JRC Scientific and Technical Reports

ERAWATCH Country Report 2008
An assessment of research system and policies

Sweden

Pauline Mattsson and Tomas Åström

EUR 23766 EN/27 - 2009

JRC EUROPEAN COMMISSION

Institute for Prospective Technological Studies

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JRC 51003
EUR 23766 EN/27
ISBN 978-92-79-11956-9
ISSN 1018-5593
DOI 10.2791/ XXXX

Luxembourg: Office for Official Publications of the European Communities

Printed in Spain

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Acknowledgements and further information:

This analytical country report is one of 27 reports for EU Member States prepared as part of the ERAWATCH project. ERAWATCH is a joint initiative of the European Commission's Directorates General for Research and Joint Research Centre. For further information on ERAWATCH see http://cordis.europa.eu/erawatch.

The analytical framework and the structure have been developed by the Institute for Prospective Technological Studies of the European Commission's Joint Research Centre (JRC-IPTS, project officer: Jan Nill) and have been improved based on comments of DG Research, Ken Guy, Stefan Kuhlmann, Nikos Maroulis, Patries Boekholt, Aris Kaloudis, Slavo Radosevic and Matthias Weber.

The report has been produced by the ERAWATCH Network in the framework of the specific contract on ERAWATCH country reports 2008 commissioned by JRC-IPTS (project manager: Nikos Maroulis, Logotech). It makes use of information provided in the ERAWATCH Research Inventory with support of the ERAWATCH Network (http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.home). It has benefited from comments and suggestions of Aris Kaloudis, who reviewed the draft report. The contributions and comments of Joaquin Azagra Caro and Jan Nill from JRC-IPTS are also gratefully acknowledged.

The report is only published in electronic format and available on the ERAWATCH website: http://cordis.europa.eu/erawatch. Comments on this report are welcome and should be addressed to Mark Boden (Mark.Boden@ec.europa.eu).

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. To support the mutual learning process and the monitoring of Member States efforts, one task of JRC-IPTS within ERAWATCH is to produce analytical country reports. The main objective is to characterise and assess the performance of national research systems and related policies in a structured manner that is comparable across countries. In order to do so, the system analysis focuses on key processes relevant for system performance. Four policy-relevant domains of the research system are distinguished, namely resource mobilisation, knowledge demand, knowledge production and knowledge circulation. This report is based on a synthesis of information from the ERAWATCH Research Inventory and other important available information sources.

R&D in Sweden has for decades had a high priority among policy makers, industry and the general public. In 2007, the total R&D expenditure amounted to 3.63% of GDP compared to the average member state country at 1.83%. Sweden is the EU country that invests most in R&D relative to its GDP. This implies that Sweden already is meeting the Lisbon objectives. One of the main attractions for foreign companies to establish their businesses in Sweden has been the knowledge base. This is partly because the strong public funding specialisation in fields corresponding to industry demands. Also the quality of knowledge production in Sweden is high. According to publication and citation rates Sweden belongs to the top countries. Since industry is the main R&D investor it is also the main employee for researchers outside universities. A number of initiatives and centres of excellence are in place aiming at improving the knowledge circulation between academia, research institutes and industry even further.

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Meeting the Lisbon objectives, which gives Sweden a competitive advantage in comparison to other EU-countries
	Securing long term investment in research	High R&D investment
	Dealing with barriers to private R&D investment	Swedish paradox: inadequate return on public investments in R&D
	Providing qualified human resources	Highly skilled R&D personnel
Knowledge demand	Identifying the drivers of knowledge demand	Strong public funding specialisation in fields corresponding to industry demand. Limited R&D demand from SMEs
	Co-ordination and channelling knowledge demands	Fragmented innovation system which makes demands from different actors unclear
	Monitoring of demand fulfilment	Lack of systematic evaluation approach

Knowledge production	Ensuring quality and excellence of knowledge production	High scientific quality according to publication and citation rate
	Ensuring exploitability of knowledge	Economic strengths and industrial needs coincide with the research focus carried out at universities Universities not able to carry out their third mission in a satisfactory way
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Instruments in place targeting academic – industry collaborations
	Profiting from international knowledge	Attractive research environment for international researchers e.g. tax incentives and social benefits
	Enhancing absorptive capacity of knowledge users	Research intensive industry sector Difficulties in transforming research results into products

The main weaknesses in the Swedish system, which are related to the Swedish paradox (Edquist, 2002), are inadequate return on public investments in R&D and transferring basic research into applied. Despite the many policies emphasising the need to encourage start-ups, many stakeholders believe that these are not sufficient. The fragmented innovation system has made it difficult to identify knowledge demands from actors that are developed in between well defined R&D phases. Further, universities in Sweden are obligated to pursue activities that produce knowledge that will have a societal impact, the so called third mission. This has not been done in a satisfying way which has resulted in a gap between academia and industry. It is first and foremost the commercialisation process resulting in new start-ups that have been criticised. A major reason is the lack of incentives for researchers to create their own companies and the unfavourable economic environment for start-ups.

Increasing globalisation ensures new funding opportunities and access to a wider research base and potential collaboration partners. Increasing foreign demand of Swedish R&D services (R&D globalisation effect) and the increasing size of European Framework Programmes, Eureka etc. have made this possible. Since Swedish researchers have a good reputation for performing high-quality research there is a readiness among foreign researchers to include Swedish researchers in funded international research projects.

The concept of long-term funded centres of excellence with the objective to support innovation and economic growth are getting increasingly popular among funding agencies. The first evaluations, mainly mid-term, have indicated high quality of the knowledge production and increasing collaborations and knowledge circulation between industry, academia and other stakeholders.

