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An assessment of research system and policies

Finland

Kimmo Viljamaa, Janne Lehenkari and Tarmo Lemola

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Advansis

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Executive Summary

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

Research and innovation have been national priorities in Finland for quite a long time. However, there has been a gradual change in policy thinking from the separate science and technology policies of the 1980s towards the more complex notion of innovation and a broader view of policies. At the same time there has been a move from the linear innovation model to a more interactive and integrative model. This change has highlighted the need for a more systemic approach to research policy. The concept of the national innovation system has provided a basic framework for policy considerations from the early 1990s and since then this model has been developed and fine-tuned to better respond to the needs of the R&D performers and particularly the private sector. The R&D investments have also developed quite substantially from €1.8b to €6.2b with the lead of the private sector with Nokia in the lead. The strong concentration of R&D activity in few sectors and to large companies has also been seen as a threat and there has been a continuous effort to also support various other promising technology areas.

The research policy model from the 1990s has worked rather well for manufacturing and especially high-tech industries but has somewhat missed non-technological innovations as well as the growing service sector (both public and private services). The Finnish research system has also been leaned heavily on domestic human capital and the research system has had difficulties in attracting talented researchers and students. The university system has also had difficulties in providing proper research careers for young researchers. At the same time, the private sector has not been able to provide proper employment for many PhDs.

The main strengths and weaknesses of the Finnish research system and governance are summarised below:

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Public and private R&D investments are on a high level
	Securing long term investment in research	A further increase in R&D investments is a widely-accepted policy objective as well as an innovation oriented approach to national policy.
	Dealing with barriers to private R&D investment	The strength of the Finnish system is that BERD is already at a very high level. The weakness is that a significant part of the BERD is dependent on Nokia and the related ICT industry.
	Providing qualified human resources	Strengths exist in the overall high level of basic education. Finland also has a large existing HRST. The weaknesses lie in the system ability to attract talented domestic and foreign students and to make research career more attractive
Knowledge demand	Identifying the drivers of knowledge demand	The strength of the Finnish research system is that national key areas are identified in co-operation between public and private sectors. On the other hand the well-established R&D funding system may have difficulties to identify the knowledge demand of new players and SMEs
	Co-ordination and channelling knowledge demands	Several co-ordination mechanisms for knowledge demand is strength. At the same time these various mechanisms are not well coordinated in practice by themselves.
	Monitoring of demand fulfilment	Evaluation is systematically carried out in many different levels
Knowledge production	Ensuring quality and excellence of knowledge production	High publication output and international visibility Mechanisms open to new scientific opportunities Research activity scattered to many organisations and units
	Ensuring exploitability of knowledge	Many mechanisms to match scientific knowledge production to economic and societal needs Many instruments to support the exploitability of knowledge
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	A number of effective instruments exists to support knowledge circulation
	Profiting from international knowledge	Good participation of Finnish partners in international collaborative research Relatively low level of foreign R&D investment Mediocre attractiveness for international students and talented knowledge workers
	Enhancing absorptive capacity of knowledge users	High level of S&E graduates and workers in S&T Low level of PhDs working in the private sector The absorptive capacity of knowledge users concentrated on large corporations

In order to better support broad-based innovation in addition to research- and technology-driven innovation as well as to respond to the various challenges, Finland has launched several reforms to revise the current research system. These include the structural development of higher education institutions, the national innovation strategy, the Strategic Centres for Science, Technology and Innovation (CSTI), the reform of sectoral research, the national infrastructure policy, the implementation of

the four-stage research career model, the internationalisation of various functions and the promotion of research and innovation funding especially in new areas such as services.

Despite the continuous changes and even proactive improving of the research system the summary table below indicates that there are still some risks in the research policy approach.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	• Development of domestic lead markets, venture capital and other mechanisms to promote demand for innovative innovation and R&D • Increase the attractiveness of Finland for investors, knowledge workers and students • Further increase joint programming activities with internal partners	• Too much selection and focus in research policy may benefit those actors who are already mobilised
Knowledge demand	• More active role of the business sector in co-ordination of knowledge demand • Creation of new demand-led innovation policy instruments to provide new ways of identifying and co-ordinating knowledge demand	• The well established national system for identifying and coordinating knowledge demand may result in too much national focus in policy despite many initiatives to internationalise the research system • The strong private sector participation in knowledge demand co-ordination may direct research too much on short-term and applied research
Knowledge production	• More dynamic university and sectoral research systems making high level research and attracting talented researchers	• Overemphasis on economies of scale instead of quality and diversity
Knowledge circulation	• Attracting more companies to participate in collaborative research activities • Increasing mobility of researchers and other highly qualified labour force	• Increased knowledge circulation affects only selected sectors and preferred businesses

Public-private collaboration has also been the strength of the Finnish research system. However, the ever increasing role of the private sector in financing public research as well as participating in defining the focus areas has also created concern that today's business needs may soon direct research already too much.

The strong national policy focus, strong national R&D funding base as well as high economic success has also made Finland less dependent on larger European developments. As a result, the integration of national research policies with broader ERA developments is still quite ambiguous at the policy level as a whole although Finland is very active in participating in various EU-level activities at both the policy as well as organisational level. Despite the questions of the role of the national policy in relation to EU activities and ERA, the general impact of EU developments has been an increasing coherence of national research policy goals and instruments with the EU policies.

TABLE OF CONTENTS

Executive Summary 3
1 - Introduction and overview of analytical framework 9
1.1 Scope and methodology of the report in the context of the renewed Lisbon Strategy and the European Research Area 9
1.2 Overview of the structure of the national research system and its governance 11
2 - Resource mobilisation 12
2.1 Analysis of system characteristics 13
2.1.1 Justifying resource provision for research activities 13
2.1.2 Securing long term investment in research 14
2.1.3 Dealing with uncertain returns and other barriers to business R&D investment 14
2.1.4 Providing qualified human resources 15
2.2 Assessment of strengths and weaknesses 16
2.3 Analysis of recent policy changes 17
2.4 Assessment of policy opportunities and risks 19
2.5 Summary of the role of the ERA dimension 20
3 - Knowledge demand 21
3.1 Analysis of system characteristics 21
3.1.1 Identifying the drivers of knowledge demand 21
3.1.2 Co-ordinating and channelling knowledge demands 23
3.1.3 Monitoring demand fulfilment 24
3.2 Assessment of strengths and weaknesses 25
3.3 Analysis of recent policy changes 25
3.4 Assessment of policy opportunities and risks 27
3.5 Summary of the role of the ERA dimension 28
4 - Knowledge production 29
4.1 Analysis of system characteristics 29
4.1.1 Improving quality and excellence of knowledge production 29
4.1.2 Improving exploitability of knowledge production 30
4.2 Assessment of strengths and weaknesses 31
4.3 Analysis of recent policy changes 32
4.4 Assessment of policy opportunities and risks 34
4.5 Summary of the role of the ERA dimension 34
5 - Knowledge circulation 35
5.1 Analysis of system characteristics 35
5.1.1 Facilitating knowledge circulation between university, PRO and business sectors 35

5.1.2 Profiting from access to international knowledge 37
5.1.3 Absorptive capacity of knowledge users 38
5.2 Assessment of strengths and weaknesses 39
5.3 Analysis of recent policy changes 39
5.4 Assessment of policy opportunities and risks 41
5.5 Summary of the role of the ERA dimension 42
6 - Overall assessment and conclusions 43
6.1 Strengths and weaknesses of research system and governance 43
6.2 Policy dynamics, opportunities and risks from the perspective of the Lisbon agenda 44
6.3 System and policy dynamics from the perspective of the ERA 45
References 47
List of Abbreviations 49

1 - Introduction and overview of analytical framework

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

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

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

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

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

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

On the *second* level, the analysis within each domain is guided by a set of generic "challenges" common to all research systems that reflect conceptions of possible bottlenecks, system failures and market failures (see figure 1). The way in which a specific research system responds to these generic challenges is an important guide

for government action. The analytical focus on processes instead of structures is conducive to a dynamic perspective, helps to deal with the considerable institutional diversity observed, and eases the transition from analysis to assessment. Actors, institutions and the interplay between them enter the analysis in terms of how they contribute to system performance in the four domains.

Figure 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
• Justifying resource provision • Long term research investment • Barriers to private R&D funding • Qualified human resources	• Identification of knowledge demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment	• Quality and excellence of knowledge production • Exploitability of knowledge production	• Knowledge circulation between university, PRO and business sectors • International knowledge access • Absorptive capacity

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

This report is based on a synthesis of information from the European Commission's ERAWATCH Research Inventory[1] and other important publicly available information sources. In order to enable a proper understanding of the research system, the approach taken is mainly qualitative. Quantitative information and indicators are used, where appropriate, to support the analysis.

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

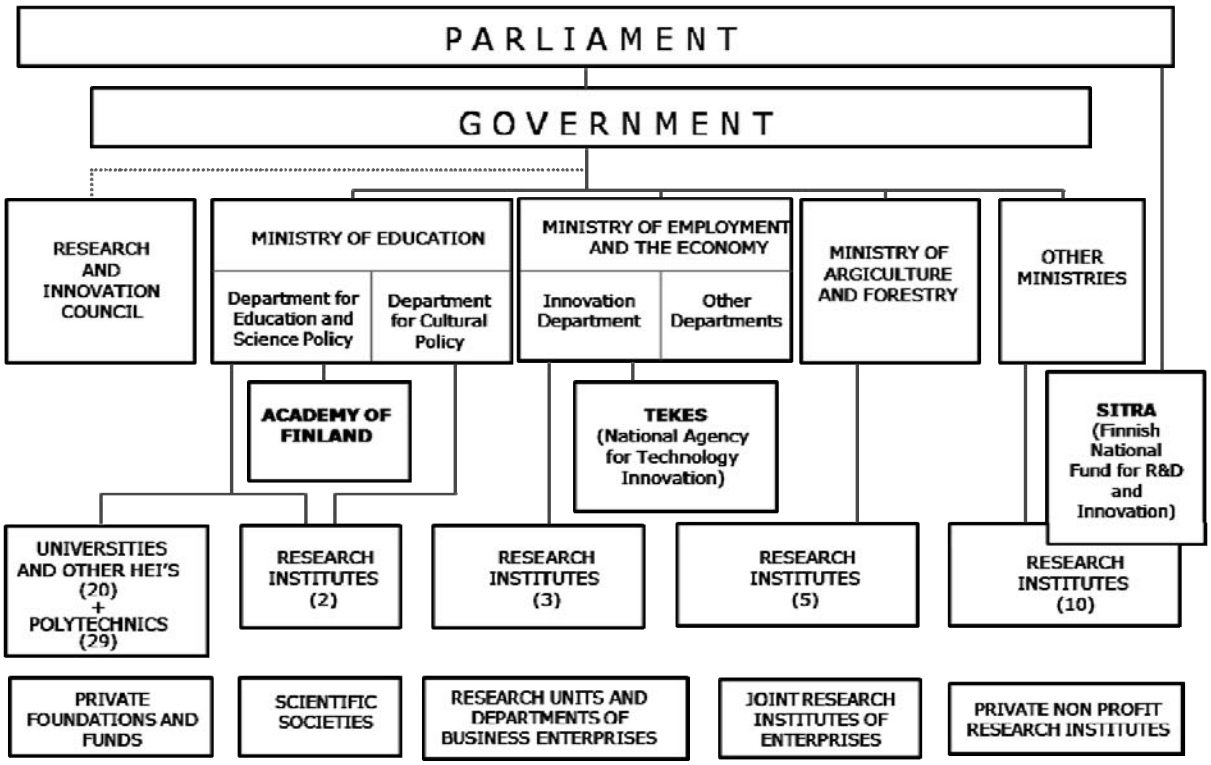
[1] ERAWATCH is a cooperative undertaking between DG Research and DG Joint Research Centre and is implemented by the IPTS. The ERAWATCH Research Inventory is accessible at http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home. Other sources are explicitly referenced.

