KNOWLEDGE-BASED ESTONIA

Estonian Research and Development and Innovation Strategy
2007-2013

Contents

Foreword

The economic competitiveness of Estonia has a major role in improving the living standard of our people as well as helping Estonia to take a position among the most prosperous countries in Europe. In order to achieve this goal, we have to pay much more attention to research and innovation. We have to turn Estonia into a country with innovative top-level research and high technology. Although investing in innovation requires great efforts and hard work, and it takes time until the investments will pay off, it is worth the effort. There is no alternative to this path.

I can assure you, that we have already chosen this path. In February 2007, the *Riigikogu* approved Estonian Research and Development and Innovation Strategy for the period 2007-2013. The implementation of the previous strategy made Estonia the leading country in the European Union concerning the growth of research and development investments. Estonia is also among the leading countries concerning investments in information and communication technology. We have also other positive indicators, for instance, a large number of people with higher education or the remarkable innovativeness of Estonian small and medium size enterprises.

At the same time, Estonia remains significantly behind the leaders of today's Europe – the Scandinavian countries and Switzerland. Our weaknesses are the low level of research and development investments of the private sector, too few patent applications, a small number of graduates in natural sciences and technology and a modest amount of high-tech export.

Taking into consideration our ambitious goals in such a starting position, I consider three aims to be the most important in research and innovation policy. These three aims are the following:

- a motivating system of remuneration and research environment for researchers, attractive conditions for Doctoral studies;
- building a modern research and development infrastructure;
- supporting the environment of high-tech entrepreneurship.

I am certain, that we are capable of achieving these goals. However, in order to achieve them, we must significantly increase expenditures on research and development. In the strategy "Knowledge-based Estonia" the Government has set a goal to raise the total expenditure on research and development to 1.9% of GDP by 2010 and 3% of GDP by 2014. However, these goals will certainly not be achieved only by means of money.

We have to consider our actions carefully and acknowledge that we cannot achieve the best results in all fields. No country can do that. We are able to offer internationally competitive salary and working environment to the researchers of only some fields. In this strategy, we have defined the key areas, in which Estonia does have the competitive edge already today. These are the fields which attract also private sector investments and which contribute directly to the development of Estonia.

I am convinced that when acting purposefully, we can turn Estonia into a country that is internationally known for its innovative solutions, top-level research and technology.

Prime Minister
Andrus Ansip

Basic principles

Research and development, and innovation (RD&I) are at the core of the knowledge-based society model in developed countries. Knowledge-based society is constantly developing, sustainability of the society is based on creating and using knowledge aimed at efficient operation of the society and innovative economy, to increase welfare of the people.

Estonian RD&I strategy 2007–2013 "Knowledge-based Estonia" focuses on sustainable development of the society by means of research and development, and innovation. It contributes to achievement of the goals of Estonia's long-term development strategy "Sustainable Estonia 21" as well as the Lisbon strategy (the strategy for growth and jobs). The current strategy is the follow-up of Estonian Research and Development Strategy 2002–2006 "Knowledge-based Estonia".

The RD&I strategy addresses the following challenges that Estonia is facing, i.e. challenges:

- to the organisation of RD&I;
- to entrepreneurship and economic competitiveness;
- to the public sector and development of RD&I policy.

Research and development need skilled people and a competitive infrastructure, clear orientation towards Estonia's needs and opportunities as well as stable increase in financing. Challenges facing Estonian entrepreneurship and economy include increasing productivity as well as high added value export, creation of cooperation networks that encourage innovativeness; and a challenge for the public sector is to value the knowledge-based approach and design compatible policy-making processes.

The Strategy sets out three main objectives:

- competitive quality and increased intensity of research and development;
- innovative enterprises creating new value in the global economy;
- innovation friendly society aimed at a long-term development.

Achieving success at international level requires the concentration of human as well as material resources, the increase of specialisation, and the division of tasks among research and development institutions. Resources are preferably directed into those fields of RD&I which have the potential to achieve results in frontier research at global level, are important for sustainable economic development and support important socio-economic objectives as well as the preservation of a nation and its culture.

The strategic key technologies in supporting research and development, and innovation are:

- information and communication technologies;
- biotechnologies;
- material technologies;

as these technologies are at the frontier of modern R&D, they are rapidly developing and increase the added value and productivity in various fields of life.

National research and development programmes will be launched on the basis of the strategy:

1) for developing key technologies;
2) for solving socio-economic problems and achieving the objectives in socio-economic sectors that are important to every resident of Estonia, as for instance energy, national defence and security, health care and welfare services, environmental protection, and information society;

3) for ensuring and promoting the sustainability of research related to Estonian national culture, language, history, nature and the Estonian state.

The objectives set in the strategy will be achieved through four measures:

- development of human capital;
- organising the public sector RD&I more efficiently;
- increasing enterprises' innovation capacity;
- policy-making aimed at long-term development of Estonia.

The strategy (incl the national programmes covering different fields) will be implemented under the leadership of the Ministry of Education and Research (MER) and the Ministry of Economic Affairs and Communications (MEAC) in cooperation with other ministries, which are responsible for initiating and implementing national R&D programmes in their areas of administration. The Government of the Republic, advised by the Research and Development Council (RDC), organises the overall implementation of the strategy.

As for general indicators of implementation of the strategy, the total expenditure on research and development is planned to be increased to 1.5% of GDP by 2008 and to 3% of GDP by 2014, of which the business sector research and development investments cover more than a half (1.6% of GDP). The proportion of employees involved in research and development has to increase to 8 researchers and engineers per 1000 employees and the productivity of enterprises per employee has to reach 80% of the average of the European Union 25 member states (EU 25).

Introduction

The Estonian RD&I strategy 2007–2013 "Knowledge-based Estonia" is an RD&I area development plan approved by the Government of the Republic, which sets objectives and measures to ensure high quality and increased intensity of Estonian research and development, to increase business sector innovativeness and the added value they create as well as to establish Estonia as an innovation friendly country in 2007–2013. The strategy and its implementation plan provide the framework and scope of public sector support measures until 2013 giving guidelines and motivation to research and development institutions and enterprises for planning and organising their activities in a longer perspective. Pursuant to the Organisation of Research and Development Act, the Research and Development Strategy is to be approved by the Estonian Parliament (*Riigikogu*).

This strategy is the follow-up of the Estonian Research and Development Strategy 2002–2006 "Knowledge-based Estonia". Due to necessity to outline a clear vision and a stable framework for development of the sector for the years following the implementation of the present strategy, the Minister of education and research formed a committee for preparing the strategy with his directive on July 16, 2004. The committee, led by the Vice President of the Estonian Academy of Sciences, included representatives of the Ministry of Education and Research, the Ministry of Economic Affairs and Communications, the Ministry of Finance, the State Chancellery, the Enterprise Estonia foundation, Tallinn University of Technology, University of Tartu, Estonian University of Life Sciences and entrepreneurs.

The RD&I strategy focuses on ensuring the sustainable development of society through the research and development and innovation, contributing to the implementation of Estonia's long-term development strategy "Sustainable Estonia 21". At the same time, the strategy also helps Estonia as a member of the European Union to achieve the objectives of the Lisbon strategy (strategy for growth and jobs).

The activities planned in this strategy are in accordance with the priorities of the "Estonian Action Plan for Growth and Jobs 2005–2007" approved by the Government of the Republic on October 13, 2005 and the "Estonian National Strategic Reference Framework 2007–2013" (NSRF). Implementation of the activities and achievement of the objectives of the strategy is connected with successful implementation of several other area-specific development plans (particularly the "Estonian Higher Education Strategy 2006-2015", "Estonian Enterprise Policy 2007–2013", "Lifelong Learning Strategy 2005–2008" and the "Estonian Information Society Development Plan until 2013").

"Estonian Enterprise Policy 2007–2013" includes strategic objectives and activities deriving from these objectives for the development of entrepreneurship in Estonia. For 2007–2013, the strategic activities of enterprise policy include the development of legal environment, creation of necessary conditions for entrepreneurship in the regions, development of human resources and entrepreneurship based on the needs of enterprises, facilitating access to the capital as well as supporting the internationalisation of Estonian enterprises, including the engagement of foreign investments. "Knowledge-based Estonia" (2007–2013) and "Estonian Enterprise Policy 2007–2013" are documents supplementing each other. Duplication will be avoided in implementing development plans and preparing the programmes, and synergy will be created through close cooperation among implementers.

The "Estonian Information Society Development Plan until 2013" provides for the principles and priorities for organising the activities concerning the information society at the state level.

It is a horizontal development plan, which coordinates issues concerning the development and implementation of information and communication in all state institutions and therefore it consolidates inputs from several sector-based development plans, including the development plan "Knowledge-based Estonia" (2007–2013).

Estonian RD&I strategy 2007–2013 "Knowledge-based Estonia" provides for the main positions in this field. Following the strategic directions outlined in the strategy, implementing the activities and achieving the objectives provided in the strategy is organised by the Government of the Republic, advised by the Research and Development Council (RDC). The strategy will be implemented under the leadership of the Ministry of Education and Research (MER) and the Ministry of Economic Affairs and Communications (MEAC), in cooperation with other ministries. An overview of the implementation of the strategy, achievement of its objectives and efficiency of the measures will be presented to the Government of the Republic yearly, making also proposals for supplementing the strategy, if necessary[1].

The approval of this strategy by the *Riigikogu* is a long-term agreement of the Estonian political groups on the objectives of the RD&I strategy and their achievement. The growth rate of financing determined by this strategy will be complied with throughout the whole period of the strategy.[2]

[1] The types of strategic development plans and the procedure for drafting, amending, evaluating the implementation and reporting thereof. Regulation of 13 December 2005 No 302 by the Government of the Republic.

[2] Several European countries have achieved this, incl Finland and Latvia. In Finland, all major political parties and social groups agreed on the long-term financial plan for ensuring the RD&I financing already at the beginning of the 1990s and have consistently implemented it. In Latvia, the growth of public R&D investments is provided for by the law.

1. MAIN ASPECTS AND UNDERLYING PRINCIPLES

Research and development, and innovation are in the centre of the knowledge-based model of society in developed countries. A society is called knowledge-based when knowledge and skills are the most important strategic resource and the achievement of objectives in state governance, economy, social life and environmental protection is based on knowledge, analysis, discussions and cooperation. Scientific research expands knowledge, provides directions for education, develops values and forms the basis for society's development. Solving the practical problems of society requires goal oriented research with direct applied output. Research foresight and goal-oriented applied research are closely connected and they overlap increasingly. Therefore, it is important to find a suitable balance between these two directions of research. Yet, in spite of the direction of research, excellence or frontier research is crucial.

Knowledge-based economy is defined by having high added value of products and services, which is achieved by constant innovation. Innovation includes implementation of latest outcome of scientific research as well as already existing knowledge, skills and technologies in an innovative manner.

The key technologies (information and communication technologies, biotechnologies, materials' technologies), which are in the centre of a knowledge-based society, have a deep impact on economic sectors, replace or improve existing technologies and give stimulus to development of new technologies. The implementation of key technologies has a profound effect on productivity growth and it strongly influences all aspects of society's functioning.

However, economic success today does not lie only in concentrating on new technology, but ever more in concentrating on creativity and consumer orientation. In recent years, it has become clearer that a society, which is capable of creating synergy between culture and business, has more prospects for economic growth. Factors, such as quality, efficiency and constant improvement of work operations that once brought success to big corporations have now transferred to countries with well-trained low-wage labour force. Soft values, such as culture, emotions and lifestyle, are gaining more importance in developing new products and services.

When setting the targets, Estonia has to consider development trends at home as well as in the world around us. The variety of capacities and opportunities has grown, but the need for resources in order to improve as well as maintain the present level is also growing. Globalisation of economy and increasing division of labour intensifies competition. Growing consumption conflicts with limited natural environment. Demographic problems emerge along with growing welfare of people. Security risks have become more complex compared to previous times. All this sets ever more complicated requirements to the overall arrangement of the society. Tackling these problems requires educated people who are capable of creating and developing knowledge and technologies as well as using them creatively. But the competition among countries is intensifying, particularly in the area of human resources. First of all, the demand for highly qualified researchers and engineers grows; for instance, the European Union will need approximately 700 000 additional researchers and engineers by 2010 in order to comply with the Lisbon objectives.

Estonia is not the only country facing these challenges. For maintaining good position in global division of tasks, many countries have vigorously started to target their economy towards achieving higher added value, incl increasing the intensity of RD&I, increasing the

number of top level specialists, supporting quick implementation of new technologies and internationalisation of enterprises. The European Union is developing a vigorous policy for realising the vision of a knowledge-based society, setting the aim to concentrate resources on research and development, and education as the basis of progress, and planning to increase the funding of these sectors substantially[3]. For achieving the Lisbon strategy objectives, the aim is to increase the RD&I funding to 3% of GDP by 2010 (the so-called Barcelona target), of which 2/3 has to come from the private sector.

Innovative entrepreneurship and business projects that require development activities are long-term and it is very difficult to forecast their profitability. This is why the private sector is not always too eager to take these risks. Therefore, in all developed societies the state has an important role in supporting and motivating enterprises to invest in research and development and innovation.

To be successful as a part of the European research and economic area, while also maintaining its identity, Estonia has to invest in widening and strengthening its knowledge base and skills in three main areas:

- **Research and development based on the internal logic of the development of research** *(researcher-driven research)*. The primary objective of these investments is to maintain and raise the level of education and research in Estonia. It concerns investments which direct socio-economic output may occur only after a very long time but which are important for Estonia in order to develop the nation state and culture as well as for cohesiveness with global development.
- **Research and development based on the logic of global markets and technological development** (*technology-driven research*), regarding the established economic specialisation of Estonia and its partner countries, and the needs of enterprises considering their long-term development.
- **Research and development with the aim to find solutions to specific socio-economic tasks** (*problem-driven research*). This mainly includes applied research and development, which helps Estonia to accommodate to various socio-economic challenges and supports the implementation of sector policies (e.g. health care, environment protection, energy, agriculture, etc).

In order to be successful, it is vital to focus on achieving and maintaining internationally competitive quality of Estonian research and development, and as for development based on business interests, focus on creating high economic added value. State support must be focused on development of human capital and infrastructure as the two main bottlenecks.