Domain	Main policy opportunities	Main policy-related threats
Resource mobilisation	• Increasing globalisation ensuring international funding opportunities	• Increasing globalisation resulting in MNCs moving their R&D investments abroad • Decrease of competent research knowledge base
Knowledge demand	• In identified prioritised fields Sweden has a strong research base and	• International global companies reallocating R&D resources because Sweden cannot provide the required

	innovation tradition • Instruments in place target the knowledge demand from both universities and industry	knowledge base
Knowledge production	• Increasing collaboration with industry and international attractiveness through centres of excellences. • Increasing focus on target research fields, which are in accordance with the economic specialisation • Focus on quality which might increase the competitiveness	• Not living up the international demand of knowledge production • Low level of entrepreneurship at Swedish universities
Knowledge circulation	• The first evaluations of the centres of excellence indicate increasing collaborations between private and public sectors	• Decreasing industry R&D investment

The main threats are related to globalisation and MNCs moving their activities abroad. Sweden has been an attractive country providing a highly skilled knowledge base for international companies carrying out R&D activities. Since the number of S&T graduates has been decreasing and other countries provide different economic benefits for companies, there is a concern that Sweden will lose out on foreign R&D investments and existing MNCs will move their activities elsewhere. Sweden is the EU country that invests most in R&D relative to its GDP. However, in contrast to many other countries, the volume of R&D investment has decreased in recent years from a peak in 2001. There is a need to find alternative sources of funding.

The decreasing public funding to universities has resulting in a knowledge gap between academia and industry. The production of entrepreneurial skills has for several years been an issue in Sweden and indicators such as the decreasing number of patents and start-ups over the last years have underscored this problem.

The number of graduates selecting science and engineering degrees has decreased in recent years. Since many of the MNCs are found in the high-tech sector there is a need for qualified human knowledge in these fields. If Sweden cannot provide industry with this knowledge base there is a risk that these companies move their activities abroad. Also the degree of industry R&D investment has decreased which is also related to the relocation of industry.

The increasing importance of progress towards an ERA was highlighted in the most recent policy bill. The majority of the strategies and references identified are in line with the ERA approach. The document also introduces a reorganisation of the national support system for participating in EU programmes to better respond to the demands brought by the ERA. The impact in the form of Europeanization is visible in the number of programmes already targeting the mobility of researchers within Europe. Also, the openness towards other European organisation has increased, even though the majority of national founding schemes are targeting Swedish organisations.

TABLE OF CONTENTS

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 guideline 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 strengths and weaknesses, as well as of policy-related opportunities and threats. A particular consideration in the analysis is given to aspects of Europeanisation in the governance of national research systems in the framework of the European Research Area, re-launched 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.

Figure 1: Domains and generic challenges of research systems

Resource mobilisation	Knowledge demand	Knowledge production	Knowledge circulation
• Justifying resource provision	• Identification of knowledge	• Quality and excellence of	• Knowledge circulation between

• Long term research investment • Barriers to private R&D funding • Qualified human resources	demand drivers • Co-ordination of knowledge demands • Monitoring of demand fulfilment	knowledge production • Exploitability of knowledge production	university, PRO and business sectors • International knowledge access • Absorptive capacity

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

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

This report is based on a synthesis of information from the European Commission's ERAWATCH Research 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 four main subsections in correspondence with the four steps of the analysis. The report concludes in chapter 6 with an overall assessment of strengths and weaknesses of the research system and governance and policy dynamics, opportunities and threats 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

Sweden is the EU country that invests most in R&D relative to its GDP. In 2007, the total R&D expenditure amounted to 3.63% of GDP compared to the average member state country at 1.83%. However, in contrast to many other countries, the volume of R&D investment has decreased in recent years from a peak in 2001.

Sweden has a scattered governance system and, while the policy formulation is carried out on a governmental level, agencies are responsible for design and implementation of policy instruments. The government ensures policy coordination at ministry level. At agency level, policy implementation is in principle dispersed and coordination is carried out informally and on an ad hoc basis, in accordance with tradition. No formal and obligatory fora for coordination exist in the area of research policy and operations, and it is a well-known fact that lack of comprehensive coordination at this level is a weakness of the Swedish system.

R&D policies are mainly formulated by the Ministry of Education and Research, the Ministry of Enterprise, Energy and Communication and to a certain degree the Ministry of Defence. Three permanent advisory bodies assist the ministries in their work. The Research Policy Council (RPC) established in 1962 and chaired by the Ministry of Education and Research has an important role in advising and assisting the ministry in preparing research policy bills every fourth year. The Innovation Policy Council (IPC) was established in 2004 and is chaired by the Ministry of Enterprise, Energy and Communication. Its function is mainly to assist in communication between the ministry and its stakeholders in issues related to innovation policy. The third advisory body, Institute for Growth Policy Studies (ITPS) reports to the Ministry of Enterprise, Energy and Communication and its main tasks are to provide analysis, policy intelligence and evaluate governmental policies. In 2008 it was decided that ITPS together with NUTEK, the Swedish Agency for Economic and Regional Growth, and Glesbygdsverket, the Swedish National Rural Development Agency, will be closed down and replaced by two new authorities. The take over is scheduled for January 2009.

The main agency supporting R&D is the Swedish Research Council (VR), funded by the Ministry of Education and Research. The main responsibility includes funding of research across fields of natural and social sciences, medicine and education. The funding mainly takes place on an individual level, but research groups and institutions have received increasing funding in recent years. The Swedish Council for Working Life and Social Science (FAS), supported by the Ministry of Health and Social Affairs, is responsible for funding research on welfare, labour market, health and social services. The Swedish Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS), funds research on ecological, conservation, natural resources and construction issues. The funding is provided by the Ministry of Sustainable Development and the Ministry of Agriculture, Food and Consumer Affairs.

Apart from the agencies there are also six national semi-public foundations such as the Swedish Foundation for Strategic Research (SSF) supporting research in science and engineering and the Knowledge Foundation (KKS) promoting basic research carried out at newly established universities.