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

Finland is a sparsely inhabited Nordic country with only one percent of the total EU population. In 2007, Finland's GDP per capita was 16.7 % above the EU 27 average. In May 2008, Finland's unemployment rate was 6.1% that was slightly lower than EU 27 average of 6.8% (Eurostat 2008a). In 2006, Finland's GERD as a percentage of GDP was 3.45% that was significantly higher than the EU 27 average of 1.84%. Among European and OECD countries, Finland's GERD percentage was only surpassed by Sweden in 2006 (OECD 2008). During period between 2002 and 2006, there were only minor changes in Finland's GERD percentage (OECD 2008).

The structure of the Finnish research system depicted in Figure 2. Finland has adopted a centralised system of research policy planning and decision-making. The organisational structure of the Finnish innovation and research system consists of four operational levels: 1. the Parliament and at the National government; 2. the ministries; 3. the R&D funding agencies; and 4. research performers.

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



Source: ERAWATCH Research Inventory 2008, Structure of the Research System

The highest-level governance takes place at the Parliament and at the national government. Especially, the national government – regardless of its political composition – has actively taken part in science, research and innovation policy issues for more than a decade. The government is supported in by a high level advisory body, the Research and Innovation Council (formerly Science and Technology Policy Council of Finland), which is led by the Prime Minister. The council is responsible for the strategic development and coordination of Finnish science and technology policy.

The second level consists of the ministries. The key ministries concerned with research policy are the Ministry of Education and the Ministry of Employment and the Economy (established 1.1.2008 as a merger of the Ministry of Trade and Industry and the Ministry of Labour). While there is a historically-developed sectoral division of labour between the two ministries concerning science and technology policy, cross-sectoral cooperation has increased in issues related to science and innovation during the past few years. This is partially due to their shared interests to promote research funding in the government budget, for which close participation in Science and Technology Policy Council has provided a good platform. As a general trend, there is a move from narrowly defined science and technology policy towards a broad-based innovation policy incorporating issues of research policy, technology policy, and elements from various other policies.

The third level consists of the R&D funding agencies, Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation. Academy of Finland funds basic research through competitive grants. While the majority of Tekes funds are allocated to R&D projects carried out by companies, Tekes is also a large financier of university research. In 2006, 30% of the total government research funding (including direct funding of universities) was channelled through these two organisations (Statistics Finland 2007).

At the fourth level are the organisations conducting research: universities, public research institutes, private research organisations and business enterprises. There are 20 universities in Finland. They are owned by the state and get their basic funding from the state budget. There are also 20 public research institutes funded by the state.

R&D is mainly performed by business enterprises in Finland. In 2006, enterprises had 71.5% share of total R&D expenditures (OECD 2008). A distinctive characteristic is that one company, Nokia, accounts for nearly 50% of total business sector R&D in Finland (Pajarinen & Ylä-Anttila 2008). The higher education sector, mainly the 20 universities of Finland, had 18.7% share of total R&D expenditures while the share of government departmental research (including non-profit research performers) was 9.3% in 2006 (OECD 2007). In terms of money, the total domestic expenditure on R&D was €5761m in 2006 (Statistics Finland 2007).

The institutional role of the regions in the governance of the Finnish research system is small, since the research policy is mainly decided at the national level. Regional concerns have an effect on the national policy in many respects, however. For instance, the Ministry of Education reconciled the objectives of the national research policy and the regional policy in a strategy document titled Regional strategy for accomplishing education and research policies until 2013 (MoE 2002). The municipalities in Finland are relatively strong actors compared to many other countries and particularly the bigger cities and towns have had a very active role in local economic development and research policy, often related to support in building infrastructure and support services R&D activities.

2 - Resource mobilisation

The purpose of this chapter is to analyse and assess how challenges related to the provision of inputs for research activities are addressed by the national research

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

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

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

2.1 Analysis of system characteristics

2.1.1 Justifying resource provision for research activities

Already in the late 1990s, Finland contributed largely to the Lisbon Strategy target of R&D spending equivalent to 3% of GDP (Ministry of Finance 2005). In 2006, Finland's GERD as a percentage of GDP was 3.45% (Eurostat 2008a). According to the 2008 European Growth and Jobs Monitor, an annual survey of Europe's economic and social progress, Finland was the best performer when the overall performance of 14 European countries was measured according to criteria derived from the original Lisbon Strategy (Allianz Dresdner Economic Research & The Lisbon Council 2008).

In Finland, increasing R&D investments has been a widely-accepted policy objective since the 1980s. Both the current government and its predecessor have set out an objective of increasing the GERD as a percentage of GDP up to 4.0% (STPC 2006). The aim of increasing R&D investments has had a notable effect on the government budget outlays for R&D. In 2005, the share of GBAORD in general government expenditure of Finland was 2.05%. This was higher than the EU 25 average of 1.56% and, among EU member countries, only surpassed by Spain and Iceland (EC 2007). In terms of money, the total sum of GBAORD steadily increased from €1388m to €1694m during 2002-2006 (Statistics Finland 2007).

The aim of promoting R&D funding has been given a high priority on the Finnish political agenda. The current government programme – an action plan agreed by the parties represented in the government – states that investing in R&D is necessary for increasing capacity for innovation that fuels competitiveness and productivity growth in Finland (Prime minister's office 2007). In 2008, this argument was reinforced in the new proposal for the National Innovation Strategy document prepared by the current government. According to this White paper document, public resources targeted at broad-based innovation activity and R&D must be increased at a pace exceeding that of general economic growth in Finland (MEE 2008).

2.1.2 Securing long term investment in research

The trend of research funding of the Finnish higher education sector is increasing. In 2007, the research expenditure of universities amounted to €1,164m with an annual increase of €87m (Statistics Finland 2007). The base funding provided by the government budget increased by 0.7% (in real terms) between 2007 and 2008. The Ministry of Education (MoE) is the main provider of base financing that covers research and related infrastructures at Finnish universities. In 2008, universities received €452.2m from the MoE, which corresponds to c. 58 % of direct public R&D funding allocated by the ministry (Statistics Finland 2007). The amount of base funding provided by the MoE depends on the performance of universities in respect of education, research and integration with society. In total, 37% of the funding of university research expenditures consisted of base funding, the share of external funding being 63%.

The total R&D expenditures of Finnish government (sectoral) research institutes amounted to €502.3m in 2007, which was an increase of €15m from the previous year (Statistics Finland 2007). The base funding of government research institutes is allocated by several ministries. In 2007, €276.7m or 55% of the research institutes' financing came from the government budget. The share of external funding was €225.5m (45%) of which €28.6m (6% of overall funding) came from the EU sources. Between 2006 and 2007, the government base funding of public research institutes decreased by €1.1m.

The largest government research institute is VTT Technical Research Centre of Finland with an annual budget of €215m in 2006. This was 44% of all sectoral research institutes. The share of external funding for VTT was 68%, which was likewise 68% of external funding received by the sectoral research institutes. For the majority of other research institutes, the share of external funding was notably smaller.

As to the European funds, Finnish organisations were active in the Sixth Framework Programme (FP6). According to estimates (Tekes 2007), Finland received funding from the Framework Programme totalling about €365m and the total number of Finnish participants at that moment was estimated to be as many as 1,439. However, in proportion to Finnish share of R&D expenditure in the EU-25, the Finnish share of FP6 funding is below average.

In 2005, the government-financed GERD as a percentage of GDP was 0.89% in Finland (OECD 2008). This was higher that the estimated EU-27 average of 0.61%, and equal to the figures of Sweden (0.89%) and Austria (0.88%) that had the highest numbers among the EU member states. In 2002-2005, the government-financed GERD as a percentage of GDP varied only slightly staying between 0.88% and 0.91%. This development – as well as the growing or stable base financing figures of universities and public research institutes – suggests that securing long-term investment in research is taken into account in Finnish research policy.

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

In Finland, the industry-financed GERD as a percentage of GDP was 2.33% in 2005 (OECD 2008). This figure was significantly higher than the estimated EU-27 average of 0.94%. Finland and Sweden (2.55%) stand out from the rest of the EU member

states. In 2005, the next-highest number of the industry-financed GERD as a percentage of GDP was 1.68% (Germany). The industry-financed GERD has constantly been on a high level in Finland during this decade. In 2002-2005, the industry-financed GERD as a percentage of GDP fluctuated only slightly between 2.33% and 2.40%.

Large firms have a dominant role in R&D activity in Finland. It is estimated that the share of the 30 largest firms of total business R&D expenditure was 61% in 2006 (Pajarinen & Ylä-Anttila 2008). In 2001-2006, there was a downward trend in the R&D investments of large firms since the number was as high as 66% in 2001. This is partly explained by the fact that large manufacturing firms have increased R&D in foreign subsidiaries more rapidly than in domestic units in recent years. However, the 30 firms' total nominal amount of R&D spending in Finland has increased also in recent years. Nokia accounts for nearly 50% of total business sector R&D expenditure in Finland. In 2005, Nokia's world-wide R&D investments were €3,978m that was the 17th highest figure in the world (EC 2006). For comparison, the next-highest amount of world-wide R&D investments made by a Finnish firm (Stora Enso) was €88m in 2005.

Concerning the amount of early-stage venture capital investment, Finland performs moderately among the EU member states. Early-stage venture capital investment is defined as private equity covering both seed and start-up capital of young firms. It is particularly necessary for firms developing or using new technologies. In 2006, the early-stage venture capital as a percentage of GDP was 0.027% in Finland (EC 2008). In comparison, the EU-15 average was 0.053% and the figure of Sweden is even higher, 0.058%.

In 2005, the percentage of BERD financed by government was 3.8% in Finland (OECD 2008). This was lower than the estimated EU-27 average of 7.3% but similar to the estimated value of Sweden, 4.2%. In Finland, tax incentive policies are not applied for facilitating business R&D. The main Finnish public funding source of business R&D is Tekes. In 2007, Tekes provided €281m as grants and loans for business R&D projects (Tekes 2008). The incentives for business R&D are offered with an aim to promote public-private partnerships. According to Tekes (2008), large companies and large corporations received an average €78m of Tekes funding for business R&D activities annually in 2005-2007. At the same time, these companies bought research services or supported public research programmes for €87m annually.

2.1.4 Providing qualified human resources

In 2005, there were 39,582 researchers (FTE) in Finland (OECD 2008). The number of researchers per thousand employees was 16.5. This figure was more than twice as much as the estimated EU-27 average of 7.3. Among the EU member states, the next-highest number was that of Sweden, 12.7. In 2000-2005, the number of researchers increased slightly by 7%. In 2000-2006, the total amount of doctoral degrees increased by 24% (Statistics Finland 2007). With regard to science and engineering, the increase of doctoral degrees was also 24%. Simultaneously, the number of other higher education degrees increased by 12% in science and engineering

The increasing numbers of researchers and doctoral degrees is partly explained by the Finnish graduate school system.[2] In 2007, the system comprised 119 graduate schools. The schools had about 1450 graduate students who were paid for working full-time on their doctoral dissertations. The goal is that the students complete their doctoral dissertations in four years. All of Finland's 20 universities house one or more graduate schools, often in collaboration with other universities or research institutes.