Estonian RD&I strategy is tightly integrated with the need for socio-economic development as well as with maintaining and developing our physical environment. Therefore, the RD&I is horizontal, a field that cuts across administrative areas of all ministries.

New knowledge and its implementation often bring along immediate changes in society, and adjusting to them is difficult for the wider public and institutions. Therefore, researchers have a social responsibility to monitor and assess the developments of research and technology, helping the society to prepare for changes and using the opportunities related to these changes wisely. As a rule, the connections between research and economy are transboundary, and therefore, it is important to rely on international indicators in evaluating the outcome of R&D.

[3] Presidency Conclusions, Brussels European Council 23/24 March 2006

Today, competition is no longer the only driving force behind development and innovation – cooperation and networking have become almost as important. Cooperation grants an access to knowledge, facilitates risk sharing and undertaking of projects that require critical mass. Therefore, the central principle of the RD&I strategy is to encourage national as well as international cooperation between all parties.

Pursuant to the Constitution of the Republic of Estonia, Estonia "shall guarantee the preservation of the Estonian nation and culture through the ages". The RD&I strategy supports the achievement of this objective.

2. ESTONIAN RESEARCH AND DEVELOPMENT STRATEGY 2002-2006 "KNOWLEDGE-BASED ESTONIA"

Estonian Research and Development Strategy 2002-2006 "Knowledge-based Estonia" was approved by the *Riigikogu* on December 6, 2001 and has been the basic document directing Estonian research and development, and innovation. The strategy sees the future Estonia as a knowledge-based society and it sets the strengthening of knowledge base and the growth of enterprises' competitiveness as the strategic objectives of RD&I, providing the framework and scope of public sector support measures until 2006.

Unfortunately, Estonia has not been able to follow the financing intentions planned in the strategy and approved by the *Riigikogu*. Instead of the target level agreed in the strategy, actual investments over the past few years have been decided in the course of annual budget negotiations and have remained at a significantly lower level than was planned in the strategy. The strategy has been implemented to the extent that corresponds to actually allocated resources.

The intensity and quality of research have increased

Total expenditure on research and development in Estonia has increased from 0.71% of GDP in 2001 to 0.88% of GDP in 2004. Nonetheless, Estonia remains far behind the average of the 25 member states of the European Union (1.9% of GDP in 2004). Estonia has not been able to achieve the financing objectives set in the strategy 2002-2006 "Knowledge-based Estonia" (1.1% of GDP in 2004). The European Union has set a goal to increase the total expenditure on research and development to 3% of GDP by 2010. Finland invested already in 2004 3.51% of GDP in research and development and Sweden 3.74% of GDP (Appendix 1; for more details see Appendixes 1–6).

Increase in the number of articles in international peer-reviewed journals and other publications by nearly 10% a year (796 articles and other publications in 2004) is an evidence of increase in research efficiency. At the same time, research quality or impact, that scientific research performance has on other researchers and that can be estimated by citations of articles, has grown significantly. Although the growing number of articles is exhilarating, the productivity of Estonian research remains approximately two and a half times behind Finland (per capita) and Estonia is on verge of the first third in the impact[4] ranking list of articles in the world. The only exceptions are material science and pharmacology-toxicology, which impact exceeds the field's average in the world and where Estonia holds the 3rd and 18th positions, respectively[5].

Compared to developed countries, Estonia has fallen behind in applying for patents. 3.7 patent applications were filed to the European Patent Office and 11.6 United States' patents were received per million inhabitants in 2003. Compared to the average of the European Union, applying for patents is 9.6 times lower in Estonia than in Europe and 16.7 times lower than in the US. We are in an even poorer position as compared to Finland. In Europe, the Finns are 46.4 times and in America 40.4 times more active in applying for and protection of patents than us.

[4] Impact of articles in a research field can be estimated by citations. As evaluation criteria are different in different fields, this indicator is not suitable for comparing research fields with each other.
[5] ISI Essential Science Indicators, updated on November 1, 2005

The intensity of research and development and innovation in Estonian enterprises has grown

As a positive trend, private sector R&D investments have grown faster than public sector R&D investments (App. 2). While in 1999 the private sector investments made up only 23.9% of the total R&D investments, in 2004 the corresponding indicator was already 39%. The rapid growth was caused by the low level of private sector R&D investments in 1999, but also by enterprises' closer cooperation with research and development institutions, as well as state support to enterprises' research and development projects. Nevertheless, the share of the private sector in research and development is still considerably lower than in developed countries (63.1% in the USA, 69.5% in Finland, the EU average is 55.5%). This reflects the structure of Estonian economy, which is dominated by low-technology small and medium size enterprises.

According to the European Union innovation survey, innovation investments of Estonian enterprises (intramural R&D; extramural R&D; purchasing machinery and equipment directly related to product or process innovations; expenditures on acquiring patents and licences; expenditures on product design, training, and marketing of innovative products and services) amounted to 1.6% of enterprises' turnover in 2004. Corresponding average of the European Union in 2000 was 2.15%[6]. The bigger share of the expenditures (60%) was made for purchasing machinery and equipment.

The enterprises' capacity to apply for and use research and development support measures has grown, and the number of people employed in innovation support structures has grown significantly.

Estonia has been successful in developing international cooperation

In recent years, 13–17% of total R&D investments in Estonia have come as foreign investments (the corresponding average in the EU countries is 7–8%). Estonia's success in acquiring foreign resources is related to active and successful participation of Estonian researchers in the European Community Framework Programmes for research, technological development and demonstration activities. 809 project applications were submitted to the 5th Framework Programme, 195 of them (24.2%) received funding. During the first three years of the 6th Framework Programme there have been already 252 (23.4%) successful applications.

Estonia participates actively in the European Union research cooperation and has become a member of international organisations (European Molecular Biology Conference (EMBC)) and has entered into several cooperation agreements (European Organization for Nuclear Research (CERN)).

The research and development and innovation financing system has been improved

Research base-line funding was implemented in 2005, providing the R&D institutions with an opportunity to plan and extend their activities beyond the project-based financing. Centres of excellence and centres of competence have been established, several other innovation support programmes and only a few national R&D programmes have been launched. Activities aimed

[6] At the time the strategy was compiled, the results of 2004 survey of innovation activities of the European Union enterprises had not been published yet. The Statistics Estonia has published the corresponding data about Estonia as of March 2006.

at commercialisation of outcome of scientific research in institutions of higher education have been organised more extensively and efficiently.

However, in case of several main targets**,** the results planned in the strategy have not been achieved. For instance, national programmes of the key areas defined in the strategy 2002–2006 "Knowledge-based Estonia" (user-friendly information society technologies, biomedicine, material technologies) have not been launched and the scope of state financed Master and Doctoral studies has not increased substantially. The organisation of R&D financing does not favour applied research sufficiently as well as the orientation of innovation support measures towards the needs of traditional sectors of economy have not been sufficient.

On one hand, these deficiencies occur due to the fact that public RD&I investments have not increased according to the schedule, which has made the full achievement of the objectives set in the strategy impossible. On the other hand, there have been obstructions, and particularly regarding national programmes in the key areas that require cooperation between ministries, caused by poor administrative capacity of the ministries as well as other partners (research and development institutions, enterprises), and also by dispersed responsibility and the ministries' unwillingness to take initiative under the circumstances in which the stable state budget financing of multi-year programmes cannot be ensured.

The European Union Structural Funds have been used for implementing the RD&I support policies since 2004. The contribution of the Structural Funds to RD&I financing has been significant, but still, two serious problems have emerged in implementing the funds. Firstly, due to complicated bureaucracy, support is being implemented with a considerable delay and therefore actions launched under the Estonian National Development Plan for the Implementation of the EU Structural Funds – Single Programming Document for 2004–2006 (NDP) will be mainly implemented in 2006–2008. Secondly, the Structural Funds have not always been adequately added to state financing as it was planned in the R&D strategy 2002–2006 "Knowledge-based Estonia".

3. RESEARCH AND DEVELOPMENT, AND INNOVATION CHALLENGES

The Research and Development and Innovation Strategy addresses the challenges Estonia is facing:

- in the organisation of RD&I;
- in entrepreneurship and economic competitiveness;
- in the public sector and development of RD&I policy.

Challenges facing the organisation of research and development and innovation

To ensure a sufficient number of people and competitive infrastructure

Estonian research and development system has undergone several changes during 1990–2005. Research groups have gathered mainly to universities. Public sector R&D financing has been organised through targeted financing, research grants, base-line funding, and financing of infrastructure maintenance costs provided for in the Organisation of Research and Development Act, which are all decided on the basis of quality criteria. Targeted financing and research grants are both competitive, based on *peer-review*. Infrastructure maintenance costs and base-line funding are based on the weighed intensity of quality-based research. Such financing system has brought about a clear orientation towards quality, which is a prerequisite for staying internationally competitive.

However, compared to other European Union member states, there are still three major problems that the current organisation of RD&I in Estonia has not been able to solve.

Firstly, achieving good results requires a sufficient number of motivated researchers and top-level specialists. The present organisation of research and outdated infrastructure do not motivate young people enough to pursue a career in research and stay in or come to Estonia. Therefore, the proportion of researchers and engineers in the labour force (0.50% in 2004) is smaller in Estonia than the European Union average (0.54% in 2003) and many times smaller than the respective figure in the Nordic countries (1.62% in Finland and 1.02% in Sweden in 2003). The proportion of women researchers is 43.1%, which in the European Union is bigger only in Latvia, Lithuania and Portugal. The number of PhD graduates is very small, particularly in engineering and natural sciences. In order to ensure internationally competitive research, attractive career conditions must be created for researchers and engineers in Estonia and the training of PhD level specialists in natural sciences and engineering has to increase.

Secondly, in order to carry out state-of-the-art research and participate in international cooperation, competitive R&D infrastructure is indispensable. Estonia has been almost unable to invest in upgrading research infrastructure and attaining new infrastructure over the past 15 years, and therefore it is largely outdated. The pilot phase of R&D infrastructure development programme will be carried out in 2006–2008, but still, this will only cover a small part of indispensable investments. To ensure international competitiveness of research, the R&D infrastructure must be modernised or if necessary, constructed.

Thirdly, issues related to state budget financing of applied research need to be resolved.

To focus more on Estonia's needs and opportunities and to ensure the stable growth of financing at agreed level

Research and scientific approach are important in all spheres of society, and political decisions should be based on impact analyses and assessment practices as well. Although Estonian research and development are inseparably related to international research area and the research fields of Estonian researchers cover a wide range of themes, Estonia cannot be equally successful in all fields of RD&I and solve all problems at once. Therefore, it is important to focus primarily on research fields that are important for Estonia and to increase resources allocated to these fields. On one hand, the RD&I system has to ensure the diversity of research necessary for the sustainability of Estonian culture and education. On the other hand, we need to focus specifically on future opportunities (new technologies) as well as future risks, e.g. decreasing population, climate changes, energy supply, security. In addition, resources need to be concentrated for addressing several important socio-economic issues, initiating more development intensive activities in Estonian enterprises and increasing RD&I investments of enterprises.

Investments in research and development and innovation have been substantially lower in recent years than was planned in the strategy. Therefore, the possibilities for implementing the objectives set in the strategy 2002–2006 "Knowledge-based Estonia" have been also remarkably smaller than the needs. This has a notably negative impact on training and career opportunities of researchers, and the development of infrastructure, which all require long-term budgetary stability. This has also impeded the initiation of national programmes in the key areas. Such approach is not sustainable, it is vital to specialise, create unique competitive advantages and use technology developments more efficiently in meeting socio-economic challenges.

Estonia has set a target to increase the public sector research and development investments to 1.05% of GDP by 2010. Increasing public investments consistently and ensuring their efficiency create good conditions for the growth of enterprises' research and development investments and allows setting the target of total expenditure on R&D to 1.9% of GDP by 2010[7]. The target of 3% of GDP expenditures on research and development, as agreed in the Lisbon strategy, is planned to be achieved by 2014.[8] Complying with the agreement on stable growth of public financing, raising the quality and intensity of RD&I as well as increasing the involvement of enterprises' research and development investments, will ensure successful and competitive development of Estonia and provide an opportunity to advance creativity and competence in the European Research Area.

Challenges facing entrepreneurship and economic competitiveness

To increase productivity and high added value export

Estonian economy has grown very rapidly in recent years due to domestic demand, direct foreign investments and export growth. In spite of this, productivity per employee in Estonia was only 57% of the European Union member states' average in 2005. In the current phase of economic development, enterprises have been able to earn revenue without investmenting significantly in knowledge or skills. As a result, competition strategies of most enterprises are

[7] Key Issues Paper (KIP) - Input from the Competitiveness Council to the Spring European Council 2006, 6881/2/06/REV2, Brussels, 7 March 2006

[8] "Estonian Action Plan for Growth and Jobs 2005–2007 for Implementation of the Lisbon Strategy", Tallinn, 2005. http://www.riigikantselei.ee/failid/2005_10_13_MTTK_L_pp.pdf

based on cost advantage and/or the growth of domestic (credit) demand. Only a few economic sectors, such as telecommunications and financial intermediation, have high added value per employee and high long-term competitiveness.

In processing industry, while having the highest employment rate (23.7%), the added value per person is smaller than the average in Estonian economic sectors. The competitiveness of enterprises in several industrial sectors (e.g. textile, clothing and furniture industry[9]) is decreasing due to rapidly growing labour costs as the growth of productivity cannot keep up with growing employment costs. Profits decrease and a dilemma arises, whether to take production to a country with lower labour costs or re-orientate towards the supply of products and services that have remarkably higher added value.

However, development of products and services with higher added value requires investments in equipment, development projects as well as the qualification of employees. The investments of Estonian enterprises in research and development have grown every year, but still, they reached only 0.34% of GDP in 2004 compared to the European Union average, which is 1.22%[10]. The innovation expenditures of enterprises amounted to 1.6% of their turnover in 2004, while the European Union average in 2000 was 2.15%[11].