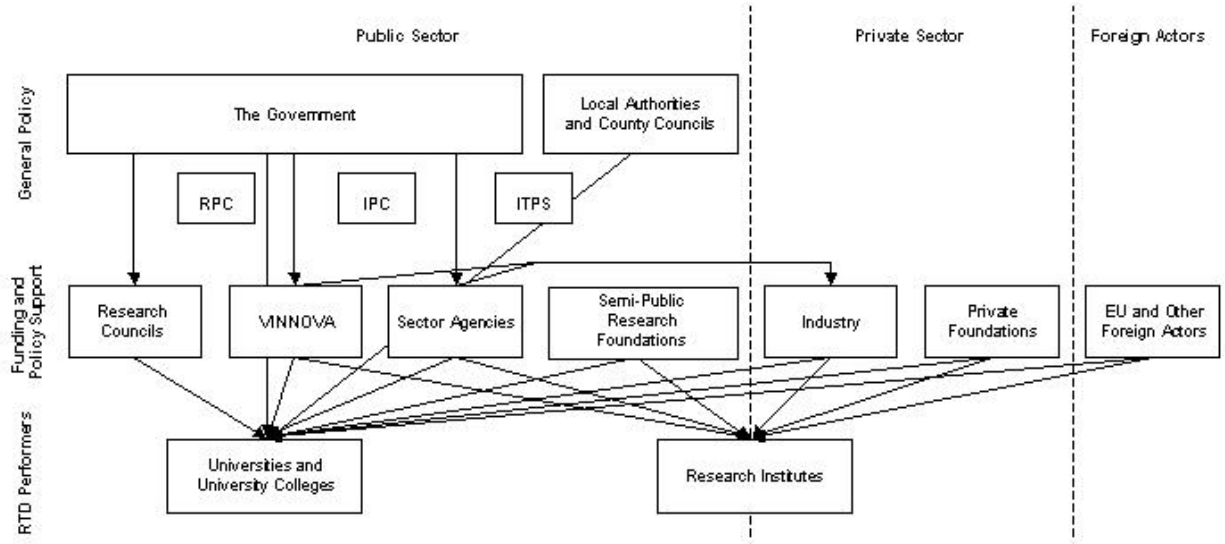
Research of applied nature is supported by the Swedish Governmental Agency for Innovation Systems (VINNOVA). It was established in 2001 and receives its funding from the Ministry of Enterprise, Energy and Communication but does also interact with the Ministry of Education and Research in research related issues. VINNOVA's area of responsibility includes funding of problem-oriented R&D and innovation-oriented activities linked to R&D. Other major R&D actors include the Swedish National Space Board, the Swedish Energy Agency, and the Swedish Defence Material Administration.

Research in Sweden is mainly carried out by the industry and the higher education sector. The business enterprise sector is the main performer with 73% of GERD in 2007 (Eurostat). The university sector is the second biggest performer accounting for 21% of GERD. In Sweden there are 14 state-owned universities and 42 public or state-owned colleges for higher education. These colleges only provide undergraduate courses and do not educate researchers and therefore only a limited amount of research is carried out. The tasks of the universities include: to educate, conduct research and provide industry with mission-oriented research. Carrying out technology transfer is also recognised as their third task. In many countries, government-run research institutes take care of the latter task. In Sweden research institutes only account for 3% of the available public resources. The main role of the existing research institutes is to act as intermediaries between academia and industry by carrying out research at the level between basic research and industrial applications (ERAWATCH Research Inventory, 2008).

Overall, research policy is decided on a national level but in the government bill "A Policy for Growth and Viability throughout Sweden" (2001/2002:4) the first regional policy was introduced. It focuses on each region's capacity in terms of economic growth and urban renewal. The regional activities take place on the county level. There are 21 counties in Sweden, which are responsible for the Regional Partnership for Growth that was initiated in the government bill "A Policy for Growth and Prosperity in the whole Country" (Prop 2001/02:04) and the "Regional Councils of Competence, Regional Growth for Jobs and Welfare" (Prop 1997/98:62). This includes policies targeting regional development, business, labour market, and research. On the municipality level, the responsibilities include business development and services. The municipalities have their own budget based on income taxes and state funding.

		Source of funding							
		All sectors		Business enterprise sector		Government sector		Abroad	
		2001	2005	2001	2005	2001	2005	2001	2005
Sectors of performance	All sectors	10510.59	11184.20	7520.03	7348.04	2235.64	2628.79	353.30	862.00
	Business enterprise sector	8118.5	8289.95	7399.44	7218.44	470.94	349.92	237.96	705.97
	Government sector	297.24	527.78	4.65	7.86	277.36	497.73	10.16	12.21
	Higher education sector	2085.44	2333.50	114.64	120.45	1481.67	1768.55	104.91	142.96
	Private non-profit sector	9.66	32.97	1.30	1.29	5.66	12.60	0.26	0.86

Table 1: Total intramural R&D expenditure (GERD) by sectors of performance and source of funding in Sweden. In Million €. 2001 & 2005. Source: Eurostat



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

Sweden has already achieved most of the targets set by the Lisbon Strategy. For example Sweden fulfils the 3% objective with an investment of 3.63% of GDP in 2007 (Eurostat). This means that the external pressure and EU-related justifications are not the main incentives for research investments.

It is rather Sweden's long history as a welfare country relying heavily on technology and having a R&D demanding industry that has been the main driver for the high investment. The policy makers have recognised this fact and in the latest research bill "Research for a better Life" one of the four major objectives was to maintain world-class quality in education and research (Government bill, 2005). This is nothing new and it has been a top priority in Swedish policy making for many years.

The MNC are the main employers of research educated personnel in Sweden and have been the main force behind many of Sweden's human capital policies. The majority of researchers working in the private sector are found in these companies. Human skills have for long been an important factor for MNCs in their decision to establish their businesses in Sweden. Therefore, the motivation to educate research skilled personnel, specifically in natural sciences and engineering, has been a justification for investing in human resources.

Even if the importance of research has been clearly visible in policy documents, the GBAORD as a percentage of the total governmental expenditure has decreased over the last years, indicating that the government has put the importance of R&D lower on the political agenda. In 2005, GBAORD was 1.57% which is somewhat above the EU25 average of 1.56% and below several countries such as Spain, Finland, Germany, and France (Eurostat).