In 2006, there were 5,434 foreign graduate or postgraduate students in Finland with an annual increase of 10% (MoE 2007). The number of foreign doctoral students was 1,641. For the sake of comparison, the share of foreign doctoral students was more than doubled in other Nordic Countries in 2004 (OECD 2007) In comparison to the total number of graduate or postgraduate students, 160,400, the share of foreign students was also low in Finland, only 3.9%.

In 2005, the rate of unemployment among PhDs was low, 2.4% (Statistics Finland 2007). The overall unemployment rate in Finland was 6% in December 2007. The Finnish business enterprises tend to recruit relatively few PhDs. Only about 15% of PhDs is employed by businesses while 80% work in the public sector, where universities and health care organizations are the largest employers.

2.2 Assessment of strengths and weaknesses

The main strength and weaknesses of the Finnish research system in terms of resource mobilisation can be summarized as follows:

Main strengths	Main weaknesses
• Increasing R&D investments is a widely-accepted policy objective • Public and private R&D investments are on a high level • Number of research workforce is increasing	• Business R&D expenditure depends on few large enterprises • The level of early-stage venture capital investment is moderate • A researcher mobility bottleneck: the share of PhDs in private sector is low • A student mobility bottleneck: the share of foreign students is low

From the point of view of resource mobilisation efforts, Finland stands out in international comparisons. The public and private R&D investments are on a high level and the number of research workforce continues to grow. On a high policy level, there is a widely-shared understanding that increasing R&D investments is necessary for securing the competitiveness and productivity of the Finnish economy. There are, however, some structural weaknesses in resource provision. The BERD is dependent on few large corporations and there is lack of early-stage venture capital investment. There are also some weaknesses in provision of human resources.

[2] The Finnish graduate school system started in 1995. Existing graduate schools in other countries, especially in the UK, had an influence on the design of the Finnish system. To a large extent, the graduate schools stand for an unregulated and informal element in the Finnish research system. They can be regarded neither as pure administrative units of universities nor funding instruments of the Ministry of Education. The schools have developed their organisation and funding base quite independently. In some cases, funding from the hosting university, research institutes and business sources has been as important as that obtained from the Ministry. As a result, graduate schools have created original and versatile venues for collaboration between universities, research institutes and business.

Private sector hires relatively few PhDs and the share of foreign students in Finnish universities is low.

2.3 Analysis of recent policy changes

The debate on need to invest in research activities has not changed much in Finland during recent years. In the triennial report by the Science and Technology Policy Council, securing adequate economic perquisites for research activities was one of the key development measures (STPC 2006). The two latest government programmes have also kept the quantitative policy objective of increasing the share of R&D funding to 4% of the GDP.

The policy objective for increasing R&D investments has not yet materialized in the R&D budget outlays. When looking at the government budget for R&D, in 2008 the GBAORD amount to €1,798m, an increase of €68m from the previous year. The increase of R&D funding was approximately 0.7% in real terms (Statistics Finland 2007). At the same time the total government budget (without debts) increased 7.5% in real terms. In this light, the recent decisions of increasing public R&D funding did not materialize in 2008. The relative proportion of R&D funding in government budget has also been on slow decline during the past few years. In 2005-2008, the proportion of funds allocated to R&D activities of overall government spending (exclusive of debt) has decreased from 4.6% to 4.4%.

Regarding the justification of resource provision for research, the 2007 government programme states (Prime minister's office 2007) that the economy's capacity for innovation should be increased. In order to strengthen this national innovation capacity the government is willing to provide "strategic inputs in selected areas". This means direct inputs, such as support for new strategic centres of expertise and increase in university funding. It also means indirect resource mobilization efforts, such as tax deductions for donations in scientific research and attracting private sector funding to strategic centres of expertise. Most of these changes are still in the planning stage, however.

In 2007, measures for preparing a university reform were started with the aim to renew the structure of the university system as well as to give universities more autonomy. The reform process is underway and is about to be finalized in the new University Act that is planned to become effective in August 2009. From a resource point of view, the objective of the reform is to concentrate resources for better performance and to give universities more autonomy to manage their own resources and to widen the resource base. The increased resources included specific government financing to the new Aalto University (created by the merger of the Helsinki University of Technology, the Helsinki School of Economics and the University of Art and Design Helsinki), as well as additional financing to other universities. In the decision of June 17th 2008 the government ministerial committee for economic affairs made the decision of investing €150m to improve the solidity and capitalization of the universities (excluding Aalto University that has separate funding reserved).

The challenges for addressing uncertain investments are mainly met by directing funding to selected key areas that are seen as most promising in terms of growth or national knowledge base. This includes many activities, such as the development of Strategic Centres of Science, Technology and Innovation (CSTI) for forest industry,

energy production, metal industry, health care and ICT industry; joint activities between regional Centres of Expertise; as well as additional funding for research in services, environmental technology, renewal energy and social innovations. The Centre of Expertise Programme (CEP) that supports regional industry clusters has been revised for 2007-2013 to promote collaboration between various regional centres working in the same technology area. The concentration of funding in selected key areas will most likely affect the planning and criteria of funding of Tekes and the Academy of Finland.

The CSTI, on the other hand, are quite a new initiative for creating networked centres of high research expertise that offer a “new way of coordinating dispersed research resources to meet targets that are important for Finnish business and society“. The government will allocate additional funding to these centres but the aim is to mobilize the private sector to take part more actively in research funding. This is achieved by giving companies (as well as universities and research institutes) the main responsibility in establishing the centres and a key role in directing the research activities carried out in these centres. In the decision to set up CSTI it has been explicitly stated that “in addition to shareholders, public funding organisations will commit themselves to providing funding for the centres for a long time period“.

Another policy change for promoting business R&D investments is to develop more market incentives for firms and other organizations to innovate. This change has been highlighted in several studies during the past few years and it is now officially emphasized especially in the proposal for the National Innovation Strategy, a white paper document prepared by the Ministry of Employment and the Economy for facilitating broad-based and multifaceted innovation policy (MEE 2008). In practice, this means changes in legislation and government practices to support the creation and commercialization of innovative products and services. One key mechanism is to develop public procurement to create new markets for innovations. Public R&D programmes and other public funding instruments are to be directed in this direction as well.

In terms of providing qualified human resources, the main policy change is the initiative of creating a genuine research career system. It addresses the phases after PhD graduation in particular, since career opportunities in these phases are limited at the moment. Another priority is to increase the international mobility of research staff and, especially, to make Finland more attractive for foreign professionals. One example of this policy is the Finland Distinguished Professor Programme (FiDiPro) that started in 2006 providing support for Finnish universities and research institutes to hire international scientists who normally work abroad.

Challenges	Main policy changes
Justifying resource provision for research activities	• Slowly declining proportion of R&D funding in government budget
Securing long term investments in research	• Increase of funding for universities and supporting donations for scientific research • Structural development of the research system • The development of national policy in order to develop research infrastructures in a more strategic way
Dealing with uncertain returns and other barriers to business R&D investments	• Focusing R&D funding to areas that are important for securing the national knowledge base • The creation of strategic centres of expertise in Science, Technology and Innovation (CSTI) • Increased focus on demand side innovation support
Providing qualified human resources	• The consolidation of the university system in order to improve the operational conditions • Development of a comprehensive researcher career system

2.4 Assessment of policy opportunities and risks

The main policy opportunities and policy-related risks can be summarised as follows:

Main policy opportunities	Main policy-related risks
• Development of domestic lead markets, venture capital and other financing mechanisms and services to promote demand for innovative solutions and mobilisation of private investments in innovation • Concentration of resources to selected key areas may provide an additional stimulation for internationally competitive research • Good reputation of Finland as an innovative country may attract more financial and human resources if the conditions for R&D are internationally competitive • A successful university reform may provide a base for qualified human resources which increases competitiveness and innovation capacity	• When investing only in a few selected technology areas, a small economy takes more risks in resource mobilisation than larger countries with more resources and variety in technological competence • The policy to concentrate resources on predetermined key focus areas and top research units may decrease the capability to learn and adopt innovations in a broad front and decrease the ability to support emerging innovations in other areas • Reforms to readjust the university system and sectoral research may be insufficient for making the Finnish research system more competitive internationally in terms of human capital • Some new instruments for focusing resources concentrate too much on domestic networking

Policy opportunities for resource mobilisation address both strengths and weaknesses of the Finnish innovation system. The levels of both private and public investments in R&D are relatively high in Finland. However, these resources are concentrated mostly on some specific sectors (e.g. ICT) and large companies. There are still many opportunities to promote innovation in SMEs and in some underdeveloped sectors, such as private and public services. There are opportunities

for developing the demand side instruments, such as public procurement and support of user-centred innovations.

In the same manner, the Finnish research system performs relatively well and effectively in many areas despite the fact that resources are scarce. The focus on specific key areas and the more active role of the industry in participating in research activities in these areas may help to bring some of these areas internationally competitive or at least to increase the commercialisation of research in these fields. However, there is a threat that too much trust in concentration of resources hinders development opportunities in other areas that are necessary for domestic innovation and absorptive capacity while not internationally competitive. Moreover, too much faith in the ability to predict growth areas and technologies may restrict the ability to direct resources to new promising fields or even radical innovations that emerge outside these focus areas.

The good reputation of Finland as an innovative and competitive country provides a good opportunity to attract foreign financial and human capital in Finland. However, the reputation is not enough and concrete initiatives are needed to improve the working environment. The university reform and the plans to develop the research infrastructure may partly help in this but there is a risk that regardless of the efficiency of these changes on a national level they may be not enough to improve Finland's international competitiveness in terms of attracting resources.

On the other hand, relatively little has been done to so far in order to attract foreign investments and even the work that has been carried out by developing the framework conditions rather than with direct financial instruments (Boekholt, 2007)

Lastly, the recent efforts to mobilise and concentrate resources by using networked structures like CSTI and CEP may be too national in focus, concentrating too much on domestic networking, which may not be optimal for many research organisations working in international knowledge networks or firms that work in international markets. These structures also easily direct research activities to support the research interests of few key companies in the sector which may limit the ability to see new emerging technologies or to support new innovative firms.

2.5 Summary of the role of the ERA dimension

Finland participates actively in various European research organisations. These organisations include the European University Institute (EUI), European Science Foundation (ESF), International Institute of Applied Systems Analysis (IIASA), European Space Agency (ESA), European Southern Observatory (ESO), European Organization for Nuclear Research (CERN), European Molecular Biology Laboratory (EMBL), and European Incoherent Scatter Scientific Association (EISCAT). Among individual organisations, the Academy of Finland and Tekes are extensively networked in order to use the resources provided by ERA.

The aim to develop research infrastructures is also partly connected to wider ERA framework. The Education and Research 2007-2012 plan states that Finland will also actively participate in the planning and implementation of the projects initiated by the European Strategy Forum on Research Infrastructures (ESFRI).

The Ministry of Education has also stated an objective to strengthen the prerequisites for high level research by coordinating national and EU level research policies and activities and by financing joint activities. In practice, this is visible e.g. in the activities

of the Academy of Finland where international collaboration in various instruments, such as research programmes and graduate school system, has increased recently.

Finnish companies and research organisations also participate actively in European R&D programmes. For example, the participation in the 7th framework programme has been above average (Finnish R&D secretariat 2008). The participation has been active also in other instruments such as the ERA-NET schemes. The increased activity is also visible in resources. The share of the EU R&D funding of all external funding at the Finnish universities has increased from 3.9% to 6.5% from 2000 to 2007.