The trends showing development and innovation activities of Estonian enterprises indicate that although the enterprises focus on implementing new technologies, increasing production and improving quality there is still not enough attention paid to expanding the product range and finding new markets. Therefore, substantially larger investments in development of new products and services, which would lead to formation of new and innovative economic (sub-)sectors, are vital for Estonia's long-term export capacity and economic growth.

Under the conditions of disappearing cost advantage**,** it is a real challenge for Estonia to continue attracting foreign investments, which have played an important role in the present growth of productivity, restructuring of economy and technological modernisation, and the amount of which per capita has until now been the biggest among the Central and Eastern European countries[12]. The proportion of reinvested profits has gradually grown since 2001. The volume of new *Greenfield*-type investments has not grown significantly. Foreign investments earned the largest proportion (more than 50%) of their profit in 2003–2004 from only two sectors – financial intermediation and the real estate sector. Only 13.3% of all foreign investments have been made in processing industry as of the end of 2005.

To support the development of cooperation networks encouraging the growth of innovation

Taking a successful idea to the market, particularly to the export market, requires knowledge and skills from entrepreneurs. Enterprises do not always have all necessary competence internally, and therefore, cooperation with other enterprises and research and development institutions is important. Cooperation among Estonian enterprises is more frequent than the European Union average[13], yet it is quite unbalanced – enterprises cooperate mainly with

[9] Urmas Varblane, survey "Analysis of short, medium and long-term competitiveness of Estonian economy and most important sectors taking into account productivity, added value and export capacity", 2005
[10] EUROSTAT http://epp.eurostat.cec.eu.int
[11] At the time the strategy was compiled, the results of 2004 of the survey of innovation activities of European Union enterprises had not been published yet. The Statistics Estonia has published the corresponding data about Estonia as of March 2006
[12] UNCTAD FDI Database, http://www.unctad.org
[13] Urmas Varblane, survey "Analysis of short, medium and long-term competitiveness of Estonian economy and most important sectors taking into account productivity, added value and export capacity", 2005

suppliers and customers who are interested in semi-manufactured articles. Cooperation with universities and research and development institutions is almost two and a half times less frequent than with suppliers or clients.

On one hand, little cooperation with universities and research and development institutions can be explained with the fact that the research and development conducted at universities and R&D institutions has not been sufficiently directed at practical applications, which is also due to the scarcity of respective financial instruments. Scarce application possibilities of research and development are also evident in Estonian research institutions' low activity in applying for patents, few contractual works, incl certification services, and a modest number of *spin-off* enterprises.

Insufficient cooperation between enterprises and universities as well as other R&D institutions can be explained by the structure of the Estonian economy, where a large proportion of enterprises operate in low added value niches, there is no considerable intramural RD&I in enterprises and therefore, the needs as well as capacity of enterprises for cooperation oriented towards knowledge and technology transfer with R&D institutions, is limited. Therefore, besides increasing the knowledge and the amount of ideas with application value at universities and R&D institutions, it is at least equally important to increase enterprises' demand for development.

In developing new products and services, the innovation process grows significantly more complex and enterprises have to develop more miscellaneous partnership networks. The role of the state is to contribute to the development of economic clusters and partnership networks that draw together enterprises, R&D and educational institutions, local governments, foreign partners, etc, especially at regional level. Broadening enterprises' market horizons and helping them to make contacts with international competitors and clients, also improves their opportunities and motivation to innovate and develop their products and services.

Challenges facing the public sector and the development of research and development and innovation policy

The role of the public sector in developing a knowledge-based economy is complicated. The state acts as an investor, a regulator, a consumer, the one who creates the environment, makes strategic choices and gives guidelines. Contemporary innovation policy views innovation as a horizontal issue, which demands significantly more complex and precisely focused action from the state compared to just ensuring the functioning of RD&I financing mechanisms at the present level. But this requires awareness, skills and commitment from policy makers and implementers in order to build a knowledge-based and innovation-oriented society.

Creation and dissemination of knowledge necessary for better policy-making

As information and knowledge are the most important resource in a knowledge-based society, efficiency of many sectors and development of the whole Estonia depends on the availability of relevant, reliable, accurate and timely information. The appropriate decisions in policy-making have to be based on high quality scientific analyses of such information.

Making strategic choices and improving the focus of support measures requires substantially more detailed information concerning Estonian society and the global trends than is available at the moment in Estonia. Therefore, it is essential to initiate research foresight, technology foresight and profound sector/cluster-based research. Foresight enables to identify common

areas of Estonian and global technological developments, i.e. the areas and sectors with higher prospects should be given priority status and foreign investments that create high added value should be systematically involved there.

Long-term rapid development requires that Estonian politicians, opinion leaders, decision makers and the wider public will share the common understanding that innovation acts as the promoter of Estonia's sustainable development and the public sector has a very significant role in guiding the economic development. At the moment, such common understanding and consensus are lacking and the awareness of politicians, opinion leaders and decision makers regarding the essence and the role of innovation in economic development and the state's possibilities to foster the growth of innovative capacity, is relatively low[14]. Therefore, besides the creation of knowledge necessary for making strategic choices, active dissemination of this knowledge is also important.

Increasing the role of the public sector in valuing the knowledge-based approach

In developing an innovative economy the state mudt be seen as a role model and a competent innovation consumer, whose procurements significantly emphasise innovativeness, quality and good design. Estonia has been successful in developing e-State and many information technology infrastructure projects and e-solutions, for instance the Tiger Leap (*Tiigrihüpe*), ID card, e-TaxBoard, X-road, eVoting, etc, which have made the provision of public services and the communication between the state and the citizens as well as enterprises remarkably easier and more efficient. Nevertheless, some single projects are not sufficient to build knowledge-based Estonia in a situation where one of the main selection criterion in public procurements is to spend less money, which may cause setbacks in quality and innovativeness. Therefore, in order to strengthen the state's role as a catalyst, the decision criteria applied in public procurements have to be more diversified and the participation of such enterprises in public procurements, which offer innovative products and services, should be supported.

The state can influence economic development and an environment promoting innovative business through taxes. The current fiscal policy of Estonia has been very successful in supporting business investments. However, its justification needs thorough analysis from the position of fostering the economy to reach the innovation-based development phase[15], as this fiscal policy does not particularly promote knowledge-intensive business, the recruitment of research and development personnel and investments creating the above average added value.

The state has to balance the risks, changes and subjective sense of danger brought along by the implementation of new technologies (for instance, the pressure on the Estonian language for using information technology or the hazards that genetically modified organisms pose to the natural environment). Therefore, the discussion between the society and science is more relevant than ever before.

[14] Center for Policy Studies PRAXIS and Hill & Knowlton Estonia "Innovation and Estonian opinion leaders", pilot study for identifying the needs of the target groups of innovation awareness programme, 2005. http://www.eas.ee/vfs/3086/Innovatsioon_ja_arvamusliidrid_2005.pdf

[15] Michael E. Porter "Competitive Advantage of Nations" London, Macmillaman 1990.

4. VISION

Estonia has become a knowledge-based society where the creation of new knowledge and the capacity to accept and implement it are the sources of increasing quality of life. Research and development, and innovation, supported by a flexible and future oriented education system, are the promoters of society's development. Being a small country, Estonia has to make choices and therefore, the emphasis in both research as well as entrepreneurship is on high quality and/or high added value areas. The connections between research and society ensure the broad dissemination of knowledge encompassing also knowledge and innovative applications created elsewhere in the world, which is particularly important for increasing competitiveness. Through its openness**,** achievements and actions, Estonia is known as an attractive environment for knowledge and innovativeness, being a highly valued partner in international cooperation. Estonia has maintained its identity, preserving and supporting national and intellectual values.

The main emphasis of the vision is on competent people. The vision will be carried out by:

- educated people, who develop their talents, and are open to new ideas and development trends in society;
- talented researchers, who are active in frontier research and are open to cooperation in order to create new social and economic values;
- innovative entrepreneurs, engineers and other specialists, who are open to cooperation in order to develop new products, services and technologies, while creating new jobs and sustaining the environment.

In realising the vision, Estonia as a member of the European Union is known as a quickly developing innovative and competitive country.

5. OBJECTIVES

The strategy sets three main objectives:

- the competitive quality and increased intensity of research and development;
- innovative entrepreneurship creating new value in the global economy;
- an innovation friendly society aimed at long-term development.

Objective 1. The competitive quality and increased intensity of research and development

The research and development system with its top-level specialists, ideas, infrastructure and social networks are a part of a wider environment of all areas of activity in society. Developing the system of research and development creates opportunities for promoting culture, education, economy and state governance and therefore improves the chances of Estonia to stay in a good competitive position. This requires an increase in the intensity of research and development as well as ensuring its quality, while the research and development conducted in Estonia must be evaluated in comparison with the world level in the corresponding field.

The intensity of RD&I can only grow significantly in conjunction with the growing number and quality of employees, thus, it is indispensable to invest in people. The development of human resources means mainly supporting the activities of higher education institutions, as the researchers and engineers who will go to work to research institutions and private enterprises are trained in higher education institutions. Many (new) researchers and engineers should go to work in the private sector. Together with increasing the intensity of research and development, its quality and efficient management has to be ensured and cooperation encouraged.

Modern research and development needs state-of-the-art conditions, including labs, buildings and suitable infrastructure. The enterprises, on their side, need equipment and experimenting and testing lines. It is reasonable to construct such lines for the joint use of enterprises and in cooperation between the private and public sectors in public facilities (for instance, in science and technology parks). We have to upgrade and construct new RD&I infrastructure. Modern infrastructure is essential for competitive research, being an environment which motivates people to work in the RD&I system and offers possibilities to entice students, researchers and engineers from other countries.

Public investments in education and research base, but even more so in innovation support structures and the lowering of long-term risks related to RD&I, are of key importance in motivating enterprises to invest in RD&I. Therefore, in the short-term, it is necessary to increase public investments rapidly compared to private sector investments, achieving a bigger flow of private capital to development over a period of time, and as a result the state's main function becomes the financing of research.

Indicators for 2013:

1) *an increase in the proportion of employees engaged in research and development[16] to 8 researchers and engineers per 1000 employees (5.0 in 2004; EU25 average 5.5);*

[16] Based on the methodology of Statistical Office of the European Communities. http://epp.eurostat.ec.europa.eu

2) *the proportion of upgraded and new RD&I infrastructures 80% (less than 20% in 2004);*
3) *total investments in research and development[17] 3% of GDP by 2014[18] (0.88% of GDP in 2004; EU25 corresponding indicator 1.90% of GDP), of which the public sector share is 1.4% of GDP (0.54% of GDP in 2004; EU25 corresponding indicator 0.68%);*
4) *the number of high quality publications, according to internationally recognised bibliometric database, 1200 (796 in 2004, according to the ISI Web of Science);*
5) *the number of European Patent Office patents per million inhabitants will grow 5 times (8.9 in 2002; EU25 corresponding indicator 133.6);*
6) *an efficient eLibrary (a common system of integrated electronic collections and services) and a digital research information system.*

Objective 2. Innovative entrepreneurship creating new value in the global economy

An improvement in the quality of life requires the growth of economic added value. Innovative enterprises which successfully implement knowledge, technologies and professional design in their products and services create the highest added value.

The state supports the endeavours of enterprises in new as well as in traditional economic sectors in becoming more innovative, encourages the creation and growth of new innovative enterprises and offers support for changing old business models that are losing their competitiveness and for developing unique competitive advantages. Support is provided for internationalisation of enterprises which is important for operating in foreign markets as well as for implementing knowledge and technologies developed in other countries.

Estonia values incoming foreign investments which are not trying to use the disappearing cost advantage, but rather focus on developing innovative products and services, and offers qualified employees and attractive infrastructure for development activities.

Indicators for 2013 :

1) *growth of enterprises' R&D investments to 1.6% of GDP by 2014[17] (0.34% in 2004; EU25 average 1.22% of GDP in 2003);*
2) *growth of enterprises' innovation investments (intramural and extramural research and development, purchase of machinery and equipment, attaining knowledge) to 2.5% of turnover (1.6% in 2004; EU25 average 2.15% of turnover in 2000);*
3) *growth of sales revenues of new products and services to 15% of the enterprise gross turnover (7.6% in 2004; EU15 average 16.8% in 2000);*
4) *growth of employment in high-technology and medium-high-technology industry and service sectors to 11% of total employment (7.53% in 2004; EU25 average 9.8%);*
5) *growth in enterprise productivity per employee to 80% of the EU25 average (57% in 2005).*

[17] Total expenditure on research and development according to the OECD statistics (Gross Domestic Expenditure on R&D – GERD) defined in the so-called Frascati Manual.
[18] Estonian Action Plan for Growth and Jobs 2005–2007 for Implementation of the Lisbon Strategy, Tallinn, 2005. http://www.riigikantselei.ee/failid/2005_10_13_MTTK_L_pp.pdf.

Objective 3. Innovation friendly society aimed at long-term development

The state's task is to create legal and business environment which promotes research and development, and take long-term business risks related to innovative entrepreneurship. Increasing political and social awareness of the challenges facing the Estonian economy and society and of the role of RD&I in overcoming these challenges, are important requirements for achieving such an environment. This, on the other hand, requires the creation and active dissemination of knowledge necessary for making strategic decisions and setting priorities.

The role of the state as a smart consumer and a demanding user of research and development, who values innovation and quality in public procurements and is an initiator of ambitious development projects (e-State, eHealth, etc) needs to be strengthened.

In order to win export markets for innovative products and services of Estonian enterprises, Estonia needs to break out of the stereotypes associated with transition countries and become globally recognised as an innovative country. Establishing the reputation of Estonia as being an innovative country will in turn reinforce innovation, as it attracts development intensive foreign investments, confirms that Estonian enterprises and research and development institutions are serious actors at the international level and also increases the belief of Estonian people in their capacities.