Decreasing national funding has enhanced the importance of collaborations and international funding. In “Research for a Better Life” the importance of FP-participation and of the ability to better respond to the challenges and opportunities brought by the ERA were highlighted (Government bill, 2005). This has resulted in increasing participation in ERA-NET projects. In addition, structural funds have had an increasing importance especially on the regional level.

All public funding agencies and councils have a responsibility to communicate knowledge and inform the general public about their activities. This is done through a number of different activities such as online information, collaborations with industry and other interest organisations, newsletters, journals, and public seminars.

Since R&D have had such a central role on the political agenda and companies such as Saab, Electrolux, Volvo, Scania, Ericsson, Astra, and ABB have had a significant role in economic growth, the public has developed a great trust in R&D. Decreasing interest among policy makers and the perception that MNCs are moving their facilities abroad have resulted in an increasing public debate that something drastic need to be done before Sweden looses its reputation and position as a world leading R&D nation. There are also concerns that Sweden will loose out on work opportunities and eventually economic growth will be affected.

2.1.2 Securing long term investment in research

The main provider of public R&D funding is the Ministry for Education and Research allocating 52% of the governments total R&D funding. The Ministry of Defence has had a pronounced position in R&D investment but in recent years there has been a dramatic reduction in the government funding to defence related research. The trend is foreseen to continue and the role of the defence sector as a R&D actor will continue to diminish. The third biggest ministry is the Ministry of Enterprise, Energy and Communication allocating 13% of the governments R&D funding to mainly sector agencies. Political parties have generally been in agreement on the high priority of the research policy. The governmental financed GERD as a percentage of GDP was in 2005 0.89% compared to the EU25 average of 0.61%. The total R&D expenditure amounted to €11 184m (SEK104b). In addition to the government’s investment, six semi-public research foundations contribute additional money. The two major foundations SSF and KKS allocate nearly 70% of all the foundations total R&D investment in 2006. KKS supports research environments with distinctive profiles at Sweden’s new universities and other higher education institutions. The SSF funds research in natural science, engineering and medicine that strengthens Sweden’s competitiveness.

56% of the Swedish government’s direct R&D investment, goes to curiosity-driven research and 42% to mission-oriented R&D (20% to defence-related research and 22% to non-defence-related research). The majority of the investment in curiosity-driven research is transferred directly to the universities and the university colleges and the remaining is funnelled through the three research councils. The main beneficiaries of government R&D funding are universities receiving 60% of the total, and industry, which receives around 20% in 2005 (Eurostat).

The industry is the main investor in R&D with 2.79% of GDP in 2006 (Eurostat). This implies that the industry accounts for 75% of the total R&D investment with the bulk being invested in intramural research. In recent years there has been a fall in industry investment. The explanation is that several of the big global companies have reallocated their R&D to other countries. This is also the main reason why the total investment as a percentage of GDP has been decreasing. If these cuts continue the pressure on the government to augment its investment in R&D will increase.

Every fourth year the government prepares a government bill where the long term objectives for public research and the budget for coming years are decided. Ahead of each bill all universities, colleges and research councils have to submit their research strategies. The responsible minister also consults with other relevant stakeholders such as foundations and industry organisations. In addition to the more general priorities, details are implemented on an annual basis as part of the budget adopted by the government. The latest bill “Research for a better life” was published in 2005 (Government bill, 2005). The next bill is expected in October 2008.

The Committee for Research Infrastructures (KFI) is the VR’s expert body on matters relating to the use and establishment of research infrastructure. A major priority for VR and for Sweden in general is the efforts put into hosting the European Spallation Source (ESS), a proposed research facility for scientific research using neutrons. VR has appointed a committee that is analysing the impact of ESS on Swedish research and how Swedish expertise in related fields can be used in the site-selection process. The work is conducted in collaboration with other providers of Swedish research funding. The activities include strategic work, calling for grant applications, monitoring and evaluation. The Committee is also engaged in promoting technical and industrial exchange between Swedish companies and international research facilities. The KFI’s budget for 2008 is approximately SEK 700 million.

European funding sources have assumed increasing importance in recent years. It is first and foremost the Framework Programmes (FP) that have been the main international source of funding. Swedish actors, mainly carrying out mission oriented research, received €651m in FP6, which amounts to almost 4.1% of the total FP funding. In FP5 the same number was 3.7%, making Sweden the eighth biggest recipient (VINNOVA, 2008). The increase in funding indicates a growing importance of FP participation. Other EU initiatives such as the structural funds are insignificant in comparison to the national investments. Sweden also participates in most of the existing shared infrastructure facilities in Europe e.g. CERN, ESO, EMBL with the VR acting as the Swedish coordinator.

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

The Swedish private sector invests 2.79% of GDP in R&D in 2006 (Eurostat), thereby being the largest R&D investor in Sweden. The private investments are concentrated to a few MNCs. The 20 biggest companies accounted for more than 60% of the total private expenditures and 67% of the business R&D was performed by companies with more than 1000 employees in 2005 (European Commission, 2007). The large firms and multinational companies have significantly shaped the R&D policy in Sweden. This can be seen in the fields of political priorities, which are closely aligned with the leading industrial sectors

including ICT (Ericsson), engineering and machinery (Volvo, Scania, Atlas Copco, ABB), and pharmaceuticals (AstraZeneca).

Foreign affiliates expenditures is rather high in business R&D, accounting for 42% of the total R&D expenditures of enterprises. This is probably related to the MNCs that have ongoing activities and subsidiaries abroad. Of the hundred highest R&D investors in Europe, seven companies are Swedish owned (European Commission, 2007). Since the Swedish MNCs are dependent on skilled human resources and basic research they are also interested in having a good quality public research base. Private actors fund 15% (10% from private non-profit sector and 5% from the business enterprise sector) of the public research carried out at universities or research institutes, 1.3% is of foreign origin. The Swedish government accounts for 5.9% of the total business investments in 2005. This is less than the average EU27 investment of 6.9%. The government has focused on funding basic research since the business sector is focusing on applied research.