In terms of human capital, Finland has been active in the Bologna process. The idea has been that new harmonised academic degree standards and other cooperation facilitate the mobility of researchers, which provides better access to human resources.

3 - Knowledge demand

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

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

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

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

3.1 Analysis of system characteristics

3.1.1 Identifying the drivers of knowledge demand

Structure of knowledge demand

In Finland, the role of private sector both in performing and funding R&D is decisive. In 2005, 66.9% of GERD was financed by business sector and 70.8% of GERD was also performed by business enterprises (OECD 2008). In comparison, the estimated EU-27 averages were, correspondingly, 54.1% and 62.6%. Because of the great effort of industry, the Finnish higher education and government sectors have relatively small part in performing R&D. In 2005, 19% of GERD was performed by the higher education sector and 9.6% by the government sector (the corresponding estimated EU-27 averages being 22.5% and 13.9%). In same year, domestic industry financed most of BERD (90.9%) while BERD investments from abroad (5.3%) and from government (3.8%) were about half of the estimated EU-27 averages. Industry's

investments in HERD (6.5%) and GOVERD (12.4%) were equal to or above the estimated EU-27 averages.

Three industries – the electronics and electrotechnical industry (€23.0b), the machine and metal product industry (€21.9b), and the forest industry (€18.4b) – accounted for 60% of the gross value of industrial production in 2005 (Statistics Finland 2008). In 2006, the BERD of electronics and electrotechnical industry was €2,320m that was more than half of the total BERD (€4,108m) of Finland. The relative importance of the electronics and electrotechnical industry for the Finnish R&D activity is huge. This is underlined by the fact that among business sectors the next-highest number of BERD was only €253m (that of machine and metal product industry). A Finnish peculiarity is that the BERD of the electronics and electrotechnical industry almost equates with the BERD of Nokia that accounts for nearly half of total business sector R&D expenditure, as noted earlier. From this it follows that Nokia's knowledge needs are essential drivers of business knowledge demand in Finland.

Concerning the socio-economic objectives of civil GBAORD, Finland is particularly specialised in R&D on industrial and production technology. In 2005, the share of industrial and production technology was 26.1% of total GBAORD (Wilén 2008). That was well-above the EU-27 average of 11.0%. In addition, the shares of R&D on energy, agriculture and social issues were above the EU-27 averages.

When the drivers of knowledge demand originating from the research sector itself are considered, it should be noted that general university funds accounted only for 26.1% of total GBAORD. This was below the EU-27 average of 31.4% and even more below that of Sweden, 46.1% (Wilén 2008). In terms of money, the general university funds were €416.7m, while the total HERD was €1042 in 2005 (Statistics Finland 2007). This implies that the universities are dependent on external funding while they have a limited degree of autonomy to allocate their R&D resources. Among providers of external funding, the Academy of Finland that funds basic research through competitive grants is an important identifier of new demands in basic research.

Processes for identifying the drivers of knowledge demand

In Finland, several instruments are used to identify the drivers of knowledge demand and attention is paid on business sector demands. On the level of strategic development and coordination of science and technology policy as a whole, the Science and Technology Policy Council plays the key role. The Council consists of members from the government, funding agencies, universities and private sector. At regular intervals, the Council produces science and technology policy reviews that analyse past developments and draw conclusions and make proposals for the future. In addition, the Council arranges various studies and consultations relating to the development of science and technology policies. These studies are then used by the government and the ministries in their planning and decision making processes. The latest study was published in December 2008.

The biggest R&D funder, Tekes, also prepares regularly its view on future priorities in the Tekes strategy. This process is carried out together with the key R&D performers. In the latest strategy (March 2008) Tekes focus areas are divided in specific Themes and practices as well as Crosscutting competences and technologies. The themes and practices are more general objectives that require convergence of people, technologies economy and environment. Wellbeing and health, knowledge society for all, clean energy, scarce resources, built environment, intelligent systems and environments, service business and service innovation and interactive media.

The key competences are those required by the thematic choices and focus areas. These are Information and communications technologies, Materials applications, Biotechnology (in the energy, environment and wellbeing), business competence and business development, service competence and societal competences are foresight competence (regulation and standardisation competence, productivity development and the quality of work).

Moreover, there are strategic areas defined from the cluster perspective. These are: Wellbeing and health, Service business, Information and communications, Energy and the environment, Forest, Metals, Real estate and construction and Food.

Several different types of foresight activities have also been carried out by the Committee for the Future, one of the 15 standing committees of the Parliament of Finland, by the ministries, Tekes and Academy of Finland as well as research institutes and universities. Foresight studies have often been organised in conjunction with the Academy research programmes or the Tekes programmes and their focus has been rather narrow. On a firm level, Tekes receives valuable information about the private sector demands for future R&D through technology roadmaps that are prepared by the companies receiving Tekes funding.

From 2005 to 2006, a foresight project called FinnSight 2015 was initiated as a co-operative effort of the Academy of Finland and Tekes. The foresight project examined the change factors that impact Finnish business and industry and on Finnish society, identified future challenges of innovation and research activity and analysed such areas of expertise which will foster societal well-being and the competitiveness of business and industry by means of scientific research and innovation activities. The focus in foresight was on social and global issues.

In addition, the Finnish National Fund for Research and Development (Sitra) launched a National Foresight network in 2005. The aim of the National Foresight Network was to recognise future challenges – trends of change and weak signals – and to improve the use of advance information in decision-making. .

3.1.2 Co-ordinating and channelling knowledge demands

National key technology and research areas are prioritized in co-operation between public and private sector actors. On a high policy level, the role of Science and Technology Policy Council is central. The Council coordinates and channels knowledge demands from different sectors of society including academia, public agencies and private sector. The Council deals with major policy development issues and its main contribution is the creation of framework conditions. Direct policy measures that are based on the Council's proposals are implemented by ministries and government agencies. An important output produced by the Council is a policy review titled "Science, Technology, Innovation" that is published every four years. The document reviews the national development of the past years and proposes a strategy and goals for the future R&D activity on a national level.

On the level ministries, there is a sectoral division of labour between the two key ministries in science and technology policy. The MoE is responsible for education and research policy while the MEE manages technology and industry policy. During this decade, however, co-operation has increased significantly between these two ministries in issues concerning science and innovation. This is partially due to their

similar and joint objectives to promote research funding in government budget, for which their close participation in the Council has provided a good platform.

Under the guidance of the MoE and MEE, the Academy of Finland and Tekes carry out the grassroots-level work of setting research priorities, making funding decisions and facilitating collaboration. As mentioned earlier, the Academy and Tekes have collaborated for forecasting future knowledge demands in a joint foresight project (FinnSight 2015). The Academy and Tekes have also prepared and launched several joint research programmes, whose objectives are defined in close collaboration. Nevertheless, most of the research programmes of the Academia and the technology programmes of Tekes are designed independently.

Concerning channelling and coordinating knowledge demands on a European level, both Tekes and the Academy are proactive actors. Tekes actively encourages open cooperation on programme level and is eager to be involved in the preparation of joint technology programmes in cooperation with other funding authorities in different countries. The management of individual programmes organises opportunities for building partnerships between foreign companies and programme participants. Research institutes and enterprises from outside of Finland can also participate in the Tekes technology programmes using a variety of means.

To promote the goal of internationalisation, the Academy has taken steps towards the wider international networking of research programmes, towards jointly funded research programmes and towards the opening up of programme components and possibly even whole programmes to the international research community, as long as this contributes to the development of Finnish research and strengthens the knowledge base in questions that are important to Finland. The Academy is also well placed to take part in programmes run by foreign funding bodies. Programme initiatives from foreign funding partners are prioritised according to current national needs.

3.1.3 Monitoring demand fulfilment

In Finland, evaluation of science, technology and innovation activities is carried out extensively and systematically especially by the Academia and Tekes. Finland pays increasingly attention to the long-term impacts of R&D activity in addition to immediate outputs. Evaluations have focused on disciplines and research fields, research programmes, research organisations, and research funding organisations as well as on research policy.

The Academy has carried out policy and programme evaluations mainly on two levels: at the level of research programmes and at the level of research fields. All the research programmes of the Academy are evaluated against the starting points of the programmes, their objectives and funding volume. The main focus is on the performance of the programme as a whole as well as on the added value it has generated, but evaluations are also carried out at the level of individual thematic areas and projects. The Academy also evaluates individual disciplines and fields of research. The purpose and objective of research field evaluation is to gain an expert and independent view of the state of the discipline in question, of the quality of its research and its development needs. The evaluations are typically carried out by international experts.

During recent years, the importance of evaluating the impacts of research has increased. This trend is evident both in applied as well as in basic research. The underlying reason for this development is the increased steering of public sector organisations based on agreed performance indicators as part of their annual performance agreements. There are increasing pressures also for research organisations to generate the evidence of impacts of their activities.

In Finnish evaluation practise, another noteworthy trend is the shift from the evaluation of individual research projects to impact evaluation at the programme level. Tekes has been particularly active in initiating evaluations that focus on the added value of programme-level activities and services. Tekes also evaluates its activities extensively. Evaluation is used to direct technology funding and to develop programme activities. In order to evaluate the impact of technology and R&D funding Tekes has defined specific indicators based on the objectives set in its strategy.

3.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Finnish research system in terms of knowledge demand can be summarized as follows:

Main strengths	Main weaknesses
• National key R&D fields are prioritized in co-operation between public and private sectors • Ability and willingness to collaboration across administrative branches in forecasting and channelling knowledge demands	• Private sector knowledge demands largely dependent on single company • Inter-organizational collaboration modest in research programme design

In Finland, public and private sectors collaborate in prioritizing the national key R&D fields on a regular basis. Also, ministries and technology agencies are used to collaborate across administrative branches when knowledge demands are forecasted and channelled. On the level of research programme design, however, interorganizational collaboration is still modest. Concerning private sector knowledge demand, Nokia's position is unique as the company accounts for nearly half of BERD in Finland.

3.3 Analysis of recent policy changes

On a high policy level, the main processes for identifying the drivers of knowledge demand have been the Finnsight 2015 foresight process, carried out in 2006, and the 2006 review "Science, Technology and Innovation" by the Science and Technology Policy Council. The Finnsight 2015 was the first major foresight effort in Finland and it tried to identify important joint future areas of expertise for science, technology, business and society. The panels include about 120 external experts whose work was supported by specialists from the Academy of Finland and Tekes. The foresight process worked also as a basis for the planning of CSTI.

In a more general level, one recent development affecting the mechanisms for identifying knowledge demand are the recent policy statements e.g. in the MEE[3] and

[3] http://www.tem.fi/index.phtml?l=en&s=2853

in the proposal for the new National Innovation Strategy (2008) that highlight the need to increase demand-led instruments in innovation policy. This new change in the policy level may also have effects in the way knowledge demand will be identified and communicated.

As a key source of public R&D funding, the Tekes strategy for future priorities is one of the mechanisms to co-ordinate the knowledge demands. The latest strategy was published in the spring of 2008 and the process involved around 200 decision makers and experts representing Finnish business, research and stakeholder groups actively participating in the process. Tekes also utilises all the everyday project discussions from the around 1,500 projects it finances annually in the strategy formulation. The strategy will guide research, development and innovation prioritisation and the use the funding of Tekes and other R&D and innovation funding resources in the future. From its own part, Tekes will implement the strategy focus areas through Tekes programmes and Strategic Centres for Science, Technology and Innovation.