Indicators for 2013:

1) *a growing number and increasing importance of foreign investors who consider Estonia to be a good location for innovative activities;*
2) *an increasing inflow of knowledge and technology intensive foreign investments;*
3) *a growing number of internationally known Estonian brands and trademarks;*
4) *a growing number of foreign researchers and students coming to Estonia;*
5) *a growing number of enterprises participating in international RD&I cooperation programmes and networks;*
6) *a continuously high position in e-State ranking lists;*
7) *a significantly higher position of Estonia in the European Union "Innovation Scoreboard" (13th position in 2006, 5th-10th position in 2013).*

6. FOCAL POINTS

In order to achieve success at international level, human as well as material resources must be concentrated; specialisation and division of tasks must be increased. Resources have to be directed preferably to these areas of RD&I, which have the potential for outstanding performance in frontier research on a global scale, which outcome and top specialists are essential for economic growth and which support socio-economic objectives as well as preserving the nation and Estonian culture.

This strategy directs the growing support from the state on the basis of the following principles:

1) preference given to R&D with **internationally competitive high quality**;
2) creation of preconditions for the RD&I system to grow and be oriented towards efficiency, first at all **creating a sustainable community of researchers and entrepreneurs** and **creating an attractive environment** for research and development, and technological innovation;
3) preference is given to innovation projects **creating high economic added value**.

Specific fields will be prioritised by initiating and implementing national research and development programmes:

1) to implement state-of-the-art technologies that provide high added value and the growth of productivity in many fields of life (information and communication technologies, biotechnologies, material technologies);
2) to solve socio-economic problems and achieve socio-economic objectives in the areas that are important for every resident of Estonia, for instance in energy, national defence and security, health care and welfare services, environmental protection;
3) to promote research related to ensuring the sustainability of Estonian national culture, language, history and nature and the Estonian state.

7. MEASURES FOR IMPLEMENTATION OF OBJECTIVES

The objectives set in the strategy will be achieved through the national research and development programmes and four measures, which are:

- development of human capital;
- organising the public sector RD&I more efficiently;
- increasing the innovation capacity of enterprises;
- policy-making aimed at the long-term development of Estonia.

The achievement of every one of these objectives will solve problems Estonia is facing, while at the same also contributing to solving other challenges. These measures concentrate on similar activities, which are indispensable for achieving all the objectives and therefore, every measure contributes to achieving all these objectives.

National research and development programmes

The national research and development programmes will be implemented in the fields of key technologies of the research and development and innovation strategy and in the fields that are important for the socio-economic and cultural development of the country. The programmes will be initiated in the fields of research which already have high quality and are important to the Estonian economy to the extent that the private sector would also actively participate (incl its financial input).

National programmes in key technologies

1) will increase the capacity of Estonian research and development in the corresponding fields of technology;
2) will ensure the distribution and implementation of key technologies in other sectors of economy (particularly in traditional industry, energy sector, transport, etc) and socio-economic fields (health care, life environment, etc).

The aims of the socio-economic research and development programmes are

1) to conduct necessary research for the development and implementation of public policy in the corresponding socio-economic field;
2) to attract (and bring to Estonia, if necessary) researchers and entrepreneurs of the corresponding field and guide them towards solving the tasks important for Estonia in mutual collaboration;
3) to facilitate the usage of products and services with high added value (new products, technologies and services which are important for Estonia or have export potential, higher technological level of enterprises);
4) to implement technologies created in the course of the programme or transferred to Estonia in order to raise the quality of life of Estonian people.

Measure 1. Development of human capital

For transferring to a knowledge-based society, both the public as well as the private sector need more researchers and engineers than they have at the moment.

In order to ensure the number of researchers and engineers comparable with the average of the European Union (8 researchers and engineers per 1000 employees), favourable conditions will be created for research and development at universities and other research institutions; PhD studies will be expanded and researchers and engineers working abroad will be invited back to Estonia. Special attention will be paid to talented young people, trying to discover them and bring them to research already at their school-age. The career models and development opportunities of RD&I personnel will be addressed systematically, the transfer of people and knowledge between educational and research institutions and enterprises will be encouraged and the stimuli will be created for students and researchers to start their own enterprises.

1.1. A set of measures will be developed and implemented at basic schools and upper secondary schools, with the aim to create deeper interest of young people in sciences and technology (incl public financing of the centres of technology and nature, as well as research societies of school students, Tartu University Science School, Tallinn University Academy of Young Students, etc.; the state will support national as well as international science competitions of specific subjects and implement additional scholarships for basic school and upper secondary school students in the fields of natural sciences and engineering).

1.2. Research, research education and innovation will be promoted in the society, as well as scientific conception of the world and basic ethical values will be promoted (incl the support for science associations, Estonian Science Centre AHHAA, Tallinn Technology and Science Centre, and other centres which introduce research and development to the wider public; portals of science news and dissemination (e.g. The Estonian Research Classification Scheme (ERCS)), mass media shows and articles which popularise science, and several contests and games for young people will be created and developed; as well as the use of the Estonian language as research language will be supported).

1.3. Engagement of students in research projects will be promoted (e.g. engagement of students is considered as one criterion of a successful science project). Connecting the research work of students with the needs of enterprises will be supported (e.g. collecting data for one's Bachelor or Master thesis in a business enterprise). A scheme will be prepared to support enterprises to organise practical training of graduate students (e.g. compensating the lower productivity of the supervisor while he/she has been supervising the student). In order to provide the students with necessary knowledge and skills for creating an enterprise, the state will support organising business courses, which have practical orientation in many fields of study.

1.4. According to the higher education strategy, **Doctoral studies** will be expanded to 300 PhD graduates a year by 2013 (to achieve this goal, the state will gradually increase the number of state-commissioned PhD students, create possibilities for foreign students to come to Estonia, and support the studies of Estonian PhD students abroad). In addition, the state will ensure the support measures for Doctoral studies (incl Doctoral grants and social benefits for PhD students) and quality evaluation; Doctoral schools will be developed, Doctoral studies and Doctoral schools will be integrated with research and development carried out in the centres of excellence and the centres of competence.

1.5. The **career model** of specialists, university teachers, researchers and engineers will be developed to offer sufficient development opportunities and to motivate young people to choose the careers of researchers and engineers (incl national science awards). The valuation of academic degrees in public services will be ensured. Women and men will be ensured equal opportunities in their research careers.

1.6. The status of postdoc will be defined as a temporary position, usually created in an Estonian research group and intended for a young researcher coming to Estonia. The number of postdocs will be increased and attractive conditions will be created to fill these positions.
1.7. Universities and other research institutions will be supported in bringing foreign researchers as well as Estonian researchers working abroad to Estonia (incl the development and implementation of repatriation scheme; collecting data about Estonian researchers working abroad and creating communication channels to keep in contact with them).
1.8. Suitable conditions will be created for establishing permanent positions (*tenure*) for excellent researchers and top-level university teachers.
1.9. International mobility (incl the creation of a mobility programme in accordance with corresponding mobility schemes of the 7th Framework Programme) and free movement of researchers between the academic sphere, public sector and private sector will be promoted so that it would not interrupt their academic career.

Measure 2. Organising the public sector RD&I more efficiently

An organisation and financing system of RD&I will be established which includes a balanced set of instruments both for financing research with the aim to create new knowledge as well as to conduct applied research, and which takes into account the needs of enterprises as well as ensure the sustainability and development of Estonian cultural and educational area in the Estonian language. The overall principle of the financing system is to be oriented towards quality, efficiency and cooperation. In order to ensure the necessary research and development and innovation in becoming a knowledge-based society, the public sector RD&I infrastructure will be systematically developed, and the research and development institutions will be guaranteed the financing for maintenance and amortisation.

Evaluation and financing

2.1. As a good practice, the international peer-review of large-scale state financed research and development projects, incl the targeted financing research themes, will be introduced in all research fields in Estonia, whereas the evaluations will be carried out in world level comparison of the corresponding field. Field-specific quality criteria will also be taken into account in the evaluations.
2.2. The research evaluation system will be changed so that in the future the financing decisions could be taken based on the evaluation grades. In evaluating the curricula of Doctoral studies and the corresponding fields of research, their interconnections will be taken into account.
2.3. The financing of research groups will be made more dependent on excellence, ensuring the concentration of funding to research groups with high international quality.
2.4. World level research will be promoted through the **centres of excellence** programme (incl a study on the current programme, development of criteria for the new period of the centres of excellence programme and starting the new period based on these).
2.5. The financing instruments of RD&I (**i.e. grant, base-line and targeted financing; infrastructure costs of research and development institutions; maintenance costs of the Estonian Science Foundation**) will be arranged to ensure their interaction and to avoid duplication. Additional costs, which may occur in relation with financing through the Structural Funds, will be covered (e.g. the value added tax of infrastructure investments).

2.6. In evaluating research and development projects, **application possibilities** will be considered as one criterion and the interdisciplinary nature of the project is considered to be an advantage. Contribution to the popularisation of RD&I, connections with Doctoral studies, and sustainability of the project will be taken into account.
2.7. The quality assessment system of public research will be improved and independent scientific expertise will be ensured for assessing the quality.
2.8. The participation of research and development institutions and enterprises in international cooperation networks as well as the participation of Estonian researchers, research institutions and enterprises in the European Community Framework Programmes for research and innovation, will be supported (incl the co-financing of the 6th and 7th Framework Programmes (FP6 and FP7), membership fees of international organisations, etc.).
2.9. The role of base-line funding will be defined in more detail and the proportion of base-line funding in the overall public financing of research and development will be gradually increased.
2.10. Research institutions will be encouraged to carry out international projects and agreements by offering them public co-financing instruments and support in covering the costs related to participation (e.g. preparing the application will be supported).
2.11. Estonia will participate in international joint programmes and infrastructure projects coordinated by science organisations, as well as in international benchmarking. Cooperation opportunities offered by international research organisations (European Organization for Nuclear Research (CERN), European Molecular Biology Organization (EMBO), European Space Agency (ESA), etc) will be used.
2.12. A research classification scheme will be implemented, which takes the recommendations of the European Union into account.
2.13. An adequate provision of research libraries including all major databases of all research fields will be ensured (incl the support for joint and individual purchases of journals and databases for research and archive libraries).

Physical environment

2.14. The **research and development infrastructure** will be upgraded in accordance with the „Research and development infrastructure development programme" and „The strategic basis for upgrading the infrastructure supporting academic higher education, research and innovation"[19] (incl R&D investments, infrastructure programme of the Enterprise Estonia).
2.15. Cooperation and specialisation between universities and other research institutions will be strengthened. Joint use of large-scale infrastructure will be ensured.
2.16. A network of Estonian core laboratories (joint use of infrastructure) will be created, particularly considering the needs of the Baltic Sea region; certified laboratories will be established and their capability to provide services to industrial enterprises will be enhanced.
2.17. Estonian researchers will have the possibilities to efficiently use research facilities open for all European researchers. Estonia will integrate into the work of international research organisations and infrastructure facilities. The existence and efficient development of international RD&I **dispersed infrastructure** in Estonia (data communication, computation resources, data collection networks, etc) will be guaranteed.

[19] Research and development infrastructure development programme, MER and MEAC, 2004, https://www.etis.ee/Portaal/includes/dokumendid/infrastruktuuri%20programm.mkm.doc; The strategic basis for upgrading infrastructure supporting academic higher education, research and innovation, MER and MEAC, 2004, https://www.etis.ee/Portaal/includes/dokumendid/strateegilised%20alused.mkm.doc.

2.18. The collections of research and development institutions, incl research libraries, which have scientific and cultural value will be improved and the necessary conditions for preserving these collections will be ensured.
2.19. The awareness of Tallinn and Tartu city governments will be raised and the cooperation will be promoted in supporting the RD&I infrastructure in these cities and implementing knowledge.
2.20. The infrastructure necessary for experimental development in semi-industrial scope will be developed in cooperation with the public and private sectors, preferably in science and technology parks.

Measure 3. Increasing the innovation capacity of enterprises

The main principles here are individualized approach to the needs of different kinds of enterprises, promoting cooperation and joint projects of enterprises, and internationalization. Consideration will be given to the more important bottlenecks in all development phases of enterprises. Special attention will be 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.

New measures will be prepared for supporting traditional industries, which are oriented towards implementation of new technologies and increasing the productivity of enterprises, the development of human capital and recruitment of leading development personnel and implementing professional design as a competitive advantage. The development of cooperation networks and clusters based on the initiative of enterprises will be promoted.

Technological innovation, growth of productivity and development capacity of enterprises

3.1. Continuous and extended support will be provided to the **development projects** of new competitive **technologies, products, services and processes**. Moreover, export-orientation and environmental sustainability are considered as advantages. Based on the needs of many enterprises of traditional sectors of economy, support will be offered for projects that include testing and certifying, design and productivity management, which in most cases are smaller than technology development and do not contain that high technology risks.
3.2. Support will be provided to **increase knowledge and competence in enterprises**, indispensable for strategic innovation management and development, incl the support for recruitment of development personnel from Estonia and abroad (researchers-engineers, designers, marketing managers, managers of development projects), training, counselling and diagnostics. The awareness and knowledge of enterprises about intellectual property will be increased.
3.3. Implementation of Estonian or imported technology in business will be supported, incl the search for and intermediation of suitable solutions, preliminary studies and implementation (incl studies on technology transfer, loan and guarantee schemes and participation in technology transfer networks).
3.4. Support will be provided for joint activities of enterprises and the development of economic clusters (incl cluster specific training and counselling, access to technological data and initiation of joint projects on technology development or technology implementation, joint marketing of the cluster, sharing the procurements and creation of export consortia). In developing the cluster, it is important to use key technologies and therefore achieve the growth of productivity.

Inflow of new innovative business ideas and their transformation into enterprises

3.5. **Science and technology parks** and incubators will be developed, and the main focus will be on expanding the range of services and support instruments offered to enterprises, raising the qualification of employees and developing the infrastructure. Cooperation with international companies and their involvement in science and technology parks will be encouraged.

3.6. Open calls for business ideas will be organised, where monetary awards will be supplemented by active mentoring and search for investors and/or partners thus ensuring the realisation of an awarded business idea into a sustainable enterprise.

3.7. Early-stage **equity investments** will be made in order to alleviate the capital deficit of research and technology intensive enterprises in their start-up and development phase (incl the establishment of the Estonian Development Fund).

Transfer of knowledge and technology

3.8. 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 (SPINNO programme). Flexible possibilities will be created for financing the prototype phase.

3.9. New centres of competence will be established and the activities of the existing centres of competence in initiating and implementing long-term and market oriented collaboration projects in cooperation with enterprises and research and development institutions will be supported.