The availability of venture capital, targeting new technology companies, has in line with many other countries decreased since the end of the 90s. Most other countries, however, experienced a sharper decrease in comparison to Sweden, which improved the Swedish world position. Venture capital targeting expansion of companies increased significantly over the last decade and accounted for 0.25% of GDP in 2006. The total venture capital investment constituted about 0.05% of total GDP in 2006. Only the United Kingdom has a higher share.

The main actor contributing to the creation of new enterprises, growing enterprises and strong regions is NUTEK, the Swedish Agency for Economic and Regional Growth. The organisation provides support and money for both new and growing enterprises and also promotes entrepreneurship.

Although Sweden has a high representation of large R&D intensive companies the number of high-tech SMEs is low. This problem is very much related to the Swedish paradox (Edquist, 2002): the high investment in R&D is not paying off in terms of economic growth to the extent expected. The biggest challenge is to change the risk-averse attitudes towards entrepreneurship. Sweden is on the lower half of the Entrepreneurship index. A decade ago the availability of venture capital was high and it was rather easy for start-ups to receive money. Since then, investors have become more careful and do not invest in high risk projects. Despite the many policies emphasising the need to encourage start-ups many stakeholders believe that R&D tax incentives are the only way to go in the attempt to improve the entrepreneurial culture. These types of tax deductions existed in the 80s but have since been abolished. However, it should be mentioned that the low corporate income tax of 28% partly compensates for the lack of other tax measures and is an attempt to encourage entrepreneurship.

2.1.4 Providing qualified human resources

Human resources have been one of the strongest incentives for foreign companies to establish their research activities in Sweden. The share of graduates is above the EU average and the proportion of R&D personnel is high. In 2005, 24,867 people were employed as teachers and researchers at universities and university colleges and there were 9,882 PhD students. Sweden spends 6.9% of GDP on human resources. Only Denmark is investing more.

In the 1990s a number of policy measures were put into place, such as dedicated postgraduate schools, with the objective to increase the number of persons with postgraduate degrees. This resulted in an increase of PhDs by 70%. The major driver for this was MNCs that needed more research educated employees. The majority of R&D personnel in the public sector work for universities, since research institutes account only for a small part of the research carried out in Sweden. Since the unemployment rate of graduated researchers is rather low and the big companies offers secure work opportunities, often in relation to R&D activities, graduates choose to work for big companies, rather than starting their own businesses.

The biggest challenge is to secure a replacement of 45% of researchers that are expected to retire within the coming decade. Measure such as more secure conditions for PhD students (e.g. through salaries instead of grants) and social benefits, are being put in place to attract more postgraduates.

In recent years the number of students enrolling for natural science or engineering degrees has decreased. There is a growing concern that the reputation of Sweden providing a good knowledge base for high-tech companies will diminish. Initiatives promoting natural sciences and engineering at high schools are in place to attract more students to related university degrees.

The Swedish universities have an international reputation of providing high quality education and in recent years the number of foreign students applying to universities has increased substantially. Also initiatives attracting foreign researchers are in place e.g. tax reductions. Such tax incentives include the provision that foreign nationals only pay tax on 75% of his/her income during the first three years in Sweden.

2.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Swedish research system in terms of resource mobilisation for R&D can be summarised a follows:

Main strengths	Main weaknesses
• High R&D investment from both public and private sources. • Meeting the Lisbon objectives, which gives Sweden a competitive advantage in comparison to other EU-countries • Highly skilled R&D personnel	• Swedish paradox: inadequate return on public investments in R&D

The role of R&D on the Swedish political agenda has for many years been pronounced both among the general public (e.g. position statements by NGOs and industry associations) but also in formal documents such as research bills and other official governmental papers. The overall R&D investment is evidence for this priority: 3.73% of GDP in 2005. It is mainly the industry investing in R&D. One of the main attractions for foreign companies to establish their businesses in Sweden has been the knowledge base. The government has for many years invested a fair amount of money on producing

postgraduates with research skills. Since the vast majority of MNCs in Sweden has a high-tech focus the prioritised areas have been natural sciences and engineering.

The Swedish paradox (Edquist, 2002) has for years been the strongest weakness of the system with inadequate return from the public investment in R&D. This is partly related to the lack of entrepreneurship and transferring basic research into applied. Instruments promoting and funding start-ups and SMEs are partly in place but are still not sufficient.

2.3 Analysis of recent policy changes

Since 2006 Sweden has had a new government coalition with the Moderate Party (conservative) in majority. The priorities have not changed much from the previous government but in the Budget Bill the need to focus on high quality in research and graduate education was highlighted.

Since R&D investments in Sweden have decreased in recent years there is a need to find alternative sources of funding. Increasing foreign demand of Swedish R&D services (R&D globalisation effect) and the increasing size of European Framework Programmes, Eureka etc. have made this possible. Sweden could take more advantage of these options, even though the participation rate has increased for every FP contract. EU participation has become more important both in evaluation studies and as an indicator of research quality, Since Swedish researchers have a good reputation for performing high-quality research there is a readiness among foreign researchers to include Swedish researchers in funded research projects.

The importance of strong research and innovation environments was highlighted in the research bill. To secure long term funding and to attract foreign investment a number of centres of excellence in both curiosity-driven and mission-oriented research have been established. The aims of these environments are to continue performing world-class research, provide innovative environments and maintain a strong knowledge base. The final objective is to establish Sweden as an attractive partner for both companies and R&D investments. A strong knowledge base would also increase the chances of researchers competing successfully for international grants. Existing initiatives of this kind include VINN Excellence Center (2007-2016), Berzelii Centres, FAS Centres, and VINNVÄXT (2005-2014) (ERAWATCH Research Inventory, 2008).