The establishment of several CSTI during 2007 and 2008 is another new mechanism for coordination of knowledge demand. The organisation of the various CSTI has been carried out together by the industry, universities and research institutes. On specific task of the CSTI is namely to increase co-ordination of research activities between partners to meet the knowledge demand. According to the framework set by the Science and Technology Policy Council of Finland in June 2006, in CSTI “companies, universities and research institutes will agree on a joint research plan”. The plan will aim to meet the application needs for practical application by companies within a 5 to 10 year period.

There is also an ongoing initiative to renew the sectoral research system. Based on the specific report for developing sectoral research (Sektoritutkimusryhmän mietintö, 18 December 2006), the government made a decision on 28 June 2007 to develop the sectoral research to better meet the changing needs of the society (sectoral research is defined to mean all research that supports public policy and public services). In the resolution sectoral research was divided into four main areas: regional and community structures and infrastructure, knowledge, work and well-being, and sustainable development and safety, with each area constituting a sufficiently wide, synergic entity. The more specific research agenda for the thematic areas will be defined from the suggestion by a consultative committee established in July 2007.

Two important mechanisms for co-ordinating and channelling knowledge demands at the R&D project level are the Tekes programmes and Academy programmes. The Tekes programmes concentrate mainly on knowledge demands by the industry (with more applied focus). The programmes are also prepared in collaboration with industry and the research community and in this way the private sector knowledge demand is communicated to the public R&D funding system. The Academy research programmes are more focused on the fields that are of importance in terms of science and society (and have more basic research focus) and concentrates research efforts on topics that are currently important. The co-ordination of knowledge demands takes place in the planning stage. Research communities and other national and international stakeholders (e.g. associations, societies, delegations, committees, and authorities) are allowed to make proposals for important topics.

Monitoring the demand fulfilment is mainly carried out through various evaluations. E.g. one of the key tasks of Tekes is to analyse the impact of technology. The findings are used to steer Tekes funding and the development of the Tekes programmes. Impact analysis has been integrated into Tekes operations, which are steered according to impact targets and monitored at the project level. Impact is monitored and evaluated at the project level. The Academy, on the other hand, commissions frequently external international evaluations of the research activity in particular fields (the most recent from 2008 covers mechanical engineering research). These evaluations also consider the relevance of research in terms of knowledge demand.

In addition, external evaluations of all the Tekes programmes and the Academy research programmes are carried out, which will give feedback on the success and relevance of the programmes compared with the knowledge demand. These mechanisms have not changed much during recent years.

Challenges	Main policy changes
Identifying the drivers of knowledge demand	• Technology foresight (Finnsight 2015) • The Tekes strategy • Increasing interest in demand-led innovation policy
Coordinating and channeling knowledge demands	• The establishment of several CSTI to co-ordinate and channel the knowledge demands • The development of sectoral research to better meet needs of the society
Monitoring demand fulfilment	• No new developments

3.4 Assessment of policy opportunities and risks

The main policy opportunities and policy-related risks can be summarised as follows:

Main policy opportunities	Main policy-related risks
• By giving the industry and research organisations more responsibility and possibilities to self-organise collaboration the co-ordination of knowledge demand can be improved • The creation of demand-led innovation policy instruments may improve the ways of identifying and co-ordinating knowledge demand	• The overemphasis on co-ordinating industry knowledge demand may result that research imbalanced to the applied and short-term side in the project and programme level • At the same time the problems with industry organising may result in channelling industry knowledge demand in the strategic level • The mechanisms for monitoring of demand fulfilment may be biased towards those firms who are active in using public R&D support and may ignore the knowledge demand of other firms

The various initiatives in the strategy and first national foresight including various stakeholders as well as the new initiatives such as CSTI with a stronger participation by industry may be seen as a an policy opportunity. The foresight process as well as the Tekes strategy already act as tools for communicating the knowledge demand of various actors. However, these processes could still be developed to a more

continuous dialogue as it seems that the some industries still may have trouble in communicating their knowledge demand in strategic level.

The rise of demand-led innovation policy to the national agenda also provides new opportunities. If these developments will materialise as concrete policy measures in the near future, this means that mechanisms such as creation of lead markets, public procurement and the support for user- and customer-driven innovation processes will also create new mechanisms for identifying and channelling knowledge demand.

In the actual R&D projects and programmes the knowledge demand is quite effectively co-ordinated in Finland. This co-ordination will be even further supported by the creation of the new CSTI, where industry and the industry associations have a very active role in determining the future research agenda for these centres. However, there is a threat that the ever increasing role of industry in channelling knowledge demand supported by the relative increase in R&D funding for industry led-activities and applied research will lead to a situation where research become too imbalanced to the applied and short-term side, which has an adverse effect on the status of basic research. This concern has already been expressed in some studies, with the latest International evaluation of mechanical engineering research in Finland (2008) specifically addressing this threat.

Moreover, despite established mechanisms in monitoring knowledge demand fulfilment through programme and other evaluations there is a threat that these evaluations and assessments reflect too much the situation among those companies who use actively public R&D funding. This may lead to a situation where knowledge demand of firms working in new emerging fields or SMEs with a smaller role in collaborative R&D projects and policy discussions will be underrepresented.

3.5 Summary of the role of the ERA dimension

The role of ERA dimension in determining appropriate ways to identify, co-ordinate and monitor knowledge demand is yet quite limited, but the situation is changing. In the thematic priorities in FP7 are considered to in the planning of national programmes. Synergies between European research instruments such as the current and future EU Framework Programmes, ERA-NETs and Technology Platforms and Finnish research and development programmes are explicitly planned in the Tekes strategy (http://www.tekes.fi/eng/tekes/strategy.htm), setting up the framework for international and EU level co-ordination in the development of selected thematic priorities. However, the approach is mainly to make use of wider European instruments in the activities to respond to knowledge demand in Finland.

The official approach to ERA by the Ministry of Education is that one key mechanisms for Finland to participate to the development of the European Research Area by actively networking national research programmes (Education and Science in Finland 2008). In practice this means opening up programmes and setting up joint research programmes with other countries. Through this way knowledge demand is considered also from a wider international perspective with the idea to connect knowledge demand in Finland with wider European and International research competence.

4 - Knowledge production

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

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

Both challenges are addressed in the research-related Integrated Guideline and in the ERA green paper.

4.1 Analysis of system characteristics

4.1.1 Improving quality and excellence of knowledge production

In Finland, private sector R&D has a very strong role as over 70% of R&D spending is financed by the private sector (Statistics Finland, 2007). The private sector R&D (80& in 2006) is carried out mostly by large companies with over 250 employees (Confederation of Finnish Industries EK, 2008).

The main public research performers in Finland are the twenty universities and twenty government research institutes. In 2006, Finland's HERD was €1,079m of which 82.5% was spent in universities, 10% in polytechnics and 7.5% in university hospitals (Statistics Finland, 2007). The largest universities are the University of Helsinki (with the research expenditure of €230m in 2006), the Helsinki University of Technology (€106m), the University of Oulu (€83m) and the University of Turku (€77m). Many Finnish universities are small; the level of research expenditures was below €10m in seven of the 20 universities in 2006. The total research volume of twenty government research institutes was c. €500m in 2007 (MoE, 2007). Among the institutes, the main research performers are the VTT Technical Research Centre of Finland, the METLA Forest Research Institute, the MTT Agrifood Research Finland, the National Public Health Institute, the Institute of Occupational Health and the Environment Institute.

Both Finnish universities and government research institutes have a large degree of autonomy in ensuring the quality of academic research. The Ministry of Education that allocates general university funds for universities assesses research activity only in the terms of R&D expenditures of previous years, the objectives set for graduate schools and the number of PhD degrees produced (MoE, 2006). From the point of view of assessing and ensuring academic research quality, the Academy of Finland

plays the key role in Finland. The Academy is the main external financier of universities with the share of 18% of total external funding (MoE, 2007). The funding of Academy is based on competitive grants. Each year, the Academy arranges peer-review for 4,000 applications by using mostly foreign experts. These reviews have a major influence on the Academy's decision-making on research funding.

The Academy also carries out evaluation of the whole research system of Finland once every three years and research programme evaluation on a regular basis. Occasionally, the Academy also evaluates separate disciplines or research fields. Concerning the quality of research, the system level assessment mainly focuses on the publication outputs of the Finnish research system. The research programme evaluations that are produced one to two years after programme completion focus on the immediate outputs of research funded. The evaluations of separate disciplines that take place occasionally are interestingly different from the previous assessment practises. During a discipline evaluation, a foreign expert panel assesses the discipline in question as well as its subfields from the point of view of the level of international research. The time span under assessment may surpass half a decade and several dozens of research units may be evaluated concurrently (e.g. Academy of Finland, 2007).

Concerning openness to new scientific opportunities and interdisciplinary endeavours, the importance of national programmes for Finnish Centres of Excellence (CoE) in research is high. CoEs are given means to take risks and even venture into new research areas by extra funding provided by the CoE Programmes, given for a period of six years. A CoE consists of one or more research teams sharing a common set of research objectives and a joint management. The research teams may operate both at universities and research institutes, also in cooperation with business. CoEs are selected, funded and evaluated by the Academy. Additional funds are provided by Tekes, host organisations and business companies. Currently there are altogether 23 CoEs in the ongoing 2006-2011 programme.

Relative to population, the Finnish number of publications was 1,600 per one million inhabitants in 2005, and, among OECD countries, Finland had the fourth highest number (Lehvo & Nuutinen, 2006). Likewise, Finland had the fourth highest publication number relative to GDP. In the early 2000s, Finnish publications received c. 6 citations per publication that was 13% higher than the OECD average and, in a comparison of the citation impacts in OECD countries, Finland ranked 8th. These figures do not necessarily imply high quality of the Finnish research. Rather, they entail that active publishing is an established practice in Finnish research system and the international visibility of Finnish publications is on a good level. In the terms of scientific specialisation, Finnish research is specialized in social sciences and education, medicine disciplines, disciplines related to agriculture, environment, computer science and biology and biochemistry in comparison with the EU-15 average (Erawatch, 2006).

4.1.2 Improving exploitability of knowledge production

As in most European countries, the Finnish patent law and other intellectual property rights regulations support appropriating knowledge returns. The development of regulation is continuous. For instance, a government act on university inventions was passed by Parliament in 2006. The purpose of the new Act was to facilitate the

practical application of inventions made at universities by clarifying issues of property rights and revenues.

In 2004, the number of EPO patent applications per million inhabitants was 253 in Finland (Eurostat, 2008b). This figure was well beyond the EU-27 average of 108 and only surpassed by that of Germany, 271. Concerning specialization of patents with regard to industrial sectors, Finland was specialized in three sectors in 2001-2003: electronic equipment (including the telecommunication equipment), office machines and wood & publishing (Erawatch, 2007). The specialization was about the same a decade earlier. Within the sectors of electronic equipment and wood & publishing, there is strong correlation between BERD, patents and value added specialization. Among Finnish firms, Nokia stands out as an active and voluminous patent applicant. In 2005, Nokia filed over 850 international patent applications, making it one of the top five users of the Patent Cooperation Treaty (PCT) (Wipo, 2006).

The matching of Finnish research specialisation with economic specialization is facilitated by multiple mechanisms. There are three technological universities in Finland. Their fields of education and research cover most areas of technology of importance to the Finnish economy. The largest government research institute VTT, which is also the largest multitechnological applied research organization in northern Europe, provides various research services of direct interest to industry.