Measure 4. Policy-making aimed at the long-term development of Estonia

This measure is an important basis for achieving all the objectives of the strategy, as it shapes the attitude in the society and among decision-makers, valuing research and development and innovation and the understanding that RD&I applies to all fields of life and should be viewed in a wider perspective than just in the framework of a sector specific development plan. Important incentives in achieving this goal are initiating foresight and technology foresight and systematic research as the basis of policy development, valuing innovation in public procurements and analysing possibilities for making Estonian fiscal system more favourable of research and development and innovation.

4.1. Measures for increasing the intellectual property protection activity will be generated and implemented, incl increasing the awareness and knowledge of the society about intellectual property as well as the protection of intellectual property will be valued while defining the terms of reference of national R&D support programmes.

4.2. The impact of **tax incentives** and the practices of other countries in developing research and innovation will be analysed.

4.3. Demand for new technologies will be stimulated (e.g. transport, energy, environment, health care, education, communications). Functional requirements will be defined in public procurements so that business enterprises will have a numerous variety of choices for offering innovative solutions. Best practices valuing research, innovation and professional design will be disseminated among the organisers of public procurements.

4.4. Public **foresight and technology foresight** and sector/cluster-based research will be initiated to define Estonia's long-term development visions, perspective (niche) areas and sectors; and to promote the development of strategic thinking in the private as well as the public sector. Research and development and higher education institutions will be given information regularly concerning the development and future trends of economic and industrial sectors.

4.5. Attitudes supporting innovation will be shaped at the state level. Innovation awareness of the Estonian people will be raised and innovative entrepreneurship valued.

4.6. Best practices will be disseminated, according to which public research will always be accompanied by dissemination of results and initiating public discussion. A system of measures will be prepared to motivate researchers to present the results of their work to the public in an understandable and interesting manner, and to support broad dissemination of the results of scientific research in the society.

4.7. **Administrative capacity** will be raised and a system for assessing the efficiency of measures will be developed and implemented (programme of innovation and education policy studies).

4.8. RD&I cooperation will be coordinated by the **research divisions in the ministries** together with the Bureau of the R&D Council.

4.9. Research and development and innovation targeted at the goals of the administrative areas of the ministries.

8. MANAGEMENT AND FINANCING

For managing the implementation of the strategy, the RD&I strategy coordination committee will be established with the tasks:

- to supplement and revise the implementation plan of the strategy, incl the coordination of the activities with the operational programmes for using the European Union Structural Funds;
- to coordinate cooperation between the ministries in complying with the implementation plan, incl the activities deriving from the National Strategic Reference Framework (NSRF), and in applying for RD&I budgets;
- to prepare overviews and reports on enforcing the implementation plan;
- to initiate and prepare amendments to the strategy.

The committee will consist of representatives of the Ministry of Education and Research, Ministry of Economic Affairs and Communications, Ministry of Finance, Ministry of the Environment, Ministry of Defence, Ministry of Social Affairs, Ministry of Agriculture, and the State Chancellery. When necessary, the committee will engage in its work other experts and consults with social partners and the sub-committees of the Research and Development Council. The Ministry of Education and Research is responsible for organising the committees' work.

Implementation of the research and development and innovation strategy

The responsibility for implementing the strategy lies with the Ministry of Education and Research, the Ministry of Economic Affairs and Communications is the co-responsible authority. The responsibilities of other ministries, which besides preparing, approving and implementing the national programmes include also ensuring the infrastructure costs of R&D institutions in their area of administration, will be defined in the implementation plan and by prior agreement with these ministries.

The strategy will be implemented according to the implementation plan, which defines specific activities for implementing the strategy by years and responsible authorities as well as the costs for these activities by four (1+3) years. The implementation plan also provides for the initiation of R&D programmes.

The Minister of education and research will present the implementation plan to the Government of the Republic within three months after the strategy has been approved. If necessary, the Government of the Republic may decide to amend the implementation plan every year, based on the proposal of MER. When circumstances emerge, which may inhibit the implementation of the strategy, the financing plan and the implementation plan will be revised. The amended implementation plan will be presented to the government for approval before 2010, the latest, specifying the activities and their costs for the last three years of the strategy. Before presenting the implementation plan to the Government of the Republic, the Minister of education and research will present it to the RDC for approval.

The implementation plan has to be revised when the circumstances emerge that may inhibit its implementation, incl non-compliance of the actual budget and the implementation plan, constraints imposed by the NSRF operational programmes, circumstances originating from the division of tasks between the ministries, and other significant matters. The RD&I strategy coordination committee will prepare the proposals for amending the implementation plan.

When circumstances emerge due to which the objectives of the strategy will not be achieved, a revision of the strategy must be initiated. The RD&I strategy coordination committee will prepare the proposals for amending the strategy and these proposals will be discussed also by the RDC.

The main authorities implementing the RD&I strategy are universities and other research institutions as well as the Estonian Science Foundation, Archimedes Foundation, Foundation Innove, Enterprise Estonia (EE), etc. The State Chancellery, several other ministries (e.g. the Ministry of Social Affairs, Ministry of Defence, Ministry of Agriculture, Ministry of the Environment, Ministry of Finance), public enterprises, R&D institutions, business enterprises and other partners will be also involved in implementing the strategy.

The Estonian Development Fund whose task is also to organise foresight and technology foresight, will have an important role in successful implementation of the RD&I strategy. Foresight activities of the Development Fund have to provide a detailed overview of fields, sectors and sub-sectors, in which the implementation of key technologies offers considerable possibilities for raising the quality of life of Estonian people and/or increasing competitiveness of the economy; and provide the ministries with information concerning the challenges related to technological development in different fields of life.

The Estonian Academy of Sciences will compile Estonian RD&I foresight analyses based on long-term development trends. The development plans of public law universities and other research institutions will be based on the RD&I strategy.

The MER will present an overview of the achievement of the objectives and indicators; efficiency of the measures, and implementation of the development plan to the Government of the Republic every year by March 1. If necessary, the MER will also make proposals to revise and/or amend the development plan. Comparisons of indicators will be made with international statistics. When such comparison is not possible, a special methodology will be elaborated for such indicators to measure them and set the target level.

Organisation of national research and development programmes

National programmes covering different areas of administration will be initiated in the coordination of MER or MEAC, according to the implementation plan. The initiation and implementation of programmes covering just one area is the responsibility of the respective ministry. For successful initiation and implementation of national research and development programmes, administrative capacity, cooperation and initiative of the ministries need to be strengthened.

The preparation process of each national research and development programme requires the analysis of the topic, posing the problem (incl the social aspect), setting the objectives, assessing necessary resources, determining responsibilities, activities for the period immediately after the programme, mechanisms for ensuring the quality and synchronisation with other instruments. While planning research and development programmes it is recommended to use foresight which in addition to its direct output also helps to strengthen informal cooperation networks, define long-term development visions and support the development of strategic thinking both in private as well as public sectors. The national programmes will be implemented on the basis of the implementation plan of the strategy 2007–2013 “Knowledge-based Estonia” as follows:

1) The ministry administrating the respective area will identify the initial interest for preparation of a research and development programme in cooperation with representatives of the private sector or other partners in this area. Also universities and other R&D institutions and business enterprises may formulate suggestions to the ministry for preparing a programme.
2) In order to initiate a national programme, the ministry administrating the respective area will present a proposal to the Government of the Republic through MER (research policy committee) or MEAC (innovation policy committee), which has been approved by the R&D Council, to amend the implementation plan of the RD&I strategy with a specific programme. The proposal has to state the justification of the necessity of the programme, objectives, partners, measures, approximate need for financing and the sources of financing.
3) If the Government supports the proposal to amend the implementation plan (i.e. to prepare the programme), a ministry will be appointed who is responsible for preparing the programme. In the case of a programme covering the administrative areas of several ministries, the responsible and co-responsible ministry will be appointed based on the specific programme.
4) The responsible ministry will form a committee to prepare the programme, which will be initiated in the framework of the implementation plan of the RD&I strategy and coordinate the cooperation with partners (other ministries and state institutions, research institutions, enterprises, etc.).
5) All ministries that participate in a programme, which is initiated based on the implementation plan of the RD&I strategy, will apply for financing necessary for implementing the programme from the state budget.
6) The programme will be adopted by the Government of the Republic consistent with the proposal of the R&D Council through adopting the implementation plan of the "Knowledge-based Estonia" (2007-2013).
7) The responsible minister will form the programme steering committee and appoint the managing organisation (through public competition, if necessary) to manage and implement the programme.
8) The responsible ministry will enter into agreements with the participants and co-financing organisations of the programme, in which the rights and obligations of all partners will be defined.
9) The responsible ministry will organise the monitoring and evaluation of results of the programme engaging also MER and MEAC in the process.

The tasks of the Ministry of Education and Research in the programmes initiated by other ministries:

- to participate in formulating and improving the objectives and actions of the programme with the aim to ensure the training of qualified people necessary for developing the respective area of research and development and to increase the research and development capacity;
- to pay special attention to training university teachers in the specific area, bringing foreign researchers and students to Estonia, etc.

The tasks of the Ministry of Economic Affairs and Communications in the programmes initiated by other ministries:

- to participate in formulating and amending the objectives and actions of the programme with the aim to ensure the efficiency of the programme on economic development;
- to support R&D and innovation projects that have economic output related to the specific area, organise thematic calls for proposals in the support programmes for RD&I projects implemented by the Enterprise Estonia;

- to direct, when feasible (and in agreement with the ministry administrating this area), other innovation support measures to focus more on the specific area that is being developed.

A report on implementing national research and development programmes will be presented to the Government of the Republic together with the implementation report of the RD&I strategy.

Assessing the implementation of the research and development and innovation strategy

The assessment of the achievement of strategic objectives will be based mainly on official and internationally comparable statistics, which forms the basis for assessing the achievement of objectives and the target levels of indicators. Methodology will be elaborated for measuring current implementation of the strategy's objective "An innovation friendly society focusing on long-term development" and setting the objectives and target levels.

For monitoring the results of the programmes implemented on the basis on the strategy, sets of indicators will be developed in cooperation with responsible ministries and implementing authorities. Data for these indicators will be collected and analysed yearly.

In addition to monitoring indicators, preliminary studies will be carried out during the implementation of the strategy, which will prove the feasibility and the best implementation of planned actions. Also regular assessments will be carried out that will analyse the implementation success and the mutual effect of different actions and measures.

Secretariat of the R&D Council will organise the preparation of RD&I overview in every two-year cycle, monitoring the implementation of the RD&I strategy (implementation plan).

Financing and main indicators

Table 1. Targets for main indicators in implementing the strategy by year, based on international statistics.

Indicator	2003	2004	2008	2010	2013	2014
Intensity of R&D, % of GDP	0.79*	0.88*	**1.5**[20]	**1.9**[21,22]		**3.0**[18]
incl private sector R&D, % of GDP	0.27*	0.34*	0.7	0.9		1.6
Public expenditure on R&D, % of GDP	0.38*	0.39*	0.8	1.0	1.3	1.4
Researchers and engineers per 1000 employees		5			8	
Proportion of upgraded new RD&I infrastructures (%)		20			80	
Number of high quality publications **		749			1200	
Number of European Patent Office patents per one	8.9***				45	

[20] Estonian Action Plan for Growth and Jobs 2005–2007 for Implementation of the Lisbon Strategy, Tallinn, 2005. http://www.riigikantselei.ee/failid/2005_10_13_MTTK_L_pp.pdf.
[21] Ibid.
[22] Key Issues Paper (KIP) – Input from the Competitiveness Council to the Spring European Council 2006, 6881/2/06/REV2, Brussels, 7 March 2006.

million residents						
Innovation investments of enterprises (% of turnover)		1.6			2.5	
Sales revenue of new products and services (% of turnover)		7.6			15	
Employment in high-technology and medium high-technology industry and service sector (% of total employment)		7.53			11	
Enterprise productivity growth per employee, % of the EU25 average		50.6	68	72	80	

* according to the data of Statistics Estonia

** according to the data of *ISI Web of Knowledge*

*** data from 2002

Table 2. The estimated cost of the strategy for the period 2007–2013 and the cost by the measures in the first 4 years (in mln kroons). The cost estimate will be revised regularly according to official economic forecasts of the Ministry of Finance of Estonia.

	2007	2008	2009	2010	2011	2012	2013
National R&D programmes	**14**	**82**	**208**	**393**			
Incl. MER	14	52	133	243			
MEAC	0	30	75	150			
Measure 1, Development of human capital	**89**	**163**	**187**	**224**			
Incl. MER	89	151	175	212			
MEAC	0	12	12	12			
Measure 2, Organising the public sector RD&I more efficiently	**865**	**1106**	**2091**	**2263**			
Incl. MER	794	1093	2036	2208	4091	4864	5743
MEAC	71	13	55	55			
Measure 3, Increasing the innovation capacity of enterprises	**400**	**618**	**632**	**644**			
Incl. MER	0	0	0	0			
MEAC	400	618	632	644			
Measure 4, Policy-making aimed at the long-term development of Estonia	**156**	**161**	**163**	**167**			
Incl. MER	5	13	15	18			
MEAC	41	52	51	51			
Other ministries	110	96	97	97			
TOTAL	**1525**	**2130**	**3281**	**3690**			
Incl. R&D activities*	1298	1853	3007	3341	3704	4404	5200
Compatibility with R&D expenditures of the State Budget Strategy (SBS) (2007-2010):							
Investments in R&D as planned in the SBS, total	1298	1595	2931	3190			
Additional request from the SBS	0	258	75	151			
incl. the R&D strategy – MER	776	1132	2185	2432			
Investments in R&D as planned in the SBS – MER	776	882	2185	2432			

Additional request from the SBS - MER	0	250	0	0			
incl. the R&D strategy – MEAC	412	625	725	812			
Investments in R&D as planned in the SBS – MEAC	412	617	649	661			
Additional request from the SBS – MEAC	0	8	76	151			
incl. the R&D strategy - other ministries	110	96	97	97			
Investments in R&D as planned in the SBS - other ministries	110	96	97	97			
Additional request from the SBS - other ministries	0	0	0	0			
Incl. the finances connected with the EU structural aid	480	775	1873	2048			
Estimate of private sector R&D expenditures	1453	1758	1931	2164	3235	4404	5600
The estimate of the Ministry of Finance of GDP from August 2006 is taken as the basis (the change in GDP calculation methodology has also been taken into account)	223600	251200	278900	308900	336700	367000	400000

* an estimate based on international definition (Frascati manual).