Globalisation is not only an opportunity for researchers but also a threat for private investments. In the most recent decade several MNC have moved their activities and investments abroad because of lower costs. If the government is not compensating for this decrease in R&D investment, there is a risk that Sweden will lose its position as a world leading research nation. In 2007 the Government decided to set up the Globalisation Council consisting of experienced people from a number of sectors of society. The aim is to analyse how Sweden can address the challenges of the future and to suggest a strategy how to benefit from the potentially welfare gains generated by globalisation. The work will be summarised in a final report including recommendations in mainly in the area of economic policy.

Sweden already fulfils most of the Lisbon goals but the main challenge is to achieve the 1% target of publicly financed R&D investment. In the Swedish National Reform Programme (NRP) a number of action plans how to reach the Lisbon goals are stated.

Relevant instruments related to resource mobilisation include: financial support for SMEs to invest in R&D, expanding availability of seed capital for commercialisation of research results, development of action plans for commercialisation and technology transfer at universities.

To achieve this goal of increasing quality in research the government increased the grant to higher education. There is also a need to educate more researchers since 45% of all university employees will retire in the next decade. Also the number of students in engineering and natural sciences is an increasing problem since the industry is in great demand of these skills. The VR is supporting different kinds of fellowships for postdoctoral student as well as PhDs and more senior researchers. The aim is to provide resource provision for research activities initiated by the researchers themselves. This is a means to support researchers staying in academia.

A new research policy bill is expected in October 2008 where the government is expected to increase the public R&D investment. As an input to this bill a number of agencies, councils, and industry organisations have been asked to provide strategy documents and visions for the coming four years together with an estimation of the resource requirements for new instruments.

Challenges	Main policy changes
Justifying resource provision for research activities	• Increasing importance of EU-participation • Major objective to maintain world-class quality in education and research in latest research bill
Securing long term investments in research	• Focus on strong research and innovation environments with granting for up to ten years • Instruments targeting prioritised research fields
Dealing with uncertain returns and other barriers to business R&D investments	• Establishment of a Globalisation Council • Some instruments in place targeting SMEs • Technology transfer offices at universities
Providing qualified human resources	• Increasing individual grants for excellence among PhDs, postdocs and seniors

2.4 Assessment of policy opportunities and threats

The main opportunities and threats for resource mobilisation in Sweden arising from recent policy responses include:

Main policy opportunities	Main policy-related threats
• Increasing globalisation ensuring international funding opportunities	• Increasing globalisation resulting in MNCs moving their R&D investments abroad • Decrease of competent research knowledge base

The challenge of justifying resource provision for research activities does rather present an opportunity in Sweden since research is an important element in the society and industry has been investing heavily in R&D.

Securing long term investments in research can be considered a risk since R&D investment has decreased in recent years mainly due to MNCs moving their activities abroad. It is important that the government acknowledge this fact and increase the public funding.

Dealing with uncertain returns and other barriers to business R&D investments has for long been a risk in Sweden and has been referred to as the “Swedish paradox”. Even though some instruments are in place targeting SMEs they might not be enough to stimulate economic growth.

The challenge of providing qualified human resource has for long been the main opportunity why MNCs base their activities in Sweden. Globalisation and increasing competition from other countries highlight the importance to continuing and maybe even increase resources put into providing a qualified knowledge base.

2.5 Summary of the role of the ERA dimension

Sweden is taking part in most of the existing shared European infrastructures. These environments provide a platform for Swedish researcher to meet other European researcher and exchange ideas and experiences. It is also an opportunity to create long-term collaborations between foreign and Swedish research organisations. This is particularly important in application processes for funding within the framework programmes often requiring collaborations between different countries.

The existence of the Marie Curie fellowship has increased the mobility of especially young researchers. The number of foreign students in Sweden has increased significantly in recent years, which partly is due to the increasing mobility 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 expenditures on R&D as targeted by IG7 of the Lisbon Strategy.

3.1 Analysis of system characteristics

3.1.1 Identifying the drivers of knowledge demand

Structure of knowledge demand
In Sweden R&D is seen as the main contributor to economic growth, labour market performance and welfare. Research is contributing with new knowledge that can be used both in the public as well as the private sector.

Swedish aggregate R&D intensity grew significantly over the period 1993-2003. The main R&D investor is the business sector accounting for over 75% of the total R&D expenditure. Also HERD exhibited strong growth over the same period, while GOVERD as a percentage of GDP remained constant with a marginal 0.1% share. The numbers indicate that the government's share in financing research has been reduced, while the private sector and funding from abroad increased their relative shares. Since 2003, the industry's R&D investment has decreased mainly due to globalisation and companies moving their activities to other countries (Erawatch Network, 2006).

The research priorities in Sweden do very much coincide with the business sector's demand. It is mainly the MNCs rather than the SMEs that have been in demand for R&D even though the picture is changing. The MNCs can be found in sectors such as engineering (accounting for 50% of the production), forestry, ICT, biotechnology and life sciences, environmental industries, and renewable energy. According to the country specialisation report priorities for GBAORD by socio-economic objective, show a pattern oriented toward specialisation in social issues, general university funds, land use, defence and agriculture. EU15 was used as a reference. The public funding of BERD, is directed toward sectors in Sweden that exhibit strong or relatively strong specialisation, such as office machinery, research and various services sectors. The larger share of public funding however, was directed toward motor vehicles (35.4%) that lost in specialisation in BERD over the 1993-2003 period. What is notable in the case of Sweden is that public funding for

BERD is dispersed over a relatively small number of sectors compared to other countries such as Germany and France (ERAWATCH Network, 2006).

The main identifier of new demands in basic research is the VR. The supported research fields include natural and engineering sciences but also projects in humanities and social sciences, medicine, and educational sciences receive funding.

Increasing globalisation has put more pressure on the universities to stay competitive. Still the R&D investment in the HERD, by field of science, has been stable over the last decade. It is noteworthy that over 70% of civilian public R&D expenditure is allocated to so-called curiosity driven basic research, i.e. research controlled by academic quality criteria. Medical sciences and engineering receive over 50% of the total funding dedicated to the higher education research system.