The newly established CSTI are one of the key mechanisms matching of scientific knowledge production specialisation with economic specialisation. The leading companies in each selected CSTI have been very actively involved in defining the focus research areas based on their views in future knowledge needs of the private sector.

Within the technology programmes of Tekes, supporting and stimulating academia-industry collaboration with various means is a common practice. For a long time Tekes funded collaborative knowledge production has mainly concentrated in technology based innovation in “high-tech” areas. However, recently Tekes R&D support has increasingly focused also on supporting non-technological innovations as well as other promising areas such as services, tourism and leisure services as well as workplace development. In this way the exploitability of knowledge production has also been expanded to new areas.

On a regional level, the Centres of Expertise Programme of the government has facilitated collaboration between research performers and business in selected fields, such as energy technology and food development, since 1994. The programme promotes the utilisation of the highest international standard of knowledge and expertise that exists in the different regions of Finland.

4.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Finnish research system in terms of knowledge production can be summarized as follows:

Main strengths	Main weaknesses
• High publication output and international visibility • Both universities and government research institutes are active in	• Only few universities active in knowledge production • Unbiased assessment of research quality largely dependent on the

knowledge production • Multiple mechanisms supporting exploitability of research	Academy • Low number of businesses engaged in R&D work.

The knowledge production of Finnish research system results in a high quantity of publications with international visibility. In higher education sector, knowledge production is largely dependent on few main universities while there are many poor performers among universities. The unbiased quality assessment of the Finnish research is largely dependent on one agency, the Academy. Concerning mechanisms supporting exploitability of research, Finland has much strength in terms of regulation, institutions and patenting activity in industry.

In the private sector, even though the level of BERD is high, R&D work is heavily concentrated in few high tech industries, such as electronics, and relatively few large companies.

4.3 Analysis of recent policy changes

The most important policy change is the development of the university system. There has been some critique during recent years about the quality of Finnish university research. This debate has been backed up with international rankings of universities, in which Finnish universities have not done as well as various interest groups would have wanted. There has been a widely shared fear that the Finnish university system is falling behind in the international comparison.

In March 2008, the Ministry of Education published the new guidelines for the structural development of the universities between 2008 and 2011, based on the development plan for education and research 2007-2012 (accepted by the government in December 5 2007). According to these guidelines the autonomy of universities will be increased and the university network will be condensed in order to improve the quality of education and research and to increase in internationally competitive research. The actual measures range from increasing collaboration between universities in education, research and services to universities mergers. The new universities will start August 1 2009. The more detailed operational plan for structural development of the university system will be ready in 2010. The most visible measure is the establishment of the new "top university" by merging the Helsinki University of Technology, the Helsinki School of Economics and the University of Art and Design Helsinki.

The preparations for the reform of the sectoral research system are underway at the Ministry of Education and at the Finnish National Board of Education (FNBE) and the government decision about the changes are planned to be made at the end of 2008. In addition to steering research activities, the reform will also aim at improving the quality and effectiveness of the sectoral research system by making changes in the structure and operations of the various state research institutes. The government is about to make decisions on these changes at the end of 2008.

The ongoing development of research career system is underway. Finland is currently developing a four-tier research career system in order to make postdoctoral research careers more predictable and attractive based on the work of the working group 'Realising a Research Career'. A specific memo was published in April 2008 (MoE 2008:15) that acts as a basis for development measures in the coming years.

There has been a conscious effort to improve the exploitation of knowledge production especially related to universities. In January 2007 a new Act on the ownership of university inventions (369/2006) came into effect. The aim of the new act is to clarify the juridical position of inventions, to improve the identification and protection of inventions and to promote the commercialization of university inventions. It is yet unclear how well this new law will in reality improve the exploitation of knowledge production from what it is now. Another effort related to this is the work on the development of university innovation services that started in 2006 with the aim to create a joint national model for exploiting university innovations and to increase collaboration between various universities. This initiative may be very helpful especially for smaller universities with less human resources for managing the exploitation of knowledge production.

The initiative to renew the administration of issues related to intellectual property rights. The preparation of the National IPR Strategy began in the fall of 2007 under the leadership of the Ministry of Trade and Industry together with the Ministry of Education. The new strategy is expected to be ready at the end of 2008.

Internationalisation of research is one of the key activities in the ongoing research system reform and the development of the international dimension is also stated in the 2007 government programme. In practice this means increasing support for the international networking of universities and R&D organisations. The Ministry of Education has also stated an objective to strengthen the prerequisites for high level research by coordinating national and EU level research policies and activities and by financing joint activities.

In practice, this is visible e.g. in the activities of the Academy of Finland where international collaboration in various instruments, such as research programmes and graduate school system, has increased recently. Increasing the international mobility of research staff and making Finland more attractive for foreign professionals has also been one of the objectives. The typical approach in Finland has not been to set up many new instruments but to promote the international dimension in the existing activities. This includes the active use of EU funding and mobility instruments as well as promoting international collaboration in R&D programmes. During recent years both Tekes and the Academy of Finland have actively developed the international dimension of their programmes.

The changes in the university system, the sectoral research system and the IPR system respond to the elements of the Lisbon strategy, especially with the recommendations to modernise management of research institutions and universities and more effective and efficient public expenditure.

Challenges	Main policy changes
Improving quality and excellence of knowledge production	• University reform process • The creation of Aalto university to improve cross-disciplinary excellence • The development of sectoral research system to develop research in various research institutes • The development of research career system for attracting and retaining talented young researchers • Promoting international collaboration in research activities
Ensuring exploitability of knowledge production	• Improving the management of university inventions • The development of university innovation services

4.4 Assessment of policy opportunities and risks

The main policy opportunities and policy-related risks can be summarised as follows:

Main policy opportunities	Main policy-related risks
• More attractive university and sectoral research systems that ensure better conditions for making high level research and attract talented researchers	• The reforms in the universities and in the sectoral research system may also have negative effects to research activity due to expected streamlining of activities • Overemphasis on development activities that try to find improved research performance on economies of scale • The structural changes may not be enough if sufficient resources are not given to research activities

The policy opportunities in developing knowledge production arise from the new policy efforts to make structural changes in both the university system and the state research institutes. The idea for developing the university system is to make universities more dynamic actors in the innovation system by giving them more autonomy, by making the university network more effective and consistent and by improving the personnel policy to make universities better working environments for high level research.

However, the significant opportunities may be partly lost if the reforms are not carried out properly. Firstly, the reforms include streamlining activities with potential closing down of some activities and units and mergers and division of labour. If these activities are not carried out carefully, important knowledge and capabilities may be lost, which are not compensated with improved efficiency. Secondly, there is a risk that mergers and economies of scale by themselves automatically lead to improved research quality and as a result organisational changes are not carried out truly as planned. As a result the new system may look better in paper but the actual underlying operations have not changed as planned. Thirdly, structural changes may be not enough in some cases if sufficient resources are not attached to them. For example the new research career system may create more interesting job opportunities for researchers but that may not be enough to attract talented researchers if the salaries are not competitive with the private sector.

4.5 Summary of the role of the ERA dimension

Internationalisation of research is one of the key activities in the research system reform and one of the focus areas in both the 2007 government programme as well as the new National Innovation Strategy (2008). The Finnish research policy aims to increase the internationalisation of research and ERA has an important role in these plans. In practice this means increasing support for the international networking of universities and R&D organisations.

More specifically as a response to the government programme the process of preparing a national strategy for internationalisation of the university system has been initiated. This strategy process is about to be completed by the beginning of 2009. The aim of the strategy is to promote and steer the internationalisation strategies of universities. The Academy of Finland has also published a new strategy for international activities, where the internationalisation of research careers and research programmes are especially related to ERA.

The approach to ERA by the MoE is that one key mechanisms for Finland to participate to the development of the European Research Area by actively networking national research programmes (Education and Science in Finland, 2008). In practice this means opening up programmes and setting up joint research programmes with other countries. Through this way knowledge demand is considered also from a wider international perspective with the idea to connect knowledge demand in Finland with wider European and International research competence.

ERA is not specifically addressed very clearly but is only one dimension in the internationalisation. Moreover, it seems that ERA dimension is mainly associated with Finnish participation in the activities of European programmes (Framework programmes, ERA-NETs, ERC etc.), initiatives (e.g. the development of Research infrastructures) and various organisations such as COST, EUI, ESF, IIASA, ESA, ESO, CERN, etc.

5 - Knowledge circulation

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

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

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

5.1 Analysis of system characteristics

5.1.1 Facilitating knowledge circulation between university, PRO and business sectors

Knowledge circulation within the Finnish research system is relatively strong in international comparison and the interaction between public and private research has not been identified as a major issue.

In 2005, the percentage of HERD financed by the Finnish industry was 6.5% that was the same as the estimated EU-27 average (OECD, 2008). In the same year, the percentage of GOVERD financed by industry was 12.4% that was much higher than the estimated EU-27 average of 8.5% and only surpassed by Poland. These figures imply that university-business R&D linkages are on an average level in Finland while public research institute-business linkages are above average. The high percentage of GOVERD financed by industry is largely due to the business collaboration of one research institute, VTT. In 2006, the share of external funding for VTT was 68%, which was likewise 68% of total external funding received by the Finnish research institutes. Half (51%) of the external funding of VTT was provided by domestic or foreign business (VTT, 2007). For the majority of other research institutes, the share of external funding – let alone business funding – is notably smaller.

Since the beginning of the 1980s, the technology programmes of Tekes have provided important venues for knowledge circulation between the universities, research institutes and business sector in Finland. The technology programmes are established in strategically important R&D areas that Tekes has identified jointly with the business sector and researcher community. Half of the Tekes funding is channelled through the programmes. Since 1993, special technology programmes have been dedicated to supporting commercialization of research and academic spin-offs. These TULI programmes aim at supporting commercialisation of publicly funded research results, developing commercialisation services in universities, polytechnics and research institutes, promoting cooperation between research organisations and companies, as well as creating viable businesses through start-ups, spin-offs and technology transfer. Projects funded by the programme are run by 45 universities, polytechnics and research institutes. In 2008-2014, the programme budget is approximately €50m.

According to a recent study (Kankaala et al., 2007), the research services and technology transfer organizations (TTOs) of Finnish universities - including also VTT - have a staff of two to three employees whose tasks are exclusively concerned with research commercialization. The study notifies that many TTOs of European universities report having a similar staff of ten. International comparisons are difficult to make, however, since job descriptions of the staff and interpretation of survey results vary from country to country. For instance, the TTO of Helsinki School of Technology has a staff of 30 while only a few of them are exclusively devoted to handling research commercialization tasks. During this decade, both the work force and competence of the Finnish TTOs have increased and in 2006 there were 19 university TTOs with the total of 107 people working in them (15 TTOs and 41-46 people in 2001) (Kansallinen yliopistojen..., 2007). Moreover, several polytechnics have also recently established their own TTOs.

TTOs are quite capable of counselling university staff about IPR issues and helping them to find suitable partners or service providers on a regional level. Concerning national or international collaboration, the Finnish TTOs have a limited amount of collaborative relationships and some TTOs may even lack international contacts.

According to the study mentioned above, Finnish TTOs received 40 invention announcements from university staff on average in 2005. At the same time, 7 university inventions received a patent granted, 5 spin-out companies were founded, and the license revenue of the universities was €236,000 on average per university. In comparison with British TTOs, the Finnish figures were similar with the exception

of the license revenue that was twice as large in the UK than in Finland. Even though spin-out companies are actively founded in Finland, their economic performance has proven somewhat disappointing. Among 171 spin-out companies founded in 2000-2005, only one company had an annual turnover over €2m and only 15 companies had succeeded in increasing turnover over €400,000 by 2005.

As mentioned earlier, the public sector employs most of the Finnish PhDs, which also sets the limits for researcher mobility between academia and industry. At the Finnish universities, academia-business collaboration is often intensified by founding professorships in close collaboration with the business sector. Private enterprises participate in defining the research area of a professorship and provide its total or partial funding. During the 1990s and 2000s, the number of professorships based on external funding has steadily increased in Finland. In 2005, there were 189 externally funded professorships at the Finnish universities (Vilhula et al. 2006). The share of business sector in the external funding of professorships was moderate, however, since only one third of external funding came from business. Many of the professorships based on external funding are located outside the university cities, and, therefore, their importance for local business may be considerable on a regional level.

In 2006, the Academy founded a programme supporting PhD mobility between the academia and private sector. A researcher could apply for a project that is accomplished outside home organisation by moving from academia to a firm or vice versa. When the programme was launched, it did not attract researchers' attention and half of the funding remained unused. This was an abnormal situation in the Finnish research funding system in which hard competition among applicants is a general rule.

The collaboration between PROs and universities is also relatively common in research projects. Despite this there have been many discussions to extend the collaboration between the universities and PROs. The aim of the increasing collaboration is not only to increase knowledge circulation through joint research activities but also more efficient use of shared knowledge infrastructures (labs, libraries etc.) as well as better utilisation of international collaboration (Ministry of Education, 2008). It has also been argued that the division of labour between the PROs and universities has left gaps in the research and that more collaboration and joint structures in the “interfaces” are needed to better meet the needs of the society (Sektoritutkimuksen..., 2006).

5.1.2 Profiting from access to international knowledge

The international mobility of university researchers is a well-established practice in the Finnish research system. In 2007 Finnish teachers and researchers made a total of 614 visits of a minimum of one month's duration to foreign universities (www.research.fi). Correspondingly 1,104 foreign researchers visited Finnish universities. In the same year, the Academy had bilateral agreements with 27 countries or regions and with 42 science and research funding organisations. On the basis of these agreements, the Academy granted around €1.5m to support the international mobility of researchers. With this support, a total of 373 foreign researchers visited Finland, and 113 Finnish researchers worked abroad for a fixed period of time. Most of the Academy's funding to international mobility is, however,

channelled through project and programme funding as well as through funding supporting researcher training.

In addition to the Academy, researcher mobility is supported by the Centre for International Mobility CIMO. In 2007, CIMO granted altogether 650 grants for longer-term postgraduate studies and shorter visits, 358 of which were for foreign postgraduate students coming to Finland. The largest numbers of visitors came from Russia, Hungary and India. Tekes supports internationalization of research by providing funding for researcher exchanges during research projects, for organizing information sharing meetings, as well as for joint projects with foreign partners. Tekes also supports planning phases of international research projects.

From the point of view of European R&D collaboration, Finland stood out as an active player in the FP6. In 2006, there were Finnish participants in 862 EU-funded projects within the FP6 (www.research.fi). The projects usually had several Finnish participants and the total number of Finnish participants was 1,213. Participation was divided by organisation type as follows: universities 34%, research centres 27%, large companies 15%, SMEs 15% and others 8%.

5.1.3 Absorptive capacity of knowledge users

The absorptive capacity of knowledge users is largely dependent on few large corporations in Finland. As INNO-Policy TrendChart - Policy Trends and Appraisal report of Finland (PRO INNO Europe, 2007) states, the Finnish R&D spending is in absolute terms concentrated on a handful of large domestic MNCs, Nokia being in its own class. The report identifies lack of innovative growth-oriented SMEs and start-ups as one of the weaknesses of the Finnish innovation system. Broadening of the base of companies that are innovative, internationally competitive and growth-oriented requires, according to the report, more policy efforts in Finland. The European Innovation Scoreboard 2007 (EC, 2008) indicates, however, that Finnish SMEs perform relatively well in European comparison. The share of SMEs innovating in-house (24.7%) was higher than the EU-27 average (21.6%). Moreover, the share of innovative SMEs co-operating with each other (17.3%) was significantly higher than the EU-27 average (9.1%).

The main support for R&D activities in Finnish SMEs is provided via Tekes funding. In 2000-2007, more than 50% of Tekes funding was allocated to SMEs (Tekes, 2008). Especially, the importance of Tekes funding for small Finnish firms carrying out R&D is substantial. In 2007, Tekes funding covered one third of R&D expenditures of Finnish firms with less than 50 employees.

Concerning the availability of skilled work force, Finland also performs well in European context. The share of S&E graduates and population with tertiary education were above the EU-27 averages in 2007(EC, 2008), On a regional level, some areas, including the Helsinki Metropolis Region and the Oulu region, are increasingly suffering a shortage of skilled labour or a mismatch between labour demand and supply (PRO INNO Europe,, 2007). Employment-based immigration, combined with the increased professional and regional mobility of labour, is an issue that has emerged lately in policy agendas.

5.2 Assessment of strengths and weaknesses

The strengths and weaknesses of the Finnish research system in terms of knowledge circulation can be summarized as follows:

Main strengths	Main weaknesses
• Multiple support mechanisms for commercialization of research and academic spin-offs • Participation in international research collaboration on a high level • Highly-skilled work force available	• Researcher mobility between academia and business on a low level • Poor economic success of academic spin-outs • Lack of innovative growth-oriented SMEs in spite of high investments in SMEs' R&D and innovation activities • Insufficient collaboration between sectoral research performers

The Finnish research system has made continuous efforts to support research commercialization and academic spin-outs. From this perspective, the economic success of academic spin-out companies during this decade is surprisingly poor, which indicates system inefficiencies. The Finnish researcher community actively participates in international collaboration while the researcher mobility between industry and academia is on a low level. There is lack of innovative growth-oriented SMEs in Finland even though the public investments in SMEs' R&D activities are on a high level and the level of innovation activities reported by SMEs is high. This seems to be in many cases more of a problem with financing, growth-orientation and management than with innovation. Therefore instruments related to seed funding and various support services have been developed recently (Ministry of Trade and Industry, 2007). However, more policy support is still needed.

As for public-public knowledge circulation, the interaction between various sectoral research activities has been seen as problematic. An ongoing reform in sectoral research system also partly addresses this issue.

5.3 Analysis of recent policy changes

If looking at co-operation as an indicator, knowledge circulation has been less of challenge in Finland than in many other countries. According to the Fourth Community Innovation Survey (Eurostat, 2007), innovation co-operation was third highest in Finland after Lithuania and Slovenia. Moreover, in private-public co-operation Finland was in the first place. Research and innovation policy instruments such as Tekes collaborative R&D funding instruments and the Centre of Expertise Programme (and other sector specific funding) have actively facilitated knowledge circulation between universities, public research organisations and firms. Despite this, there are still challenges in further developing knowledge circulation.

The new National Innovation Strategy (October 2008) contains several challenges and proposals related to knowledge circulation. One proposed key measure is to increase government support for demand oriented and user-centred innovation. This approach requires broad based interaction between knowledge users and knowledge producers but also between the producers and users of various products and services. Another key mechanism is to develop the utilization IPR. One part of this development is to enhance the capabilities of SMEs to protect intellectual property but also to make better use of it. Another dimension is to develop the IPR

mechanisms to support better knowledge circulation. There is process underway to create a dedicated IP strategy for the national intellectual property rights system. In November 2007, a committee representing both business world and public bodies was formed to plan and prepare the IP strategy. The new government IP strategy is expected to be completed by the end of 2008.

More generally, support for new collaborative research and innovation environments is slowly rising at least in the general policy level. New mechanisms, such as open innovation, living labs, lead markets are actively analysed and according to the proposed national innovation strategy capitalising on these new interactive mechanisms should be supported in the future.

In order to increase the use of international knowledge, the new national innovation strategy highlights the need to promote international mobility of researchers for improving access to international knowledge and to make better use of the competences of experts with foreign background. Several initiatives are proposed, such as new incentives and operations for accessing international expertise and to participate in open innovation processes, accepting R&D work carried out abroad in nationally R&D funding schemes when it's strategically justified. The idea behind this approach is to facilitate access to international knowledge as it is acknowledged that in a small country there is a need to utilize technology and know-how created elsewhere to complement the domestic knowledge base. Another proposed initiative to increase access to international knowledge is to promote the mobility of international experts. This is proposed to be achieved by supporting the mobility of researchers with increasing funding for researcher exchange and other international activities of researchers. The research policy activities are planned to be supported by an improved immigration policy that encourages work-related immigration. There is also a pressure to change personal tax system to make Finland more attractive for international experts.

One of the objectives in the university reform is to develop the university management and financing system to support interaction between university, firms and the society. The basic idea is to make interaction easier by making rules and practices more flexible.

The Education and research 2007-2012 development plan explicitly addresses the need for universities and research institutes to participate actively in international co-operation and especially FP7. Active participation is seen as a tool for developing the internationalization of research, which on the other hand facilitates access to international knowledge.

One specific policy aim is to support co-ordination and steering of sectoral research to better support policy decision making. One of the aims of the reform in sectoral research is to increase collaboration between various sectoral research institutes. The Advisory Board on Sectoral Research (established in 2007) aims to "promote the standardisation of research information management, the evaluation of research materials and the joint use of such materials, with the aim of facilitating cooperation between research producers and making more efficient use of knowledge" (Academy of Finland, 2008). The reform in sectoral research also aims at icreasing public-private research collaboration in order to better jointly respond to innovation needs in the public sector (Science and Technology Policy Council, 2008).

As already mentioned in the previous chapters, the establishment of Strategic Centres for Science, Technology and Innovation (CSTI) is one of the key research

policy initiatives in Finland, addressing several policy challenges. Facilitating knowledge circulation between university, PRO and business sectors is one of the key functions of the CSTI besides other objectives. The role of CSTI is not only to mobilize resources and to direct them to strategic areas but to also facilitate interaction between knowledge producers and knowledge users.

The operations model of the Centre of Expertise Programme has also been reformed for the term 2007–2013 to a more "cluster-based" model. Ever since its creation in 1994 the programme has been the active cooperation between universities, R&D organisations, companies and local governments. In 2007 the programme was renewed to strengthen cooperation between various centres of expertise working in the same sectors and to promote specialisation inside these clusters by forming 13 "competence centres" in specific fields (Osaamiskeskusohjelma 2007-2013).

The increasing role of lifelong learning in ensuring the absorptive capacity of knowledge users is recognized in the Finnish science policy. This has been addressed in the new initiative to renew the continuing education system to better response the changing education needs based. In August 2008 the Ministry of Education set up a steering committee to help develop a reform of vocational adult education (AKKU), which was one of the reforms addressed in the government programme. According to the plan the key proposals will be presented in 2008 and 2009 and the implementation will start in 2010.

Challenges	Main policy changes
Facilitating knowledge circulation between university, PRO and business sectors	• The proposal for National Innovation Strategy • The revision of the IPR administration and the creation of the new National IPR Strategy • The development of university management and financing system to support interaction between university, firms and the society • Revised Centre of Expertise Programme • The establishment of Strategic Centres for Science, Technology and Innovation (CSTI)
Profiting from access to international knowledge	• The proposal for National Innovation Strategy
Absorptive capacity of knowledge users	• The continuing education system reform

5.4 Assessment of policy opportunities and risks

The main policy-related opportunities and risks in addressing knowledge circulation in Finland are as follows:

Main policy opportunities	Main policy-related risks
• Promoting a more active role of the private sector and also customers and users in the innovation process may create additional pressure for collaborative research • Improving the support mechanisms for SMEs to develop their capabilities to absorb new knowledge may increase knowledge circulation significantly • New policy initiatives to increase mobility of researchers and other highly qualified labour force to increase access to international knowledge	• The policy instruments that support knowledge circulation may favour large companies and companies with more experience of R&D collaboration and have difficulties in reaching SMEs

The increasing role of demand oriented innovation policy instruments and new more innovation practices may also provide additional boost to research activities and knowledge circulations as it changes the logic from science push to demand pull (even more than it is already now). The new innovation practices demand extensive interaction between research organisations, producers and users, which provides new and enhanced channels for knowledge circulation.

However, there is a risk that the currently well working instruments that support knowledge circulation as well as the new initiatives such as the CSTI and the ne IP practices mainly benefit larger companies and those firms that have experience of participating in various collaborative projects, programmes and forums. The real challenge is to improve the ability of SMEs and firms in more traditional sectors to make use of new knowledge as well as new innovations from other sectors.

Although many SMEs work in a supplier role and therefore mainly collaborate with other companies in their value chain in R&D, it does not mean that knowledge circulation only happens between firms. Mechanisms to support the absorptive capabilities of SMEs does not only help them in their business-to-business interactions but may also open up new business opportunities by enabling them to using knowledge from many sources, including universities and public research organisations.

The increase in the mobility of researchers and other highly qualified labour force are needed to increase access to international knowledge. Some measures are already in action and some new are proposed in the national innovation strategy. These activities should be further strengthened.

5.5 Summary of the role of the ERA dimension

The support for the creation of the European Research Area is one of the key objectives proposed in the national innovation strategy proposal. ERA (or ERIA, as mentioned in the white paper) is seen as an extended “home market” for R&D activities that strengthens and complements the Finnish research environment and therefore Finland should aim to take an active role in the development of ERIA at the European level (Valtioneuvoston selonteko, 2008). It is especially seen that new initiatives to encourage firms to participate in European decision making forums and to make better use of wider ERA resources in R&D.

ERA is also a key dimension in the Finnish IPR policy. One of the key objectives of the new IPR strategy is also to define Finland’s objectives for developing the IP policy of the European Union and facilitate harmonised interpretation of the IPR legislation all over the EU as well as on the international level is one of the key issues for those using IPR tools.

6 - Overall assessment and conclusions

6.1 Strengths and weaknesses of research system and governance

Research and innovation have been national priorities in Finland for quite a long time. However, there has been a gradual change in policy thinking from the separate science and technology policies of the 1980s towards the more complex notion of innovation and a broader view of policies. At the same time there has been a move from the linear innovation model to a more interactive and integrative model. This change has highlighted the need for a more systemic approach to research policy. The concept of the national innovation system has provided a basic framework for policy considerations from the early 1990s and since then this model has been developed and fine-tuned to better respond to the needs of the R&D performers and particularly the private sector. The R&D investments have also developed quite substantially from €1.8b to €6.2b with the lead of the private sector with Nokia in the lead. The strong concentration of R&D activity in few sectors and to large companies has also been seen as a threat and there has been a continuous effort to also support various other promising technology areas.

The Finnish research system has also been leaned heavily on domestic human capital and the research system has had difficulties in attracting talented researchers and students. The university system has also had difficulties in providing proper research careers for young researchers. At the same time, the private sector has not been able to provide proper employment for many PhDs.

The Finnish research governance system is very integrated with well-established connections between the government, the public research performers and the private sector. There has also been a quite heavy belief in the planning and co-ordination of activities. This has been the strength of the research system but it also possesses a threat that the system supports too much existing industries, technologies and organisations and does not allow enough room for new unexpected areas to emerge and grow.

The strengths and weaknesses of the Finnish research system and governance can be summarised as follows:

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Public and private R&D investments are on a high level
	Securing long term investment in research	A further increase in R&D investments is a widely-accepted policy objective as well as an innovation oriented approach to national policy.
	Dealing with barriers to private R&D investment	The strength of the Finnish system is that BERD is already at a very high level. The weakness is that a significant part of the BERD is dependent on Nokia and the related ICT industry.
	Providing qualified human resources	Strengths exist in the overall high level of basic education. Finland also has a large existing HRST. The weaknesses lie in the system ability to attract talented domestic and foreign students and to make research career more attractive

Domain	Challenge	Assessment of strengths and weaknesses
Knowledge demand	Identifying the drivers of knowledge demand	The strength of the Finnish research system is that national key areas are identified in co-operation between public and private sectors. On the other hand the well-established R&D funding system may have difficulties to identify the knowledge demand of new players and SMEs
	Co-ordination and channelling knowledge demands	Several co-ordination mechanisms for knowledge demand is strength. At the same time these various mechanisms are not well coordinated in practice by themselves.
	Monitoring of demand fulfilment	Evaluation is systematically carried out in many different levels
Knowledge production	Ensuring quality and excellence of knowledge production	High publication output and international visibility Mechanisms open to new scientific opportunities Research activity scattered to many organisations and units
	Ensuring exploitability of knowledge	Many mechanisms to match scientific knowledge production to economic and societal needs Many instruments to support the exploitability of knowledge
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	A number of effective instruments exists to support knowledge circulation
	Profiting from international knowledge	Good participation of Finnish partners in international collaborative research Relatively low level of foreign R&D investment Mediocre attractiveness for international students and talented knowledge workers
	Enhancing absorptive capacity of knowledge users	High level of S&E graduates and workers in S&T Low level of PhDs working in the private sector The absorptive capacity of knowledge users concentrated on large corporations

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

In order to better support broad-based innovation in addition to research- and technology-driven innovation as well as to respond to the various challenges, Finland has launched several reforms to revise the current research system. These include the structural development of higher education institutions, the national innovation strategy, the Strategic Centres for Science, Technology and Innovation (CSTI), the reform of sectoral research, the national infrastructure policy, the implementation of the four-stage research career model, the internationalisation of various functions and the promotion of research and innovation funding especially in new areas such as services.

Despite the continuous changes and even proactive improving of the research system the summary table below indicates that there are still some risks in the research policy approach.

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	• Development of domestic lead markets, venture capital and other mechanisms to promote demand for innovative innovation and R&D • Increase the attractiveness of Finland for investors, knowledge workers and students • Further increase joint programming activities with internal partners	• Too much selection and focus in research policy may benefit those actors who are already mobilised
Knowledge demand	• More active role of the business sector in co-ordination of knowledge demand • Creation of new demand-led innovation policy instruments to provide new ways of identifying and co-ordinating knowledge demand	• The well established national system for identifying and coordinating knowledge demand may result in too much national focus in policy despite many initiatives to internationalise the research system • The strong private sector participation in knowledge demand co-ordination may direct research too much on short-term and applied research
Knowledge production	• More dynamic university and sectoral research systems making high level research and attracting talented researchers	• Overemphasis on economies of scale instead of quality and diversity
Knowledge circulation	• Attracting more companies to participate in collaborative research activities • Increasing mobility of researchers and other highly qualified labour force	• Increased knowledge circulation affects only selected sectors and preferred businesses

6.3 System and policy dynamics from the perspective of the ERA

European and international context is important for Finland. Despite strong national priority of research and innovation policies, international linkages are necessary not only for scientific reasons but also to economic reasons to complement the rather limited national resources in a small country. Although ERA is specifically addressed in the internationalisation activities of various research policy actors, ERA is not explicitly addressed very clearly but is only one dimension in the internationalisation.

A common approach seems to be that at the European level that various European policy instruments and organisations are used to “to reinforce and complement the Finnish innovation environment” as it is explicitly stated in the new national innovation strategy (MEE, 2008). On the other hand in some cases the reality seems to be increasingly the other way around so that the participation of Finnish organisations in European level activities (R&D programmes, research infrastructure, mobility etc.) is actively promoted and national initiatives are only launched for those activities that are not already covered at the European level or for international activities with non-EU countries (e.g. the Academy of Finland international activities).

Finnish research policy organisations are therefore very active in international initiatives and especially those within ERA. Finland participates actively in many European research organisations such as the European Space Agency (ESA), the European Organisation for Astronomical Research in the Southern Hemisphere

(ESO), European Organisation for Nuclear Research (CERN), European Molecular Biology Laboratory (EMBL), and the European Molecular Biology Conference (EMBC). Finnish partners also participate above average in European R&D programmes, such as FP6 and FP7 and ERC and COST. Finland has also been very active in participating in the European ERA-NETs. Finnish companies are also active in European initiatives such as European Technology Platforms (ETP's) and Joint Technology Initiatives (JTIs).

Besides collaborative research activities and participation in the activities of European research organisations the other main efforts with a clear ERA dimension are the networking and opening up of various research programmes to foreign participants, the promotion of researcher mobility and interaction in the development of research infrastructures. During recent years both Tekes and the Academy of Finland have actively developed the international dimension of their programmes. Many of the programmes are open to foreign participants (although not always funding) and international co-operation within research projects is actively encouraged.

The support international researcher mobility is also closely related ERA developments. The mobility of talented Finnish researchers is seen as important in order to strengthen the quality of research and the education and research system as a whole. Both national and European instruments are actively used for promoting research mobility.

The European joint development of research infrastructures is also an important topic. The current national focus on development on developing research infrastructures is tied to wider European developments as the cost of modern research infrastructures is often quite high. For coordinating the development activities Finland is actively participating in the operations European Strategy Forum on Research Infrastructures (ESFRI) for steering the development of research infrastructures in Europe.

Besides active focus on operating within ERA, the Finnish science policy has also a specific Nordic dimension. The Nordic countries collaborate in many different operations and arenas, e.g. in various Nordic Centre of Excellence Programmes. Finland has collaborative activities also with many other countries outside the ERA.

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List of Abbreviations

BERD	Business Enterprise Expenditure on R&D
CEP	Centre of Expertise Programme
CIMO	Centre for International Mobility
CoE	Centres of Excellence
COST	European Cooperation in the field of Scientific and Technical Research
CSTI	Strategic Centres for Science, Technology and Innovation
EC	European Commission
ERA	European Research Area
ERC	European Research Council
ERIA	European Research and Innovation Area
EU	European Union
FDI	Foreign direct investments
FNBE	the Finnish National Board of Education
FP6	Sixth Research Framework Programme (European Commission)
FP7	Seventh Research Framework Programme (European Commission)
FTE	Full-time employee
GBAORD	Government Budget Appropriations or Outlays on R&D
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
HERD	Higher Education Expenditure on R&D
HRST	Human Resources in Science and Technology
ICT	Information and Communication Technology
IPR	Intellectual property rights

MEE	Ministry of Employment and the Economy
MoE	Ministry of Education
OECD	Organisation for Economic Co-operation and Development
PRO	Public Research Organisation
R&D	Research and Development
S&E	Science and Engineering
S&T	Science and Technology
Sitra	Finnish National Fund for Research and Development
SME	Small and medium sized enterprises
STPC	Science and Technology Policy Council
Tekes	the Finnish Funding Agency for Technology and Innovation
TTO	Technology transfer office
VTT	VTT Technical Research Centre of Finland

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Abstract

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

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the Joint Research Centre functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

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