Definitions of terms

Added value – an indicator used in assessing the efficiency of activities of an enterprise or an economic sector, which includes employment costs, depreciation or costs made for replacing fixed assets and residual revenue or profit.

Applied research – original investigation undertaken in order to acquire new knowledge; directed primarily towards solving a specific practical problem within a relatively short period of time.

Base-line funding – financing of research and development in order to attain strategic development objectives of research and development institutions, particularly to co-finance foreign and national projects and open new research directions.

Basic research – theoretical or experimental work undertaken in order to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view.

Centre of competence – a centre, which activities are mainly oriented to applied research, development and implementation of global know-how as well as on the basis of these activities increasing the competitiveness of enterprises in this sector.

Centre of excellence in research – a research centre that has international recognition in its field of research. A centre of excellence may consist of one or more research groups who have a clearly defined common research target and management structure. Activities of a centre of excellence are mainly directed towards basic research in fields that are relevant to the country's development and are preferably also related to Doctoral studies. The Ministry of Education and Research will give the status of the Centre of Excellence together with additional financing.

Cluster / economic cluster – network of cooperation, exchange of information and interaction of enterprises and institutions in one sector (e.g. education and research institutions, local government, business enterprises). They have common environment for activities and a set of employees with certain skills.

Commercialisation (**using for commercial purposes**) – marketing an innovative product, technology or process; selling intellectual property or the right to use it.

Development personnel – people involved in management and implementation of development projects, who have at least tertiary education and/or a certificate of competency in technologies or production management, innovation management, quality management, design or international marketing.

Evaluation – benchmarking research and development efficiency. In the course of research evaluation, research excellence is evaluated in international comparison, evaluation of development and innovation is mainly based on the assessment of economic results of these activities.

Experimental development — systematic work drawing on existing knowledge gained from basic or applied research and experiences which is directed towards producing new or improve existing products and services, processes, etc.

Foresight – a process of vision creation, which is systematic, involves different stakeholders, looks into the future and has a mid-term and a long-term prospect. The aim of foresight is to influence present decisions and planning joint activities.

Grant financing – resources from the state budget to finance research (incl post-doc) grants.

Greenfield-type investments – a new enterprise, which has been built up from scratch by the investor, in most cases also on the land that has not been in economic exploitation before (not an already functioning enterprise bought by the investor or a production process transferred to an already existing production facility).

High-technology and medium/high-technology industry and services – based on the OECD definition it includes chemicals (NACE[23] 24), machinery and equipment (NACE 29), office machinery and equipment (NACE 30), electrical machinery and apparatus (NACE 31), radio, television and communication equipment (NACE 32), medical, precision and optical instruments (NACE 33), cars (NACE 34), planes and other transport equipment (NACE 35), post and telecommunications (NACE 64), information technology including software development (NACE 72), research and development services (NACE 73).

Innovation – utilisation of new ideas in order to: 1) market a competitive product or service; 2) rearrange internal processes of the organisation (production, marketing, delivery, management, etc); 3) utilising a new or significantly improved technology in industry, services or public sector. Innovation has the following sub-types:

product innovation – a product or service that differs significantly from enterprise's current products by its qualities or exploitation;

process innovation – utilising a new or significantly improved production process, delivery method or production support activity with the aim of increasing product quality, efficiency and/or flexibility of production or its support activities, the level of environmental sustainability or security;

organisational innovation – introducing significant changes in enterprise's business practice, job structure or communication with other enterprises and institutions in order to increase enterprise's innovation capacity and improve economic indicators (quality, efficiency);

market innovation – introducing significant changes in marketing enterprise's products and services, incl changes in design and packaging;

technological innovation – innovation related to the development and implementation of new technological solutions;

non-technological innovation – innovation, which will not bring about technological changes (mainly organisational and market innovation).

Innovation investments and expenditures – enterprise expenditures on the following articles/activities: 1) intramural research and development (carried out by enterprise's

[23] Nomenclature generale des Activites economiques dans les Communautes europeennes (NACE) indicates to industry classification; http://stats.oecd.org/glossary/detail.asp?ID=1713

employees); 2) extramural research and development; 3) purchasing machinery, equipment and software; 4) acquiring other sorts of extramural knowledge (patents, unpatented inventions, know-how or attaining other knowledge (licensing from other enterprises or institutions)); 5) training of employees; 6) marketing innovations; 7) other kinds of preparatory activities for developing new or significantly improved products and processes.

Innovation support structures – institutions, which main aim is to support the implementation of outcomes of research and development on commercial purposes. Innovation support structures include science and technology parks, technology and innovation and incubation centres, technology transfer divisions of universities and professional higher education institutions, etc.

Internationalisation – export of products and services, receiving and making foreign investments (start-up of branches in other countries, acquiring a holding in a foreign company), participating in international programmes and cooperation networks.

Key technologies – research intensive and quickly developing groups of technologies with many application possibilities outside of their field.

Knowledge and technology intensive enterprise – an enterprise that closely collaborates with R&D institutions and develops innovative products, services or technologies which are based on state-of-the-art scientific data and/or which investments in research and development exceed 5% of enterprise's turnover and/or which places a lot of emphasis in its activities on creating and managing intellectual property and/or which employees' education level is high and a significant part of the labour force consists of employees engaged in research and development.

Knowledge and technology transfer – transfer of knowledge and technologies from a creator to a user or from one user to another, implementing knowledge and technologies created in one country and/or company in other institutions and/or countries for introducing new products, technologies and services. Knowledge transfer is mainly based on mobility of people between enterprises or between enterprises and research and development institutions. In technology transfer, in addition to mobility of people, the transfer of property rights or the right to use intellectual property from an owner to a client or a user is a very important factor.

Postdoc – a researcher who has recently been awarded a Doctoral degree, who has applied for and has been granted financing for a two-year period as a result of open competition. In applying for postdoc status, the applicant cannot be older than 35 years and not more than three years have passed since receiving his/her Doctoral degree.

Research and development (R&D) – systematic activity based on person's freedom of creation, which aim is to acquire new knowledge on humans, nature and society and their mutual effects using scientific research and applying this knowledge. Research and development includes basic research, applied research and experimental development, which may also partially overlap.

Research and development, and innovation (RD&I) – in addition to research and development, it includes activities in the enterprise related to marketing of outcome of R&D and other innovations (introduction of technologies, improvements in processes and work arrangement, etc. *(see "innovation")*).

Research and development institutions – institutions and legal persons, which principal activity is research and development and that are registered pursuant to the Research and Development Organisation Act § 5[1].

Research and development programmes – these are intended for developing the areas that are important from the perspective of the key technologies of the RD&I strategy and socio-economic and cultural development of the country as well as to conduct necessary research for developing and implementing government's policy in this area.

Researchers and engineers – persons who have a scientific degree or university diploma, who carry out basic and applied research as professionals or are engaged in experimental development. They include also managers and administrators, who are engaged in planning or organising scientific-technical aspects.

Science and technology parks – enterprise support structures, which main activity, according to their statutes, is promoting knowledge and technology transfer in cooperation with universities and research and development institutions and creation of knowledge and technology intensive enterprises as well as supporting their sustainable development through offering them a high-level infrastructure and support activities**.**

Spin-off **enterprise** – an enterprise established for commercialising intellectual property created at a university or another R&D institution.

Targeted financing – financing of research and development institutions based on research themes.

Technology – knowledge, skills and information materialised in machinery and equipment and in the non-material manner in human capital.

Technology foresight – implementing foresight based on technology trends, formulating structured expectations and projections for technological developments and needs in the future. In addition to foresight of development trends, technology foresight includes setting strategic objectives for technological development of economy, defining consensual opinions on development objectives of the society and dissemination of these opinions.

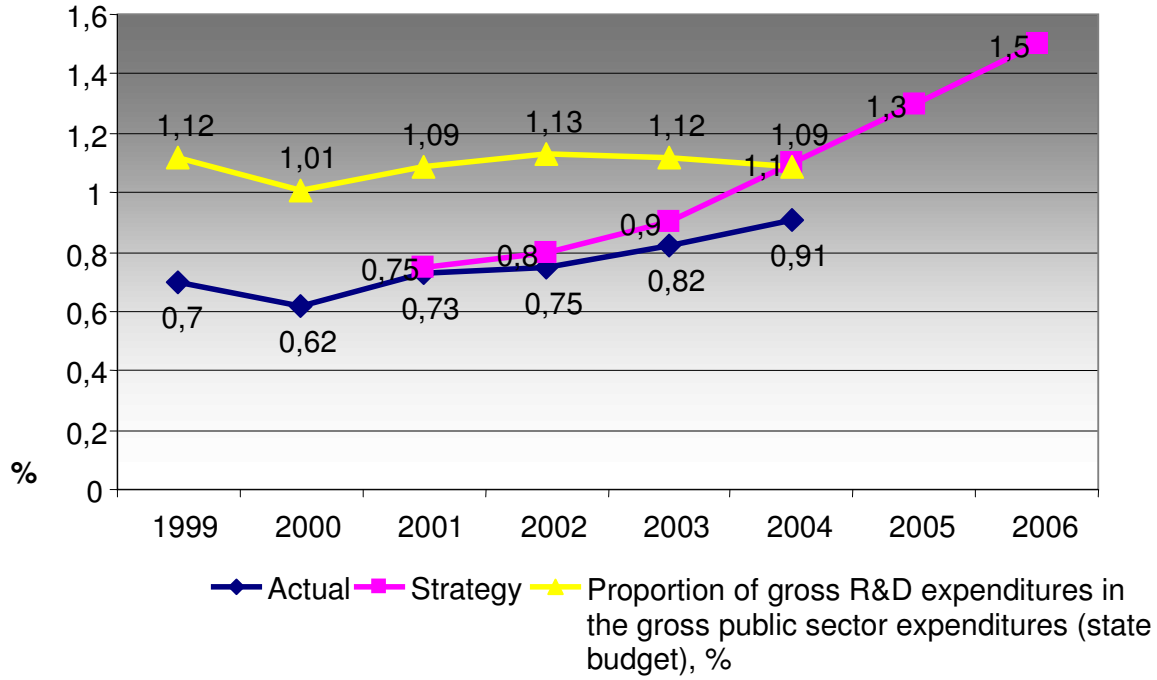
Technology transfer division – structural divisions at universities and in other R&D institutions, which main task is to commercialise the intellectual property created in the institution and developing cooperation between the institution and enterprises.

APPENDIX 1

Gross expenditures on research and development of GDP in Estonia in international comparison (2004)

The aim of Estonian Research and Development Strategy for 2002–2006 "Knowledge-based Estonia" was to increase the proportion of total research and development expenditures to 1.5% of GDP by 2006 (EU average 1.9% of GDP in 2000). The actual proportion of R&D expenditures of DGP in recent years has been lower than the objective set in the strategy. This is partly due to the rapid growth of GDP, which has exceeded the growth rate estimated when the strategy was prepared. However, the public financing of research and development in absolute numbers has also failed to reach the level forecasted in the strategy.

Figure 1. The proportion of research and development expenditures of GDP and of the public sector gross expenditures, %



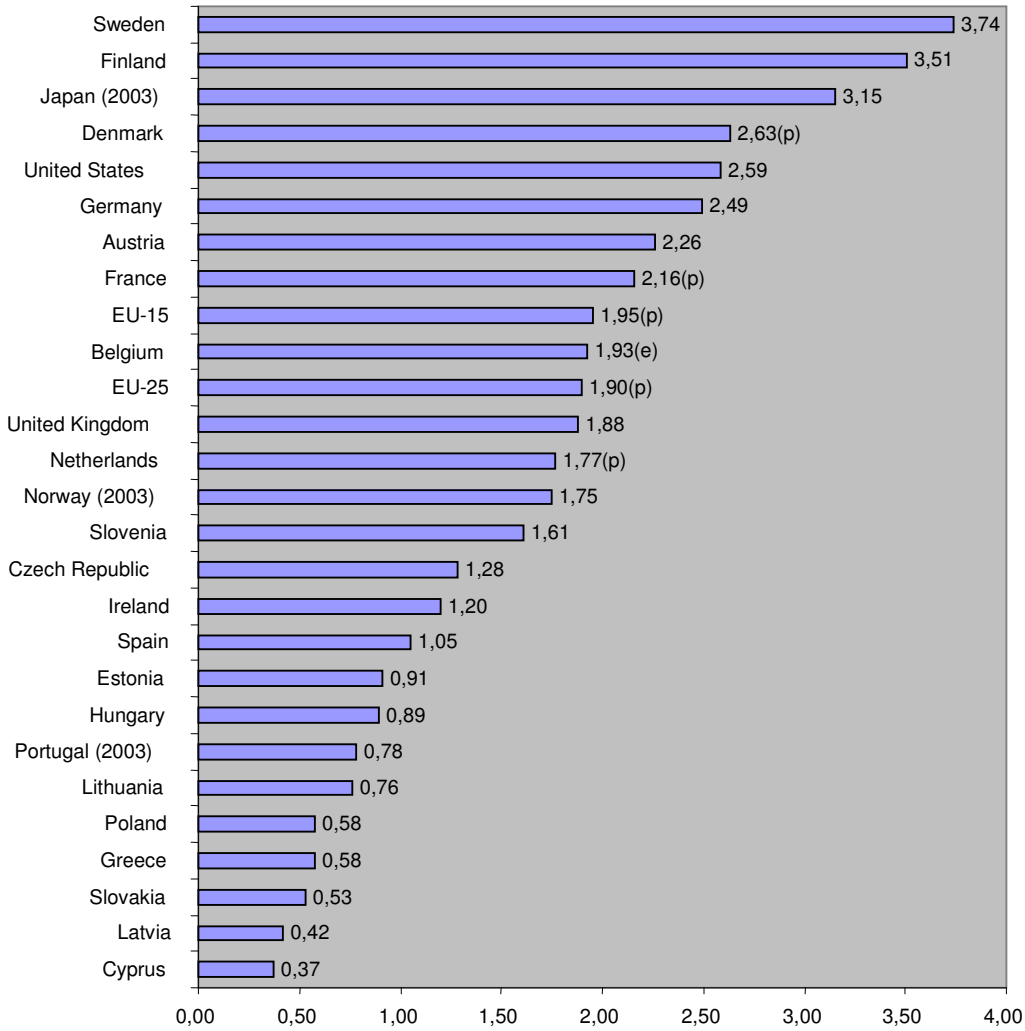
Source: *Estonian Research and Development Strategy 2002-2006 „Knowledge-based Estonia"; Statistics Estonia.*

The European Union initiated the so-called Lisbon process in 2000 with the aim to make the union the most competitive economic area in the world by 2010. An important success factor in achieving this aim is to increase the research and development expenditures which are planned to be increased to 3% of GDP by 2010.