Processes for identifying the drivers of knowledge demand
Every fourth year the R&D priorities for the coming years are identified and analysed in a research policy bill, prepared by the ruling government. The system for preparing government bills includes a comprehensive and well-proven coordination function. More important proposals from the government are prepared by ad-hoc committees appointed by the government, which often include members of Parliament representing political parties from all sides. The reports of the ad-hoc committees are directed to the government, and are then usually sent out for comments to a large number of stakeholders, including a range of government agencies and industry organisations, to ensure that their views and demands are taken into account. Examples of such agencies and organisations include: VINNOVA, the State Audit Institution, the Swedish National Agency for Higher Education, the Swedish Agency for Public Management, the National Courts Administration, universities, unions, and research councils. The process at ministry level then includes a consultation mechanism between the ministries concerned, often in the form of internal coordination committees, which in principle guarantees that the bill put before Parliament represents the collective wisdom and will of the entire government. At this stage, informal consultations with agencies normally take place.

National technology foresight projects have been carried out twice in Sweden, the first one was finalised in 2000 and the most recent one in 2004. The Royal Swedish academy of Engineering Sciences was the platform for both exercises. The government together with national agencies financed the first foresight study. Almost 130 representatives from academia, industry, and other research communities participated. Sweden's strengths and weaknesses in eight different fields: ICT; materials and materials flows in the community, society's infrastructure; biological natural resources; health, medicine and care; education and learning; service industries; production systems were identified. The second activity was financed by eight large organisations. The purpose was to initiate a debate on how to prioritise research.

3.1.2 Co-ordinating and channelling knowledge demands

Sweden has a private sector that invests heavily in R&D. Since the industry mainly invests in applied sciences the government mostly considers and funds basic research carried out at universities. In Sweden there are separate policies for industry, research, and education. The Ministry of Education and Research is responsible for issues concerning research and education and the Ministry of Enterprise, Energy and Communications for

industry related questions. Other ministries involved in the decision making process are the Ministry of Environment in issues concerning education and research, the Ministry of Integration and Gender Equality and the Ministry for Foreign Affairs deciding on issues related to industry, trade and regional growth. In 2004, the relationship between science performing organisations and industry was raised as a concern for the efficiency of the system. The Swedish innovation system had been accused for being linear with VR handling and financing basic research and VINNOVA taking care of the needs-driven research. A strategy, "Innovative Sweden", trying to merge and coordinate issues related to education, research, trade, and industry policy areas and to improve the coordination and collaborations with involved actors was developed. The project was jointly initiated by three ministries: the Ministry of Education and Research, the Ministry of Enterprise, Energy and Communication, and the Ministry of Defence. The strategy identifies VINNOVA and VR as the main funding actors and takes many of its ideas and formulations from the Lisbon strategy (Government White Paper, 2004).

Research policies are formulated by the ministries assisted by the councils and agencies. The implementation is carried out at the agency level, acting and deciding rather independently on what kind of programmes should be designed within the framework of white papers and other regulations issued by the government. Since the innovation policy was adopted in 2004 the government has implemented a new body, the Innovation Policy Council (IPC) (Government White Paper, 2004). The aim is to improve the possibilities for coordinating research and innovation policies.

In the inquiry "Research funding – quality and relevance"[2], commissioned by the government, the establishment of a new coordinated research funding agency, the Research and Innovation Agency, is suggested. The inquiry makes the assessment that the agency structure implemented in 2001 has not been fully able to realise the goals and ambitions that were intended. In organisational terms the inquiry proposes that four councils should be set up focusing on nature, engineering and innovation; medicine and health; climate, environment and agricultural sciences; society and culture. The councils would be coordinated by a central agency organisation that also would include central research policy, strategic, analytical and international activities, a department for research infrastructure and departments for legal affairs and communication. The final observation concludes that the present system can be made more efficient and better suited to its purposes by making a new body responsible for certain tasks and by every agency reinforcing its strategic planning and being more active in the selection of funding instruments. At the same time there is still a need for better coordination.

Thematically oriented R&D funding is decided on a governmental level. In the latest research policy bill a number of prioritised areas were identified namely life sciences, engineering, and sustainable development. Initiatives such as the "Green Car", and the "National Space Research Programme", initiated by the government in consultation with the industry, and "Swedish Brain Power" are programmes that directly can be linked to the White Paper. In parallel with these initiatives different sector programmes have been developed in dialogues between government, industry and trade unions, so called Industry Branch Talks. The automobile and aerospace sectors were the first sector to receive funding in 1994. Since then, additional sectors have been selected, including wood and forestry, metals, IT and telecom, and pharmaceuticals and biotechnology. In the budget bill

[2] Published in May 2008

for 2008 the government has announced that more resources will be put into medicine, technology and energy and climate. More than three milliard SEK will be allocated to climate and energy related issues. The allocation is a mean to achieve the goals of EUs energy and climate agreements. The objective is also to improve and expand exportation, employment, and economic growth in Sweden. In comparison to previous focus of governmental granting the activities will target technological development, more efficient markets and increasing global solidarity (Government bill, 2008).

According to the Country Specialisation Report, priorities for GBAORD in Sweden show a pattern oriented towards social issues with strong specialisation also in general university funds, land use, defence, and agriculture. Within the higher education research system, medical sciences and engineering receive over 50% of total funding (ERAWATCH Network, 2006).

The bill “Research for a Better Life” provides many references to the ERA and introduced a reorganised national support system for participation in EU programmes to better respond to the challenges and opportunities brought on by the emerging ERA. The national focal points for these activities are VINNOVA and VR, which has been commissioned to develop ERA-related national strategies and to absorb the previously independent agency for information regarding EU programmes. The aforementioned research policy bill also favourably mentions Swedish participation in ERA-NET projects. VINNOVA is by far Sweden's most frequent participant in the ERA-NET taking part in 13 projects within the block "Strengthen the Foundation for the European Research Area" (Government bill, 2005).

3.1.3 Monitoring demand fulfilment

Research policy evaluations have a long tradition in Sweden. Initiatives to perform evaluations of research policies and programmes are usually taken by the funding agencies themselves and managed on the micro level. In the 1980s and the 1990s, most innovation related evaluations at the micro level focused on the effects of need driven research. The evaluations where mainly used to measure the quality of the research carried out in the frame of the programme and with no overall coordination system, see chapter 4. Therefore, no coherent overview of these efforts is available and there are no figures on how many evaluations have been performed.

Today, evaluations have a different objective mainly due to declining public budgets. It has become more important to motivate ongoing measures and increase their effectiveness. Still there is no systematic approach in place comparable to those found in England or Germany. This implies that the quality and structure of evaluations differ between agencies and other actors. In the operational work, the evaluations have proven to be a good tool for programme managers or the individual organisation. The knowledge is rarely distributed to the aggregated agency level and used as input for policy learning. Thus, the research councils, VINNOVA, the semi-public research foundations, etc. initiate evaluations of their own programmes on a regular basis. While small scale evaluations targeting projects or specific parts of bigger programmes are performed in-house, there are also more extensive evaluations using a systems perspective. It is common that larger programmes include ex ante, half-time and ex post evaluations. The most widespread type of evaluations are impact analysis and do often include peer reviews to assess the scientific quality of the research. There has been an increasing trend to engage foreign experts.

This is an attempt to increase the recognition of Swedish research abroad and to test the quality of the results in an international environment.

The most influential evaluating organisations are the Swedish National Audit Office, the Swedish National Financial Management Authority and the Swedish Agency for Public Management. The Institute for Growth Policy Studies plays an important role in evaluations concerning innovation and growth policy. The bodies report directly to either the government or the parliament and all reports are publicly available.

An example of a recent evaluation with significant impact is the centres of excellence. The programme was already evaluated at an initial level by foreign experts. Since the programme was regarded a success it has been used as a model on how to support industrial academic cooperation (Stenius and Mårtensson, 2008).

3.2 Assessment of strengths and weaknesses

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

Main strengths	**Main weaknesses**
• Strong research base in fields corresponding to the industry sector demand.	• Fragmented innovation system which makes demands from different actors unclear • Limited R&D demand from SMEs • Lack of systematic evaluation approach

Governmental priorities addressed both in the latest research bill and the White paper on innovation highlight a number of key research fields that should be given specific focus in research programmes and funding opportunities. These priorities are in line with the knowledge demands in industrial sectors investing most in R&D.

Since Sweden has a rather linear funding system with the Research Council funding and dealing with demands related to basic research, VINNOVA with a more applied research focus, and Nutek being responsible for the development side, the coordination is not always efficient. The demands that are developed in between these well defined R&D phases have problems to receive attention because of the lack of coordination and communication that arise when the different agencies are supposed to implement the knowledge demands.

Swedish SMEs are not taking advantage of the existing R&D competences. It is rather the MNCs carrying out and investing in research. This is partly the explanation for the Swedish paradox, which was mentioned in chapter 2.

There is no national evaluation system in place in Sweden, which makes it difficult to draw major conclusions about policies and if they live up to the demands of private and public sector.

3.3 Analysis of recent policy changes

In the most recent research policy bill "Research for a better life", 2005, three priority research fields were highlighted: life sciences, engineering, and sustainable development. These research fields received increasing research allocation over the period 2005-2008: life sciences €42.7 m, engineering €37.4m and sustainable development €22.4m. Research skills in life sciences and engineering have been two of the main areas where industry has a demand for skills, since the majority of the large companies and main R&D investors are found in sectors such as life sciences, IT, telecom, material and transport (Government bill, 2005). Identified prioritised research fields where Sweden has a strong knowledge base in both research and innovation is a mean to continue staying internationally competitive and to live up to the demands of research foundations and industry.

A general request in Sweden is that research should have a societal impact that goes beyond teaching and publishing. One way to accomplish this is through internationally competitive centres of excellence. The establishment of excellence centres will create highly educated researchers with experience in carrying out both applied and basic research. Experiences in solving industrial problems will target the knowledge demand of industry.

A number of instruments have been put into place to support these priorities from funding to universities e.g. Linnaeus Grants first implemented in 2006 when 20 environments received funding and with a second round in 2008 when additional 20 were selected, to collaborations between public and private sectors in the strong research environments e.g. VINN Excellence Centres implemented in 2006, Berzelii Centres also from 2006 plays an important role.

There has been limited horizontal coordination between ministries and little or no formal horizontal coordination between implementing authorities (research councils, sector agencies, etc.) and weak vertical coordination between ministries and implementing authorities, meaning that in the end there is little coordination of RTDI measures. The centres of excellence are an attempt to narrow these coordination problems since the programmes are managed by several authorities.

The project "Forsknings- och Innovationsframsyn", published in 2008 is a jointly initiated project between VINNOVA and IVA. It puts forward a number of principles and requirements that should be met to achieve the maximum benefits for society and international competitiveness. The document provides the government with suggestion in the process of making Sweden Europe's most attractive country. It brings together conditions how the public financed research, with an effective innovation system in cooperation with industry should contribute to social benefits. The project consisted of one steering committee with representatives from industry, academia, and public sector. Three different reference groups representing the academic community, industry, and the demands of the broader society assisted the committee. The project listed five main principles for how Sweden will remain a leading knowledge and research nation with high quality research relevant for the society (VINNOVA and IVA, 2008a).

The Swedish National Reform Programme (NPR) sets forward a number of priorities that need to be addressed for Sweden to reach the stated Lisbon goals. The plan was prepared with stakeholder involvement and discussed at national, regional and local level.

In addition to the measures mentioned earlier e.g. excellence centres, "Industry Branch Talks", tech-transfer offices at universities, it also emphasises the importance of financial support to SMEs, increasing protection of IPR, strengthening of the industrially oriented research institutes, and strengthening of availability to seed capital.

Challenges	Main policy changes
Identifying the drivers of knowledge demand	• