour market Forecast of MEAC until 2014, the number of employed people will increase to 623,000 in 2011 and to 646,000 in 2012, and most new jobs will be created in service sectors. The demand is focused mostly on specialists and qualified workers.

³⁴ Unemployment rates (in the 25-64 age group) are lowest for those with third-level qualifications: 3.8% in 2005, respectively half and a quarter of the rate of those with secondary and basic education) and have remained relatively stable between 3.5% and 6% in the period 1997- 2005 (Estonian Statistical Office).

align the higher education curricula with national economic and social development goals and “better define the role of professional tertiary education in a system moving from a largely undifferentiated and markedly academic tertiary education system to one in which there are varied institutions to respond to a range of societal and labour market needs” (OECD, 2006).

Organisational interests and ambitions of research and higher education institutions are influential drivers of development of curricula, investment plans, research priorities, etc. and they tend to remain detached from business demands³⁵. Some independent studies (OMC Peer Review Report for Estonia, 2007) note the different orientation (even “huge gap”³⁶) of research and business needs, and suggest that the orientation of research organisations towards industry needs could be improved. The measures for business-academia collaboration like Competence Centres, science and technology parks, etc are helping to re-orientate the R&D institutions, especially the three main science universities, to focus more on the needs of business.

3.1.2 Co-ordinating and channelling knowledge demands

Co-ordination and consultations on knowledge demand on the national level about the *RDI Strategy* targeted mainly the R&D sector itself. The draft strategy was sent for proposals and comments to all institutions registered in the MER register of R&D institutions and related organisations (altogether about 120). Before approval by the Government and the Parliament, the draft version was debated in the Research Policy Committee and the Innovation Policy Committee and after that, in the full R&D Council. The thematic prioritisation objectives are according to the *RDI Strategy for 2007-2013*: information and communications technology; biotechnology; materials technology, i.e. no changes compared with the period 2003-2006.

However, these thematic priorities are only loosely integrated with the mix of industrial and labour market policy needs. These problems are not new; they were already outlined in the evaluation study (Reid & Walendowski 2006) on the first R&D Strategy for 2003-2006 where it was particularly mentioned that to make the strategy more precise and ensure cost-effectiveness of implementation, the MER and MEAC, in cooperation with social and business partners, should “compile and launch national programmes for the development of the key areas”. Such sector-oriented national programmes developed on a consensual basis were still missing when the new RDI Strategy was elaborated. Only a few fragmented initiatives have been carried out (Draft Biotechnology Strategy elaborated under the aegis of the Biotechnology Association). In these circumstances it is positive that several coordination and consultation bodies (mentioned in Ch.1) are actively involved in RDI policy-shaping and research funding decisions - to set focus and priorities in line with the general strategy in order to enable consistent political and administrative decisions when it comes to the design of new measures and programmes in RDI and labour and education.

The most targeted and performance-oriented consolidation of knowledge demand and related human resource development is done through the state investment plans and state support programmes (for Competence Centres³⁷, Centres of Science

³⁵ See Education Forum of Estonian Chamber of Industry and Trade, www.koda.ee

³⁶ See section 3.2 The role of the science system and industry-science relations in Polt W. et al (2007)

³⁷ See scope, objectives and budgets on <http://www.eas.ee/?id=1225>

Excellence³⁸ and R&D Infrastructure Investment³⁹). Programming of any new programme or measure of such kind normally involves consultations with the target groups (beneficiaries) and other stakeholders (Chamber of Trade and Industry, professional and business associations, trade unions, local municipalities, universities) to examine their expectations and needs.

Private (business) labour market demands have become more important and several policies try to integrate them as far it is possible with demands of different nature - personal preferences of students and organisational goals of HEIs (*RDI Strategy, NDP 2005-2007* and *Draft NDP for 2008-2011*). In practice, the most effective state means seem to be a proportion and number of student places commissioned by the state to the HEIs and vocational schools⁴⁰, the state investment plans, and support programmes co-financed by the Structural Funds (based on the NSRF). As noted above, re-directing the effort of vocational and further professional education is essential because of the structural changes and needs to shift to a knowledge-based economy. There are several public-private initiatives (like the Education Policy Forum of Chamber of Commerce and Industry), contributions of professionals from industry to the delivery of programmes in institutions, the participation of professional organisations in curriculum development, and the presence of employers in the advisory councils of vocational schools and HEI-s. The state support measures in vocational education have already started, based on ***the Development Plan of Estonian vocational education system for 2005–2008***.

3.1.3 Monitoring demand fulfilment

Several State organisations (like the State Audit Office in their duty to audit appropriateness of state expenses) exercise periodically limited monitoring activities on the extent to which public funded programmes meet their targets and obligations. However, generally, the monitoring and evaluation of the knowledge demand in the different areas is not comprehensive and systematic. However, to some extent, this role is exercised by the MER (in connection to the RDI and HE policies), MEAC (innovation policy, cluster analysis, etc.) and the Ministry of Social Affairs (labour market)⁴¹. The EDF can also be expected to play a role in the future in assessment of the nature of and fulfilment of knowledge demand of enterprises and society in general.

3.2 Assessment of strengths and weaknesses

Important pieces of the framework are in place, but enhanced coherence with the business sector in particular remains to be implemented.

Main strengths	Main weaknesses
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³⁸ See scope, objectives and budgets on <http://str.archimedes.ee/et/struktuurifondid/toetatud/tippkeskused>

³⁹ See scope, objectives and budgets on <http://www.eas.ee/?id=2073>

⁴⁰ National priorities are stated in the ***Lifelong Learning Strategy*** and connected to the human resource development measures in *NDP for Growth and Jobs 2005-2008* and *RDI Strategy 2007-2013*. Many of these priorities and supportive measures have been (and will be also in new programming period) co-financed by the Structural Funds and implemented via the respective agencies (Innove Foundation, etc).

⁴¹ For instance, monitoring and assessing mechanisms like the Adult Education Council for Lifelong Learning Strategy (e.g. Interim report of status of Vocational Education System Development Plan in 2006).

<ul style="list-style-type: none"> • Technological and economic foresight activities have now been launched by the Estonian Development Fund. • Launch of long-awaited national technology programmes (first with energy in 2008) should improve co-ordination of demand for knowledge. • Generalised use of transparent policy consultations involving social partners, use of ad-hoc or permanent expert groups. 	<ul style="list-style-type: none"> • Public R&D meets the private sector demands in very limited fora (such as Competence Centres) and services (testing, certification, some product development or applied research). • Few mechanisms for technology assessment or identification of broader societal needs for knowledge • No mechanisms or practices to monitor knowledge demand in systematic way; limited <i>ex post</i> evaluation exercises, mainly in field of industrial R&D (no major evaluation of public research funding to date).
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3.3 Analysis of recent policy changes

A positive change is that the nation-wide technology- and cluster related foresight activities were started by the EDF in mid-2008, which should create a good platform for effective coordination and channelling of knowledge demand. EDF has a pragmatic approach to focus on 5-6 key (technology) areas, where Estonia potentially could be competitive or regionally leading in the future and which have an important socio-economic impact on the society. The first foresight exercise started in the ICT sector (*EST_IT@2018*) and it looks at sub-sectors with the highest growth and development potential in the next 10 years⁴².

The NDP refers to need for new state support programmes to meet business demands in knowledge production and R&D infrastructure development. On a political level, some progress has been made in 2007-08, and the following areas for consolidated activities are identified:

- Development of the concept and network of core laboratories (joint-use of infrastructure) (2008-2013);
- Implementation of the national programme on R&D in energy technology (2008-2013) – launched in 2008;
- Implementation of a national programme on R&D in ICT (2009-2014).
- Implementation of a national programme on R&D in biotechnology (2009-2014);
- Implementation of national programme on R&D in material technology (2010-2015).

In terms of coordination and channelling the knowledge demand, business sector demands for over-coming skills shortages or mismatches in the labour market demands have become more important and several policies try to co-ordinate them with personal preferences of students and organisational goals of HEIs. Draft *NDP for 2008-2015* highlights the business demands in R&D and education as well the educational strategies. The draft NDP 2008 states that providing qualified personnel and R&D should be more connected to business needs and support economic competitiveness. In terms of implementation priorities in 2007-2013, the progress

⁴² <http://arengufond.wikidot.com/tegevused>

report of RDI Strategy in 2007 mentions that in the new period of Structural Funds, the development of human resources will be prioritised.

3.4 Assessment of policy opportunities and risks

There is increased focus on meeting business demands in policies related to knowledge demand. However, broad coordination remains rather weak.

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> • Nation-wide technology- and cluster related foresight activities were started by the EDF in mid-2008. • EDF has a sufficiently narrow approach to focus on 5-6 key (technology) areas. • Inclusion of business demands in education plans. 	<ul style="list-style-type: none"> • No common approach and implementation means established in governance level to monitor or evaluate the knowledge demand systematically and comprehensively • No coherent consistent articulation between RDI, education, labour market, industrial foresight and social policies in terms of knowledge demand and supply

3.5 Summary of the role of the ERA dimension

Participation in ERA has a positive impact on organisational structure and funding of R&D and education (some progress is underway or planned) in a small country like Estonia with limited human and economic resources. Consolidation and channelling of funding towards knowledge production and research infrastructure developments however needs to be more consistent to meet social and business demands, which requires coherent systematic foresight and strategy planning. Investment in foresight is only now beginning in a structured way through the Estonian Development Fund, although some attempts in the early part of the decade were made in this field they did not impact strongly in policy making circles.

4 - Knowledge production

The purpose of this chapter is to analyse and assess how the research system fulfils its fundamental role to create and develop excellent and useful scientific and technological knowledge. A response to knowledge demand has to balance two main generic challenges:

- On the one hand, ensuring knowledge quality and excellence is the basis for scientific and technological advance. It requires considerable prior knowledge accumulation and specialisation as well as openness to new scientific opportunities which often emerge at the frontiers of scientific disciplines. Quality assurance processes are here mainly the task of scientific actors due to the expertise required, but subject to corresponding institutional rigidities.
- On the other hand there is a high interest in producing new knowledge which is useful for economic and other problem solving purposes. Spillovers which are non-appropriable for economic knowledge producers as well as the lack of possibilities and incentives for scientific actors to link to societal demands lead to a corresponding exploitability challenge.

Both challenges are addressed in the Integrated Guidelines and in the ERA green paper.

4.1 Analysis of system characteristics

4.1.1 Improving quality and excellence of knowledge production

The Estonian system of State funding of research is based on a mix of mechanisms including both competitive funding and peer-reviewed mechanisms as well as specific funding rules based for doctoral students. The role of the science competence council⁴³ in allocating the main targeted finance and of 'peers'⁴⁴ in allocating finance for the smaller ESF grants has been described in chapter 2. Moreover, the assessment of scientific excellence of public and higher education research organisations is provided for in the R&D Organisation Act. This is a periodic review process with the involvement of international peers ensuring impartiality and a view on the international quality of the research.

The following summary of the research assessment process in Estonia was provided by the Ministry of Education and Research in the report to the OECD in 2006 on

⁴³ When deciding on research funding the SCC members look at the following three areas: 1) the quality of the research proposal; 2) critical mass of applying unit (two full-time researchers or more); and 3) there is an attempt to ensure continuity of funding so some security in the system is guaranteed. In practice, however, there are no guarantees that the funding will be continued after the 5 or so years for which allocation has been made.

⁴⁴ As noted by Nedeva & Georghiou (2003): resource allocations by the ESF are competitive and it operates a strict peer review system. Calls for new proposals are organised annually and about 500 proposals are usually submitted. Each proposal is evaluated by at least two referees and to deal with issues arising in the context of the relatively small size of the country international researchers are also used as reviewers. This is made possible by using traditional as well as more recent links to the research communities in Russia, Sweden and Finland.

Tertiary education⁴⁵. Pursuant to the Research and Development Organisation Act, every research and development institution must be assessed at least once every eight years. The objective of the evaluation is to assess the activities of R&D institutions and development themes covered by them, based on the internationally recognised R&D level of the respective area, identify main shortcomings in the evaluated R&D area and give recommendations regarding the development of R&D areas and regarding questions on the strategy of research and development activities. Evaluation of research and development activities is carried out by an ad hoc evaluation committee which has to include external experts. The updated regulations for evaluation, amended by the Government on 23.10.2008 (RT I 2008, 46, 259) took force on 1.11.2008. The new cycle of evaluation starts in 2009. The evaluation is opened to private R&D institution but they have to cover their own expenses.

The evaluation committee's work is based on the R&D institutions' self-assessment report, followed by a visit to the institution. A written summary of the expert's work must include an evaluation based on the following criteria:

- R&D activities' substantive quality and novelty compared to an internationally recognised level and the topic's significance for Estonia;
- qualification of the executors of development topics compared to an internationally recognised level and their sustainability considering the next generation of young researchers;
- research environment, including the existence of financial resources, equipment and premises; national and international cooperation, research group members' participation in international and Estonian research organisations and their management, as well as in scientific political assemblies, periodicals' editorial offices and conference organisations.

The results of assessment exercise have strong impacts as these are bases for the thematic and structural changes for target financing. Weak results in the evaluation are a reason for rejecting the state-commission to PhD graduates in specific area at particular university. By law negative mark in evaluation of research under the existing targeted financing excludes the possibility for continuing of target financing. The results of evaluations are also considered when there are decisions made for selecting doctoral schools partnership candidates, grant allocations for foreign students in PhD level, etc.

A list of the evaluations carried out since 2001 and the full evaluation reports (the reports are in English) can be found at : <http://www.ekak.archimedes.ee/eval/>

Finally, the Science Excellence Centres programme is aimed at not only rewarding the centres which perform well but also about consolidating and restructuring the Estonian research landscape. The budget for the programme is significantly larger for 2007-13 than before but the number of new centres selected is smaller (seven against the 10 in the previous programme period). The thematic coverage of research topics centres is broadly similar in the new period but some topics are not present any more (material science, applied mathematics, ethnography). The main scientific fields - biotechnology, ITC, medical research - are now more concentrated, and novel, positive development being their integration in some centres (e.g., IT with

⁴⁵ See also: <http://www.smarestonia.ee/index.php?page=294&>

biotechnology). The core R&D organisations behind the Centres remain the same - Tartu University and Tallinn University of Technology, but the research teams have been changed.

In addition to the formal funding mechanisms quality systems, the Estonian Rectors' Conference has launched a special initiative for public universities to develop a handbook on the quality of university education. The working group identified 15 quality criteria such as using curricula based on learning outcomes, the number of graduates in PhD and Master Programmes, investment rate and the number of computers per student, collecting feedback from employers and alumni; mobility of students and teaching personnel, etc. The Handbook will undergo a pilot phase, after which its content will be re-evaluated and modified.

4.1.2 Improving exploitability of knowledge production

Three broad research fields have been identified where Estonia is ranked above the world average in terms of citations: material sciences, environment and ecology and pharmacy and toxicology. In biology and chemistry Estonia is roughly on par with the world average, while in all other areas, the world average is unreachable in the short-term. The number of young researchers is relatively high in chemistry, molecular biology, geography and medicine, while the share of young researchers is the lowest in sciences, technology and agricultural sciences (Allik, 2006). In contrast, the ERAWATCH study on R&D specialisation (NIFU STEP et al, 2007) noted that Estonia presents a peculiar profile with high specialisations (publications) in geosciences and the environment, and social sciences but appears under-specialised in natural sciences. Further more, in terms of technological specialisation (patents), Estonia was highly specialised during the 2001-2003 period in pharmaceuticals and instruments and at a lesser extent in wood and publishing.

In terms of policy focus on specific technology fields, the previous national research development strategy "Knowledge based Estonia 2002-2006" recognised materials' technologies and biomedicine as two of the three suggested focal areas for allocation of resources, the third being information technology. Moreover energy technology is perceived as crucial, but this is primarily a result of Estonia's singular dependence on oil-shale energy, which requires comprehensive domestic R&D as a consequence.

In terms of intellectual property rights (IPR), the most important legal documents are the Copyright Act and the Patents Act⁴⁶, the latter regulates the legal protection of patentable inventions. The Estonian Patent Office has been actively promoting IPR related issues to the enterprise sector for the last couple of years to try and improve knowledge and awareness and created a SME support division to this end⁴⁷. In Estonian universities there is a general principle that the economic rights to industrial inventions created in the execution of duties are transferred to the employer. In the case of inventions and utility models, the economic rights are transferred to the employer on the basis of a contract. Such an agreement maybe included in the employment contract or concluded with a separate contract. All universities have their own detailed IPR regulations, which are available on their web pages.

Two main mechanisms have been introduced to attempt to improve the exploitability of knowledge production. The first is the SPINNO programme, aimed at creating the

⁴⁶ <http://www.smarestonia.ee/index.php?page=228>

⁴⁷ Annual Report 2007, Estonian Patents Office

appropriate management skills and culture in the public universities to promote improved management of IPR and improved commercialisation and exploitation. The second is the Competence Centre programme aimed at bringing together a group of industrial enterprises to work with at least one R&D institution. Both programmes have been evaluated at the end of their first funding period.

The evaluation of the SPINNO programme (SQW, 2007) noted that while the legal and management issues of intellectual property and research commercialisation had been largely improved, the absolute levels of the indicators measuring ‘knowledge transfer’ or research commercialisation are low. The report noted that “the financial and traditional academic incentives for institutions to engage in knowledge transfer are limited. They all attach higher priority to knowledge transfer than previously, and several have it as an explicit component of strategic plans but demand from Estonian businesses is still limited and the financial returns are not attractive when compared to the costs of engaging in knowledge transfer”. ‘Mainstream’ activities such as teaching and conventional research are better rewarded. In particular, the research funding system does not give explicit weight to applied research and knowledge transfer and favours conventional research outputs (publications in academic journals). Still, it is highly important to stress that under the baseline funding allocation, the grant conditions specifically favour indicators like patent application and patent instead of articles (respectively their weight is two and three times higher compared with an article in ISI database).

The evaluation of the competence centre programme (Arnold et al, 2008) found positive effects on doctoral studies through the linkages to enterprises introducing new, more applied and interesting topics for students. However, the environment for knowledge exploitation remains fragile. The interviews carried out for the evaluation highlighted a number of continuing impediments in the academic sector to the provision of services to companies. These barriers include administrative burdens (contracting delays), overhead charges of the universities on such contracts, absence of cost accounting in the university sector, etc. The independent legal structure of the competence centres allows them to act more flexibly and at lower cost and in a more business-friendly manner than the academic sector. From the enterprise side, there is not yet a broad understanding of IPR management nor often the financial means required to protect R&D results. However, this clearly varies by sector, with for instance strong IPR management in the bio-medical spin-offs in Tartu; see for instance the example of Quattromed, (Rannala 2007).

4.2 Assessment of strengths and weaknesses

The Estonian research funding system has integrated peer review mechanisms using international experts for close to a decade. Recent years have seen an effort to create more critical mass and encourage inter-disciplinary and inter-institutional co-operation through the science excellence centres, etc.. However, this is probably only a first step in a much needed restructuring of the Estonian public research system into a limited number of EU/internationally competitive institutes.

A policy focus on increased exploitability of scientific results has been strengthened, but incentives and management capacities at the university level still remains insufficient to generate significant levels of commercialisation.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> Established research evaluation system combined with a relatively longstanding experience of using international peers. Increased investment and concentration of funding in science excellence centres Funding programmes such as SPINNO are aimed at improving exploitability of research results 	<ul style="list-style-type: none"> Dominance of classic 'science' indicators as a criteria for research excellence. Lack of links to and account taken of industrially oriented research in academic promotion. Despite improvements, IPR management at universities and knowledge exploitation strategies remain sub-optimal.

4.3 Analysis of recent policy changes

There have been no major policy changes in this field in the sense that the main legislative texts have not changed and programmes such as SPINNO or the Competence Centres will continue during 2007-13. The main expected change that will potentially have an impact on the research evaluation and the research funding allocation process will be the proposed fusion of the Science Competence Council and the Estonian Science Foundation into a single body. The impact of these ongoing programmes on attitudes especially in higher education should not be underestimated, although this can hardly be analysed yet. However, the recent evaluation of the Competence Centres (referred to in chapter 4.1.2) shows that some positive effects on university-business cooperation can be traced, although the development remains fragile.

4.4 Assessment of policy opportunities and risks

The present stage of the development of IPR in Estonia could be characterised as an on-going need for further reform and reinforcement of capabilities in the management of IPR within (public) universities and increased awareness in the business sector. The extension of the SPINNO and competence centre programmes should ensure continued progress,, however further steps toward more 'entrepreneurial universities" should be encouraged in terms of the internal management procedures of the universities. Equally, a more active support for IPR management in enterprises is required from the Estonian Patent Office and/or Enterprise Estonia.

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> Measures such as the competence centres or the SPINNO programme have begun to improve academic-industry linkages. 	<ul style="list-style-type: none"> Propensity to research commercialisation not supported by academic inventive system still based on publications. Limited financial means of enterprise sector and lack of specific (financial) measures to promote improved IPR management and protection.

4.5 Summary of the role of the ERA dimension

The ERA dimension in the area of knowledge production is obviously important. There is a sense that Estonian policy makers and academic circles are aware of the need to focus investments in infrastructure and funding of areas of specialisation if

Estonia is to compete in internationally competitive fields of research. However, the current funding and evaluation systems tend to perpetuate a form of lock-in, despite improvements, due to criteria for selecting projects, etc. for funding based on standard academic outputs. More novel or applied research fields have significant difficulties in making headway. Equally, consolidation is necessary given the fragmented structure of the research system (just taking into account the number of public universities in a country of 1.3 million people should give pause for thought), yet as always, and not unique to Estonia, a subject that requires careful management of sensitivities of stakeholders. In this sense, the ERA debate on the need for sharing of research infrastructures or consolidation and specialisation are certainly relevant.

5 - Knowledge circulation

The purpose of this chapter is to analyse and assess how the research system ensures appropriate flows and sharing of the knowledge produced. This is vital for its further use in economy and society or as the basis for subsequent advances in knowledge production. Knowledge circulation is expected to happen naturally to some extent, due to the mobility of knowledge holders, e.g. university graduates who continue working in industry, and the comparatively low cost of the reproduction of knowledge once it is codified. However, there remain three challenges related to specific barriers to this circulation which need to be addressed by the research system in this domain:

- Facilitating knowledge circulation between university, PRO and business sectors to overcome institutional barriers;
- Profiting from access to international knowledge by reducing barriers and increasing openness; and
- Enhancing absorptive capacity of knowledge users to mediate limited firm expertise and learning capabilities.

Effective knowledge sharing is one of the main axes of the ERA green paper and significant elements of IGL 7 relate to knowledge circulation. To be effectively addressed, these require a good knowledge of the system responses to these challenges.

5.1 Analysis of system characteristics

5.1.1 Facilitating knowledge circulation between university, PRO and business sectors

Based on the data from the recent European Community Innovation Survey, almost 40% of innovating companies developed innovative products and processes in cooperation with other enterprises in 2006 (35% in 2004) (Statistics Estonia, 2008b). Collaboration on R&D and innovation between private and public sector agents in Estonia is more frequent than the EU average. However, enterprises cooperate mainly with suppliers and customers who are interested in semi-manufactured articles. Most of the cooperation takes place in Estonia and the partnerships are created with equipment suppliers (16% of companies) and clients (14%).

Collaboration with universities is less frequent and indeed, Indeed, an issue of concern is that extra-mural R&D expenditure has decreased from 52.5% (in 2002) to 30.8% (in 2006), as a share of total expenditures by the business sector⁴⁸. The decline has taken place for instance in chemical industry and electrical and optical equipment. This may reflect a growing gap between public and private R&D performers but also some increase in internal R&D capacity of companies. In general, financial flows do not suggest improvements in interactions between different stakeholders in the research system⁴⁹.

The development of technology transfer units at universities and higher education institutions, as well as the development of attitudes and skills promoting entrepreneurship and supporting the commercialisation of research results among the members of universities and higher education institutions will continue in Estonia (SPINNO Programme). The SPINNO programme, which was launched already in 2001, has been assessed twice during its lifecycle (in 2003 and 2007) (Brighton, R., Kells, A. (2007), as described in chapter 4.1.2.

The Competence Centre Programme is a more recent mechanism designed to encourage the creation of longer-term joint R&D partnerships of businesses and academy. Five competence centres have been established during 2004-2005 as private legal entities in specific R&D fields (ICT, cancer research, nanotechnology, food and fermentation, healthy dairy). The competence centres are focused on applied research and are expected to develop their activities according to medium-term research programmes (not single projects).

The science excellence centres established through specific programme (since 2002) aim to encourage interdepartmental collaboration in fundamental research. In 2008, a new call took place to give a qualification of science excellence for selected consortia of top researchers in Estonia. The new call was open also for new centres, as a result seven research groups (combining older and new consortia) received financing for the coming seven years. Compared with the previous period, the smaller number of new centres is a good indication of an effort to consolidate research capacities and competencies, and focus on core research topics. For example, the available programme budget, thanks to the consolidation, is €23,000 annually per scientist, which is roughly 14 times higher than in previous period.

Considering researchers' mobility, the RDI strategy foresees to connect more systematically the research work of students with the needs of enterprises. The support mechanism for recruitment of development personnel from Estonia and abroad will be launched in 2008 (see section 5.3).

5.1.2 Profiting from access to international knowledge

The EU's Research Framework Programmes is a major opportunity for R&D collaboration between Estonian and foreign researchers. By July 2007, 372 Estonian institutions were involved in 325 6th Framework Programme (FP6) projects (or in

⁴⁸ Ibid.

⁴⁹ Observing the business sector role in financing R&D in different sectors, then one can find decrease in all sectors, in higher education sector from 17.5% in 1998 to 5.3% in 2006, in government sector from 11.5% to 0.01%, in non-profit organisations from 0.41% to 0.22%. From the state financing point of view, between 4-10% (19% exceptionally in 1999) of BERD has been covered by the Government. Publicly funded innovation expenditures are only 4% of the EU27 average according (European Innovation Scoreboard, 2007).

3.65% of the total number of FP6 projects). The €33.12m in R&D funding provided by FP6 to Estonia included notably active participation from bio- and gene technology, nanotechnology, and ICT researchers, which is a common pattern in the EU⁵⁰. According to the Archimedes Foundation, the national contact point for the Framework Programmes, Estonian organisations have continued to be active in the new application period for FP7 (2007-2013). Estonian scientists are also involved in Research Networking Programme, ERA-NET Plus programme, and several regional projects (Progress Report of RDI Strategy 2007-2013).

The total foreign sourced (excl. companies) R&D financing in Estonia amounted to €77m in 2000-2006. More than half of this was funding from the Framework Programmes. It is hoped that under the 7th Framework Programme more active involvement of enterprises, particularly SMEs, will occur. A new programme, Eurostars (co-funded from the ERDF) was initiated in November 2007, which can support Estonian enterprises for international R&D activities (see more in chapter 5.3).

Based on the R&D and innovation strategy (and Estonian National Strategic Reference Framework 2007-2013 and Operational Programme for Human Resource Development), universities and other research institutions are supported in bringing foreign researchers, as well as Estonian researchers working abroad to Estonia. International mobility and free movement of researchers between the academic sphere, public sector and private sector to be promoted, thus avoiding that this would interrupt their academic career. There are a number of support mechanisms developed in Estonia or initiated by the European Union encouraging the involvement of foreign researchers in Estonian-based institutions. Besides acting as the NCP for the EU Framework Programmes, the Archimedes Foundation⁵¹, is also a coordinator of COST (European Cooperation in the field of Scientific and Technical Research)⁵² programme. Archimedes Foundation, together with the HEIs, is a member of the European Network of Mobility Centres - ERA-MORE⁵³. Under the framework of the previous ERA-MORE now EURAXESS, Archimedes maintains the Estonian Researchers' Mobility Portal www.smartestonia.ee targeted at researchers and students intending to work or study in Estonia.

The Estonian Government offers scholarships for international students. Scholarships are intended for university students, researchers or lecturers for studying and doing research at Estonian public universities and institutions. In order to promote international cooperation and the circulation of knowledge, scholarships have been established for international students who wish to enrol for an accredited doctoral programme in Estonian universities in the following fields: ICT, Materials Technology, Environmental Technology, Biotechnology, Power Engineering, Health. There are also short-term visiting scholarships available for PhD students.

The Estonian Academy of Sciences⁵⁴ fosters international mobility of researchers and aims at facilitating scientific networking. The agreements on scientific

⁵⁰ Raport „Eesti osalemine 6. raamprogrammis. Euroopa Liidu teadus- ja arendustegevuse 6.raamprogramm (2002-2006). 2007.

⁵¹ See <http://www.archimedes.ee>. Archimedes is the implementing body for EU Lifelong Learning and Youth in Action programmes; the host of Estonian Current Research System and organises the activities of the Higher Education Quality Assessment Centre, etc.

⁵² See <http://www.cost.esf.org/>

⁵³ See http://ec.europa.eu/euraxess/index_en.cfm?I1=24&I2=0&I3=0

⁵⁴ See <http://www.akadeemia.ee>

cooperation signed with partner institutions – mostly Academies – in other countries (in total 29) allows the Academy to draw on goodwill and experience of partners in shaping its own strategies and cooperation tools. On the basis of bilateral agreements, the Academy runs a Scientific Exchange Programme hosting on average 100 visiting researchers per year and nominating approximately 150 Estonian scientists and scholars per year for study and conference visits abroad. The Council for International Exchanges composed of representatives of the Academy and major Estonian public universities, supervises the programme. The funding for hosting the visitors is drawn from the budget of the EAS. Reciprocal visits between teams collaborating within joint research projects are encouraged as a priority.

While a number of support mechanisms exist to support internationalisation of the Estonian research base, there are also a number of barriers that create limitations to mobility. Within the project EST-MOBILITY-NET (as a part of the pan-European EURAXESS Network), a survey of research mobility in Estonia and the factors that influence mobility was carried out in 2006 (Archimedes Foundation 2007). Foreign researchers, lecturers, post-doctoral students and doctoral students considered that the five main problems in studying/doing research in Estonia were: 1) the insufficient remuneration, 2) difficulties with getting information about legal procedures to do with working/studying in Estonia (residence permits, etc), 3) language barrier for handling everyday issues, 4) difficulties with administrative procedures to do with working/studying in Estonia, 5) low level of research infrastructure (equipment, etc). Doctoral students emphasised also the lack of local friends, communication problems and difficulties with solving everyday problems (place of stay, service, hobbies). For foreign researchers, insufficient remuneration is emphasised most often followed by research infrastructure and general competence of researchers in the research area.

5.1.3 Absorptive capacity of knowledge users

The R&D and innovation strategy has chosen an individualised approach to increasing the innovation capacity of enterprises. Special attention is paid to increasing the demand of enterprises for development and cooperation with universities supporting the start-up and growth of new innovative enterprises and increasing the development capacity of enterprises.

The majority of collaboration taking place in R&D and innovation occurs among enterprises themselves. Referring to the European Innovation Scoreboard, SMEs in Estonia collaborate more actively than the EU27 average (176%). However, the cooperation can be mostly characterised by other innovation activities than R&D, according to the Community Innovation Survey. The R&D capacity of enterprises in Estonia is relatively modest and links to the public-academic research organisations remain weak. One factor explaining this is the low level of ‘gatekeepers’ in Estonian firms able to interact with the scientific community. The share of researchers in the Estonian business sector as a percentage of the working population, was less than a half (0.17) of the corresponding figure for EU25 (0.33). In terms of percentage of scientists and engineers in the active population, Estonia (3.5) came closer to the EU25 (4.6) in 2005. This reflects the concentration of R&D human resources in the public rather than the private sector in Estonia.

The following mechanisms encouraging enterprises’ participation in R&D nationally or internationally can be identified:

- the forthcoming programme for recruitment of development personnel from Estonia and abroad,
- the Competence Centre Programme for consortia of enterprises and research institutions in defined technology fields,
- the EU level Eurostars programme for SME international collaborations,
- the Seventh Framework Programme for research organisations, international corporations, SMEs, public administration.

In addition to the above-mentioned support mechanisms, attention has to be paid also to the role of science and technology parks in strengthening the SME participation in R&D and innovation activities in Estonia⁵⁵. In 2008-2013, the main focus of supporting science and technology parks and incubators in Estonia will be on cooperation with international companies.

5.2 Assessment of strengths and weaknesses

Based on the analysis in chapter 5.1, some particular concerns can be identified, which will increasingly determine the system strengths in the future. These circumstances are summarised in the following table. The main question of the sustainability of the Estonian RD&I system relates to the availability of proper level of human resources for R&D and innovation, the distance of enterprises and universities from the international knowledge and technology frontiers. The only way to catch up may be a systematic internationalisation of industry (export-oriented production) and active involvement of foreign researchers and engineers both in academy and business sector. In order to motivate foreign researchers to stay longer in Estonia, on-going attention to the quality of research, general infrastructure and the research funding in research institutions is required.

Main strengths	Main weaknesses
<ul style="list-style-type: none"> • Improved effort to promote information on research and study opportunities in Estonia for foreign researchers • Active participation of Estonian institutions in the EU Framework Programmes, COST, CIP, etc.) which has improved R&D internationalisation and boosted funding. • Instruments such as the competence centres have begun to create synergies between academic and business interests. 	<ul style="list-style-type: none"> • Insufficient remuneration, research infrastructure, general competence of researchers in the Estonia to attract foreign researchers. • Public-private R&D and innovation collaboration is an exception rather than a common practice • Concentration of researchers in the public sector with relatively low rates of S&T workers in industry • There is a developing but relatively standard and limited range of support services for enterprises seeking to transfer technology, etc.

5.3 Analysis of recent policy changes

Regarding particular challenges related to specific barriers to knowledge circulation, four new policy initiatives addressing the challenges could be presented. Referring to

⁵⁵ See also chapter 3 of the 2008 INNO-Policy Trendchart report of Estonia for an overview of measures targeted at encouraging the establishment and development of innovative start-ups .

the recent study on the Estonian RTDI policy mix, the reviewers propose the improvement of articulation between (higher) education, science, technology and enterprise policies to respond more efficiently to the economic needs of Estonia⁵⁶.

Facilitating knowledge circulation between university, PRO and business sectors

A new programme of recruiting development personnel in enterprises has been launched by the MEAC and opened for calls in autumn 2008. The programme will be targeted at involving employees of R&D institutions or foreign-registered companies in Estonian-based SMEs. The public co-financing ceiling for companies will be 50% of the project costs.

The forthcoming cluster initiative in 2008 will be targeted at clusters based on a group of enterprises or composed by enterprises, R&D and education institutions and other partners. The programme will give support to joint initiatives of the cluster. Already since 2006, Enterprise Estonia has been a partner in the Baltic Sea Region Innovation Network – BSR INNONet⁵⁷, which has focused on cluster development in the Baltic Region, BSR, developing trans-national programmes and policy learning.

Profiting from access to international knowledge

The programme Eurostars (opened in autumn of 2007) supports international R&D activities of SMEs. For years, the EUREKA programme has been of help, but at times, its funding plan and dependence on the possibilities of the national donor have made it difficult to receive support. As presented by Enterprise Estonia, Eurostars contains strengths of the already known and functioning EUREKA programme plus easier and faster access to support. The prerequisite for applying for a grant is that at least two companies engaged in R&D activities from different countries that have joined the Eurostars programme participate. The leading role in the project is played by a SME that involves one or more other companies and a research institute in the project⁵⁸.

In **international mobility**, the Council Directive 2005/71/EC of 12 October 2005 on a specific procedure for admitting third-country nationals for the purposes of scientific research was fully adopted by the amendments to the *Aliens Act* in 04.11. 2007.

Absorptive capacity of knowledge users

At the beginning of 2008, the Enterprise Europe network of the European Commission was opened at the Estonian Chamber of Commerce and Industry supporting common European small and medium-sized enterprises (SME). The new network brings together the networks of Euro Info and Innovation Centres that have been operating separately so far. The Estonian coordinator of the new network is the Estonian Chamber of Commerce and Industry. Enterprise Europe connects the services offered by the two networks. However, as of yet, no real evaluation has taken place of the effectiveness of the various operators.

⁵⁶ Ibid.

⁵⁷ See <http://www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=55&parentID=55>

⁵⁸ See more at <http://www.eas.ee>, <http://www.eurostars-eureka.eu>

5.4 Assessment of policy opportunities and risks

There remains a clear need in the area of knowledge circulation to increase the motivation for both the academic sector and private enterprises to engage in collaboration. This requires the improvement of know-how on IPR management, innovation management, etc and incentives to co-operate on both sides. At policy-level further efforts to coordinate policy fields such as education science, technology, and enterprise policies should also be undertaken to improve synergies between different instruments (and their articulation with the EU level funding instruments, e.g. on researcher mobility). The main risk in the field of knowledge circulation is related to both the limited human resources available in the country and the potential for the enterprise sector to restructure towards more knowledge intensive activities.

Main policy opportunities	Main policy-related risks
<ul style="list-style-type: none"> • Further improvements to the articulation between higher education, science, technology and enterprise policies. • To increase the knowledge and practice in R&D and innovation management, to develop partnerships between industrial clusters and the public sector and to increase the international R&D cooperation of SMEs. • Need to create more attractive motivation package (funding, competences, infrastructure) for foreign researchers and engineers in the Estonian business or research sector. 	<ul style="list-style-type: none"> • Relatively few business R&D engines in the economy, which may not produce the expected outcomes from public policy on R&D and innovation. • Shortage of human resources for creating a critical mass of R&D competence in specific fields of technology.

5.5 Summary of the role of the ERA dimension

Knowledge circulation in the ERA dimension predominantly associates with the researchers' mobility. European Commission has set up the European Network of Mobility Centres (EURAXESS Services Network) to assist researchers in practical matters relating to transnational mobility. The EURAXESS Services Network counts about 200 mobility and numerous local contact points in European countries. Archimedes Foundation, together with the Estonian Academy of Sciences, the University of Tartu, Tallinn University of Technology, the Estonian University of Life Science, and Tallinn University, are the members of the Network.

6 - Overall assessment and conclusions

R&D intensity has been rising but this rise is unlikely to continue since the government budget is under pressure and business expenditure is concentrated in a limited number of firms, making the Estonian system vulnerable to developments in a few companies. Investment in R&D infrastructure is dependent on EU Structural Fund support and even with current investment levels only a fraction of the accumulated under-spend of the previous decade will be made up.

Scientific specialisations seem to be only loosely connected to future economic-society needs, but on the other hand it cannot be said with certainty which sectors would qualify as such. In recent years, Estonia has performed well in sectors focused on the short-to medium term (such as financing, real estate etc.), while finding long-term paths have been paid less attention to. However, knowledge demand in Estonia is insufficiently articulated and so far based on some very sporadic interactions between companies and universities while foresight is only starting.

6.1 Strengths and weaknesses of research system and governance

The table below summarises the main elements of discussion and analysis for each of the domains and challenges addressed in this report.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	<ul style="list-style-type: none"> There is a relatively clear political consensus on the importance of working towards a “knowledge based Estonia”.
	Securing long term investment in research	<ul style="list-style-type: none"> Structural Fund programming approach has provided longer-term commitment, balancing the short-term vagaries of annual budgeting rounds The private sector is expected to contribute a significant share of the increased R&D spending by 2014, but given current trends this is unlikely to be achieved.
	Dealing with barriers to private R&D investment	<ul style="list-style-type: none"> The value added in Estonian industry production is often low and consequently also domestic demand for industrial R&D is low. Lack of attention to FDI as a source for increased investment in research Launch of Estonian Development Fund should help to structure public-private financial resources for knowledge intensive firms
	Providing qualified human resources	<ul style="list-style-type: none"> Action is being taken (graduate schools, etc.) to improve the attractiveness of science as a career, faced by insufficient levels of (doctoral) students in S&T
Knowledge demand	Identifying the drivers of knowledge demand	<ul style="list-style-type: none"> Tradition of transparent public consultation on policies; Despite recent foresight, actions, strategic planning of scientific and industrial research priorities requires greater efforts. Few mechanisms for technology assessment or identification of broader societal needs for knowledge.
	Co-ordination and	<ul style="list-style-type: none"> The launch of national technology programmes should

Domain	Challenge	Assessment of strengths and weaknesses
Knowledge production	channelling knowledge demands	improve co-ordination of knowledge demand and production
	Monitoring of demand fulfilment	<ul style="list-style-type: none"> Little is done aside from programme level evaluations to monitor impact of policy initiatives
Knowledge circulation	Ensuring quality and excellence of knowledge production	<ul style="list-style-type: none"> Research assessment and peer review mechanisms are in place but remain based largely on scientific criteria and less on their relevance for the economy or society. Initial steps towards concentrating funding in science excellence centres with sufficient critical mass to compete in the ERA.
	Ensuring exploitability of knowledge	<ul style="list-style-type: none"> Management processes and capacities in R&D institutions remain weak (despite support) and incentives to undertake applied research are low for academics. Programmes such as SPINNO aimed at improving management of IPR in universities.
	Facilitating circulation between university, PRO and business sectors	<ul style="list-style-type: none"> Instruments such as the competence centres have begun to create synergies between academic and business interests. Circulation of knowledge could be dramatically ramped up and cover a much wider range of companies.
Knowledge circulation	Profiting from international knowledge	<ul style="list-style-type: none"> Estonian research teams have been strongly involved in EU programmes and research mobility and internationalisation of the research base is a clear priority.
	Enhancing absorptive capacity of knowledge users	<ul style="list-style-type: none"> Limited number of S&T graduates working in industry able to act as 'gatekeepers' for co-operation with knowledge institutions; There is a developing but relatively standard and limited range of support services for enterprises seeking to transfer technology, etc.

6.2 Policy dynamics, opportunities and risks from the perspective of the Lisbon agenda

The table below summarises policy opportunities and related risks.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	<ul style="list-style-type: none"> Elements of medium-term horizontal strategic planning implemented and continuous efforts to link national investment and implementations plans with the strategic framework documents Political commitment of virtually all policy parties to the Lisbon goals including on R&D. 	<ul style="list-style-type: none"> Worsening budgetary and macro-economic situation for both business and public funding. Prioritisation of annual state budget process and needs and the objectives of the Coalition Agreements instead of medium/long-term strategy planning Reliance on business sector to reach investment goals.
Knowledge demand	<ul style="list-style-type: none"> Nation-wide technology- and cluster related foresight activities were started by the EDF in mid-2008. EDF has a sufficiently narrow approach to focus on 5-6 key (technology) areas. Inclusion of business demands in education plans. 	<ul style="list-style-type: none"> No common approach and implementation means to monitor or evaluate the knowledge demand systematically and comprehensively No coherent consistent articulation between RDI, education, labour market, industrial foresight and social policies in terms of knowledge demand and supply.

Domain	Main policy opportunities	Main policy-related risks
Knowledge production	<ul style="list-style-type: none"> Measures such as the competence centres have begun to improve academic-industry linkages. 	<ul style="list-style-type: none"> Propensity to research commercialisation not supported by academic inventive system still based on publications. Limited financial means of enterprise sector and lack of specific (financial) measures to promote improved IPR management and protection.
Knowledge circulation	<ul style="list-style-type: none"> Further improvements to the articulation between higher education, science, technology and enterprise policies. To increase the knowledge and practice in R&D and innovation management, to develop partnerships between industrial clusters and the public sector and to increase the international R&D cooperation of SMEs. Need to create more attractive motivation package (funding, competences, infrastructure) for foreign researchers and engineers in the Estonian business or research sector. 	<ul style="list-style-type: none"> Absence of business R&D engines in the economy, which may not produce the expected outcomes from public policy on R&D and innovation. Shortage of human resources for creating a critical mass of R&D competence in specific fields of technology.

6.3 System and policy dynamics from the perspective of the ERA

The ERA concept and priorities as such are relatively well understood in Estonian policy circles and the academic community. However, there is not per se a significant debate on the whole range of issues covered by the Green Paper, for instance. Rather Estonian policy-makers attention to certain ERA relevant topics are driven by necessity (limited national funding, scale of the research system, use of peers from other countries, researcher mobility as a way of reinforcing limited national human resources, etc.) or national priorities (specific research priorities broadly in line with European priorities under FP7, etc.). What the ERA means most concretely in Estonia is clearly funding. The figures presented in this report underline the relative importance of FP6 funding versus national funding during the 2002-2006 period. Equally, the EU's Structural Funds have provided the required funding for the launching of a series of new programmes aimed at modernising research infrastructure, funding science excellence or research-industry competence centres, boosting government support to business R&D, etc. Clearly, one can look at a watershed period before and after Structural Fund support began 2004.

Equally, for Estonia's higher education based research system, the ERA concept is in line with institutional strategies to modernise and internationalise the academic system. Taking into account that the majority of R&D activities are concentrated in the public universities, these strategies should be recognised as an important framework for international collaborations in key area of research – qualified personnel supply and development.

In terms of European mobility of researchers, the Government has passed the necessary legal measures to be in line with EU legislation and an increasingly large

number of (financial and non-financial) support measures or actions are now functioning. Ensuring that young Estonian researchers trained in the country gain international experience but ultimately return to the country is important. This depends on more than repatriation grants, it will require ongoing efforts to improve pay and conditions, modernise research infrastructure and priorities and create critical mass of researchers working in a limited number of fields where Estonia can be internationally competitive.

At the present time, Estonia's experience with joint programming with other Member States is quasi-inexistent but involvement in some ERA-NET type initiatives may lead to developments in this sense. Certainly in a number of fields joint programmes could make sense as a way of giving increased access to infrastructures, complementary knowledge of other research teams or of creating critical mass in a research field in the Nordic-Baltic space.

Finally, the issue of modernising research infrastructure is now well established as a policy priority. However, it would be exaggerating to say that there is a 'national strategy on the further development of research infrastructures in an ERA context', indeed issues related to sharing or co-investing in research infrastructure with Baltic or Nordic neighbours, while the subject of ad hoc discussions between institutions, is still not on the political agenda

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NB: statistics used in this report are sourced either from EUROSTAT or Statistics Estonia's databases and were the most recently available at the time of writing (September 2008).

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List of Abbreviations

BERD	Business Expenditure on R&D
EDF	Estonian Development Fund
ERDF	European Regional Development Plan
ESF	European Social Fund
GDP	Gross domestic product
GERD	Gross expenditure on R&D
HERD	Higher education expenditure on R&D
MER	Ministry of Education and Research
MEAC	Ministry of Economic Affairs and Communications
NDP	National Development Plan
NSRF	National Strategic Reference Framework
SBS	State Budget Strategy

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Abstract

The main objective of ERAWATCH country reports 2008 is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries. The reports are produced for each EU Member State to support the mutual learning process and the monitoring of Member States' efforts by DG Research in the context of the Lisbon Strategy and the European Research Area. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. The reports are based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

This report encompasses an analysis of the research system and policies in Estonia.

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