The R&D intensity of the Estonian economy has been growing since 2000, which is evident also in the growing share of R&D expenditures in GDP. The same dynamics has been evident also in the financing of R&D from the state budget in 2000–2003. But since 2003 the trends split – the proportion of R&D expenditures in GDP has grown, but at the same time in the public sector gross expenditures (state budget) decreased.

One of the main indicators in international comparison is the intensity of R&D, which is measured by the relation of R&D expenditures to the gross domestic product. There are countries with very different R&D intensity in the European Union. This indicator is the highest in our neighbouring countries Sweden (3.74%) and Finland (3.51%), while in big countries like Germany (2.49%) and France (2.16%) the R&D intensity is closer to the European Union average. The new Member States have an evident gap in development not only compared to developed countries but also the EU average. Among the new member countries, Slovenia had the highest level of R&D expenditures (1.61%) in the gross national product in 2004. Estonia held quite a modest position in 2004, although it was the highest among the Baltic countries. Yet, the actual expenditures of the countries in absolute values differ even more, as the gross national product per capita is significantly higher in developed countries than in the new Member States.

Figure 2. Gross domestic expenditure on R&D (as percentage of GDP), 2004



p – provisional; e – estimated

Source: *EUROSTAT, Structural Indicators, Innovation and Research; Statistics Estonia.*

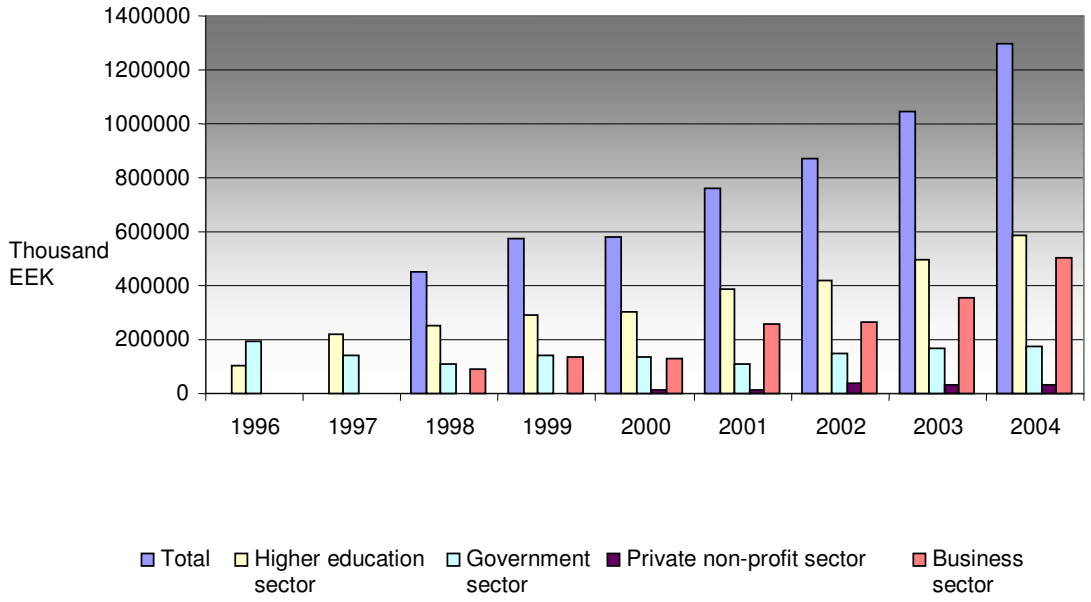
APPENDIX 2

Expenditures on Research and Development by Institutional Sector 1998–2004

Table 1. EXPENDITURES ON RESEARCH AND DEVELOPMENT (Unit: thousand kroons)

Indicator, year and institutional sector		Total (thousand EEK)	Higher education sector %	Government sector %	Private non-profit sector %	Business sector %
Expenditures	1998	450 969	56,0	23,8	0,4	19,7
	1999	572 836	51,2	24,4	0,4	23,9
	2000	579 418	52,4	23,1	1,9	22,5
	2001	763 479	50,5	14,1	1,8	33,6
	2002	871 488	47,9	17,0	4,5	30,7
	2003	1 046 224	47,3	15,8	3,1	33,9
	2004	1 294 004	45,5	13,3	2,3	39,0

Figure 3. Expenditures on research and development by institutional sector 1996-2004

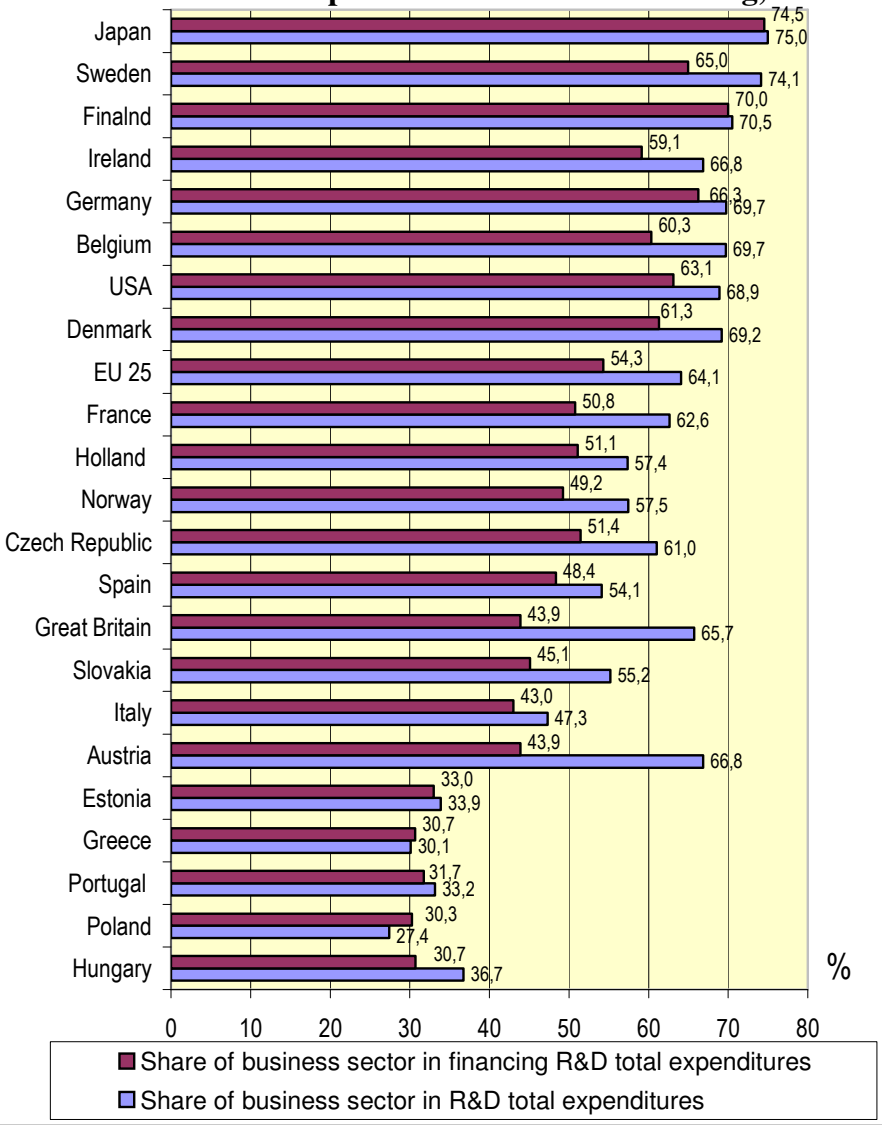


Source: *Statistics Estonia.*

During this period, R&D expenditures have grown continuously in higher education sector, by 15% a year on the average. R&D expenditures in business sector have grown very unevenly. While in 2001 the expenditures almost doubled compared to 2000, then in 2002 enterprises' R&D expenditures grew only 4%. The situation improved in 2003 – enterprises' R&D expenditures grew 33% compared to 2002. However, the main share of the growth is probably the result of the change in accounting principles, as the enterprises of the finance sector were also included in the enterprises' sample for the first time in 2003. However, the business sector R&D expenditures have grown significantly again in 2004 (42%), which raises expectations that the strong growth trend will continue also in the future.

R&D investments of Estonian enterprises in international comparison

Figure 4. Share of business sector R&D expenditures in R&D total expenditures and their financing, 2003



***Source**: Eurostat, R&D internet database, 9.05.2006.*

The most important reason for low R&D intensity in most European Union new Member States, including Estonia, is insufficient R&D in the business sector. In developed countries, the share of business sector reaches from 2/3 to 3/4 in total R&D expenditures. 68.9% in the USA as well as 75.0% in Japan are higher than the European Union average (64.15%). Furthermore, the gap is even wider in financing R&D expenditures: the business sector finances only 54.3% of total R&D expenditures in the EU25, while the business sector financing of R&D reaches 74.5% in Japan and 63.1% in the USA.

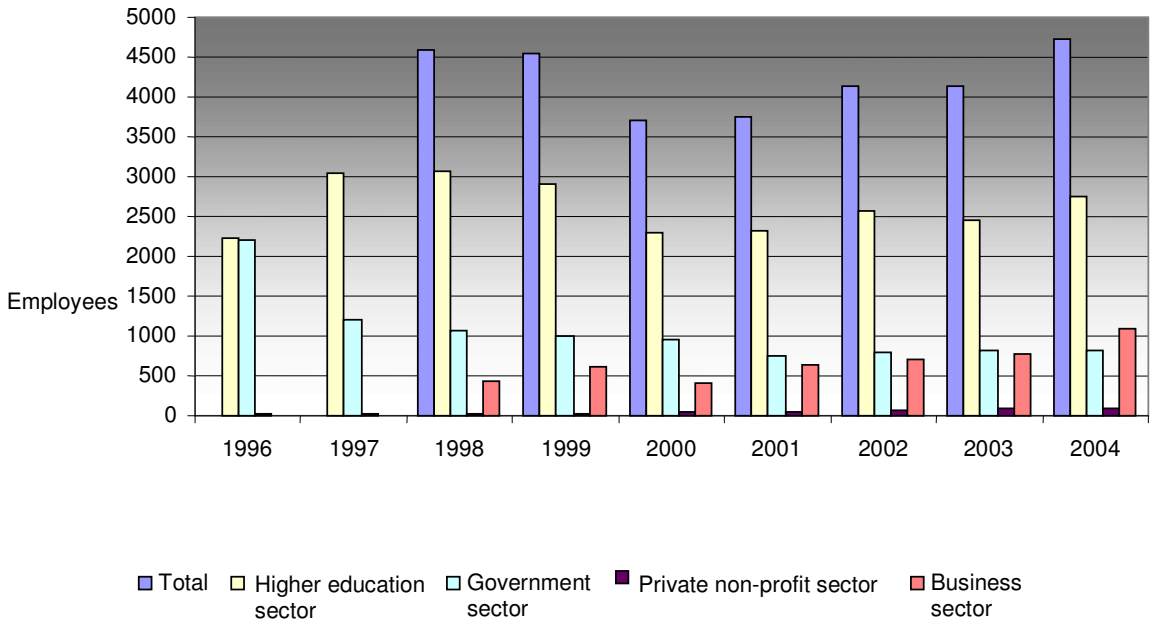
APPENDIX 3

Research and Development Personnel by Institutional Sector, full-time equivalent, 1996–2004

Table 2. RESEARCH AND DEVELOPMENT PERSONNEL
Indicator, year and institutional sector

	Year	Total	Total non-profit institutional sectors	Higher education sector	Government sector	Private non-profit sector	Business sector
Personnel in full-time equivalent	1996	..	4444	2224	2201	19	..
	1997	..	4272	3043	1215	15	..
	1998	4600	4160	3077	1069	14	440
	1999	4545	3927	2907	1005	15	618
	2000	3710	3292	2305	948	40	418
	2001	3745	3119	2319	750	50	626
	2002	4129	3427	2565	793	69	702
	2003	4275	3511	2585	829	97	763
	2004	4736	3652	2752	810	90	1084

Figure 5. Research and Development Personnel by institutional sector, full-time equivalent 1996-2004



***Source**: Statistics Estonia.*

Full-time equivalent (FTE) – working time spent on R&D by research and development personnel in person-years. University teachers have to divide their working hours between teaching and research, as well as employees involved in R&D in enterprises may divide their working time between research and development and production work. The value of FTE is based on estimation and is between zero and one. It can be one only in the case the person is fully engaged in R&D during the whole working time.

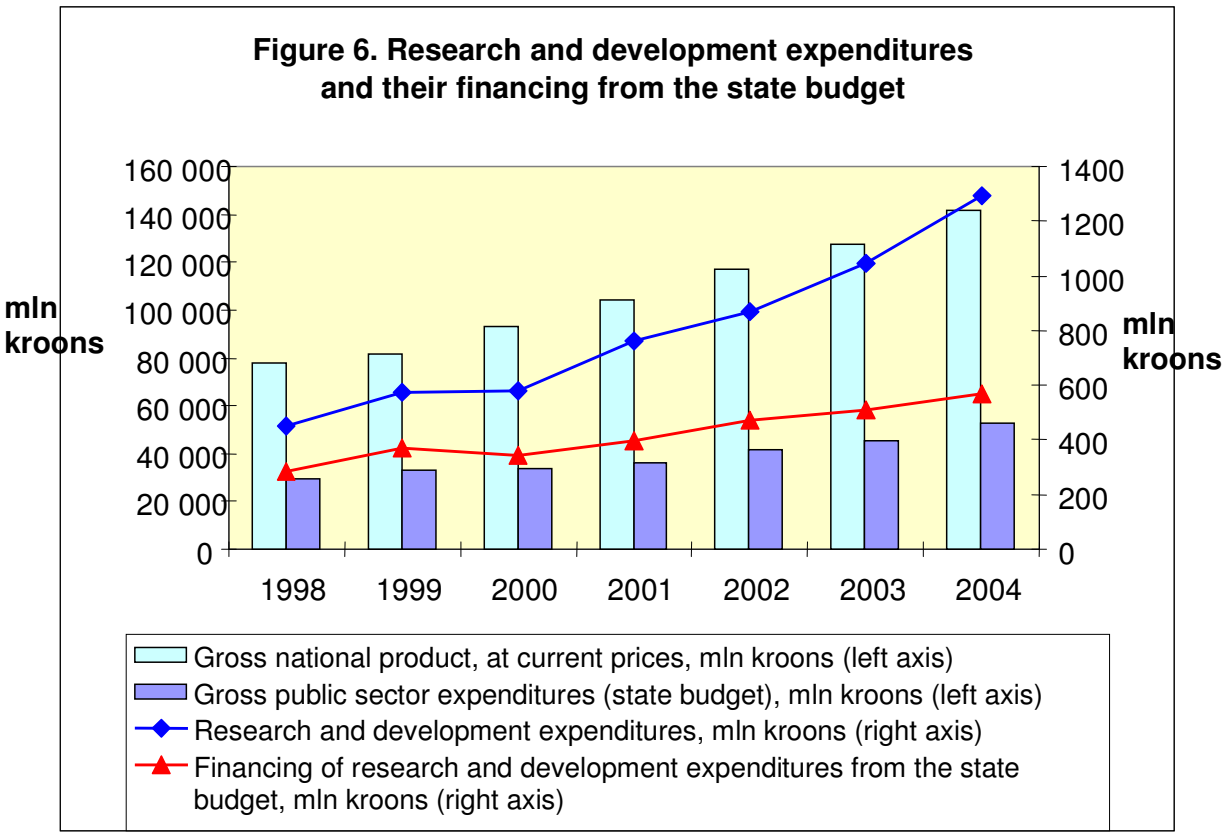
APPENDIX 4

Research and Development Expenditures by Main Sources of Financing 1996–2004

Table 3. RESEARCH AND DEVELOPMENT EXPENDITURES AND THEIR FINANCING FROM THE STATE AND LOCAL BUDGETS (data for 1998–2003 have been revised on 13.02.2006)

Year	Gross domestic product at market prices, million kroons	Research and development expenditures, million kroons	Proportion of research and development expenditures in GDP, %	Gross public sector expenditures*, million kroons	Research and development expenditures and their financing from the state and local budgets, million kroons	Proportion of research and development in gross public sector expenditures, %
1998	78 027.6	451.0	0.58	29 709.9	284.0	0.96
1999	81 775.9	572.8	0.70	32 983.8	370.9	1.12
2000	95 491.0	579.4	0.61	33 664.9	342.8	1.02
2001	108 218.3	763.5	0.71	36 249.9	397.3	1.1
2002	121 372.2	871.5	0.72	41 502.3	469.6	1.13
2003	132 904.0	1 046.2	0.79	45 346.4	508.4	1.12
2004	146 693.8	1 294	0.88	52 429.1	570.8	1.09

Gross public sector expenditures*, million kroons:
* data of the Ministry of Finance



Source: *Statistics Estonia.*

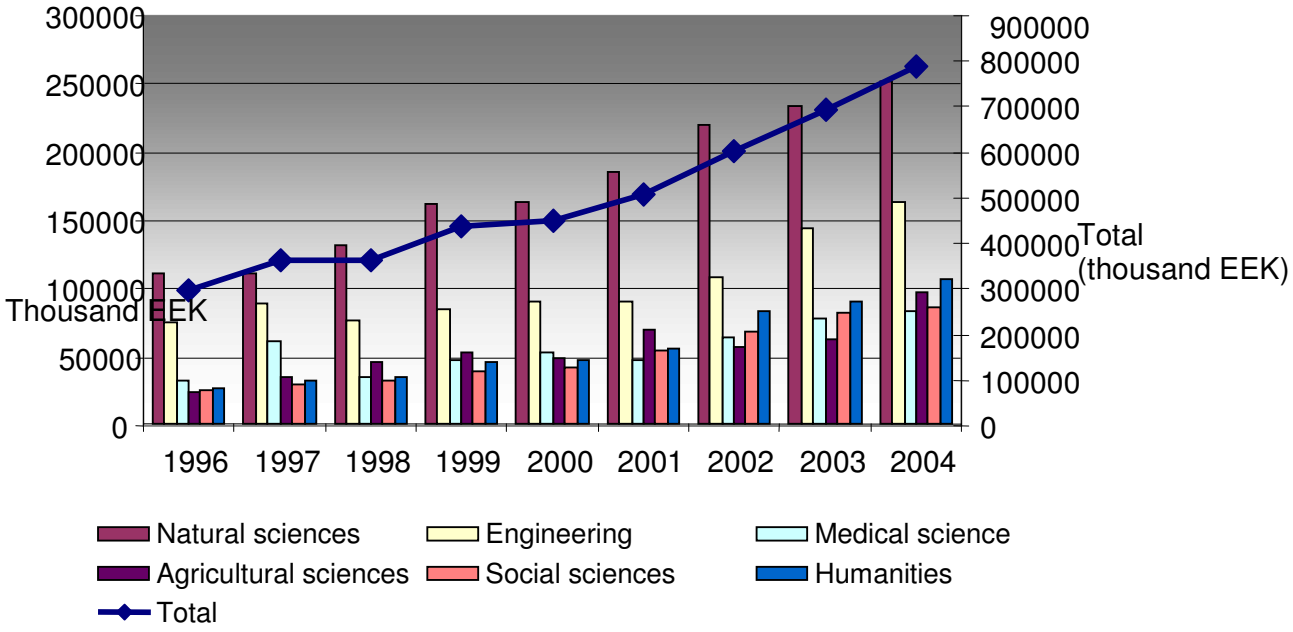
APPENDIX 5

Research and development expenditures in non-profit institutional sectors by field of research 1996–2004

Table 4. RESEARCH AND DEVELOPMENT EXPENDITURES in non-profit institutional sectors. Year and field of research (unit: thousand kroons)

Year	Total	Natural sciences	Engineering	Medical science	Agricultural sciences	Social sciences	Humanities
1996	298 560	111 049	76 270	32 702	24 443	25 994	28 102
1997	361 760	110 962	90 018	61 963	35 548	30 452	32 817
1998	362 201	132 306	76 969	36 396	47 226	33 415	35 889
1999	435 795	162 191	84 899	47 962	53 435	39 839	47 469
2000	448 986	164 234	91 053	53 433	49 863	42 506	47 897
2001	506 734	185 418	90 338	48 831	69 711	55 655	56 781
2002	604 325	220 547	108 958	65 121	57 223	69 051	83 425
2003	691 736	234 239	144 501	77 755	62 847	82 028	90 366
2004	789 764	251 237	163 422	83 485	97 923	86 261	107 436

Figure 7. Research and development expenditures in non-profit institutional sectors by field of research 1996-2004

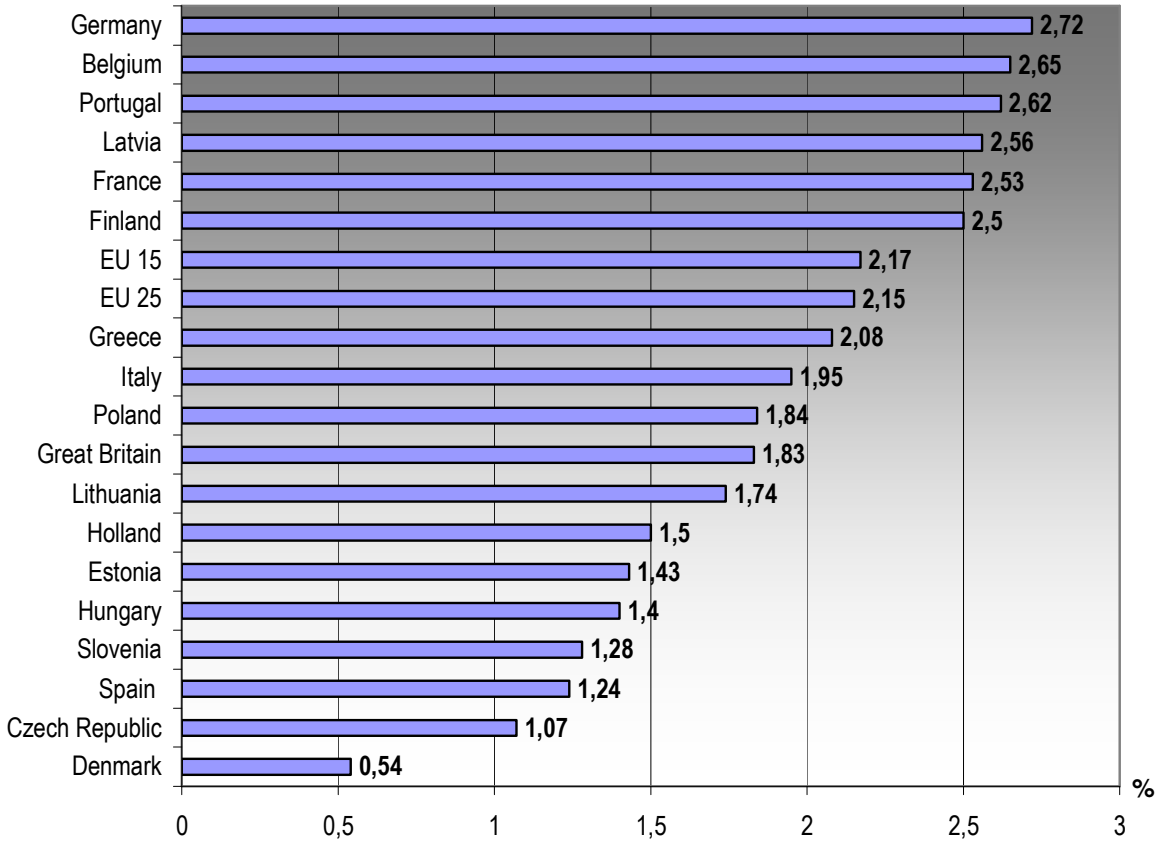


Source: *Statistics Estonia.*

APPENDIX 6

Innovation in Estonian enterprises

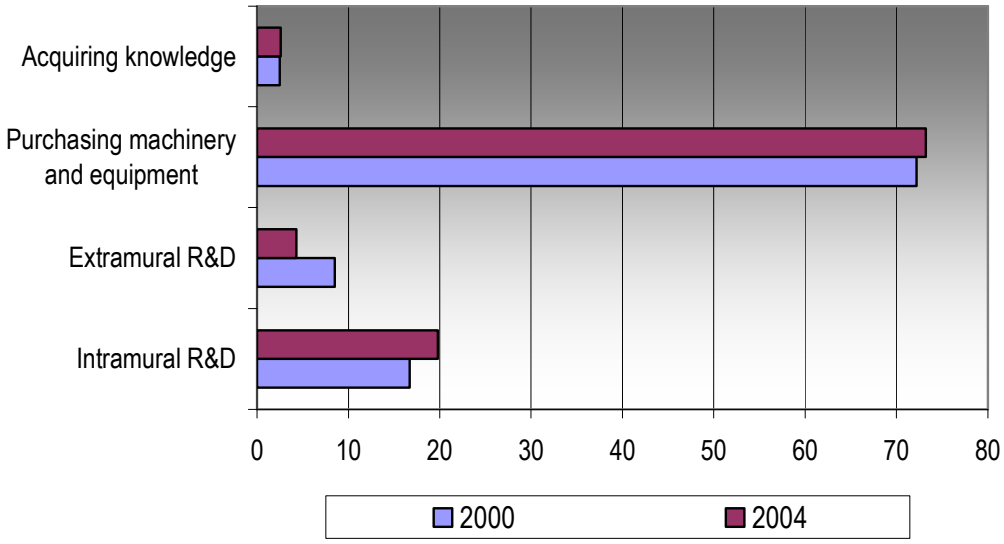
Figure 8. Innovation expenditures of enterprises (% of turnover)



Source: *EUROSTAT: New Cronos, Results of the Third Community Innovation Survey (CIS3), The European Innovation Scoreboard indicators.*

Innovation expenditures are wider than research and development expenditures. Innovation expenditures include intramural R&D; extramural R&D; purchased machinery and equipment (directly related to product or process innovation); expenditures for acquiring patents and licences, expenditures on product design, training and marketing of innovative products and services. Data concerning innovation expenditures of the European Union enterprises are collected at every four years with innovation survey *(Community Innovation Survey).* Estonia has participated in this survey since 2002.

Figure 9. Distribution of innovation expenditures in innovative enterprises (%)



Source: *Community Innovation Survey (CIS3 and CIS4), Statistics Estonia.*

Innovation expenditures of enterprises are measured in four categories in CIS[24]: acquiring knowledge (attaining patents, non-patented inventions, acquiring know-how or other knowledge or licences from other enterprises or institutions); purchase of machinery, equipment and software for producing new products/services or implementing processes; extramural research and development and intramural research and development. Enterprises invested in these four categories 1.8 billion kroons in 2000 and 3.8 billion kroons in 2004, which demonstrates the significant growth that has occurred during these years. However, expenditure structure indicates that the major part of investments is still going to machinery and equipment. Compared to 2000, the proportion of intramural R&D has grown in 2004.

[24] CIS 3 also measured expenditures on training, marketing of innovations and design. Numerical data on these types of expenditures was no longer collected in CIS 4, enterprises only reported whether they had such expenditures.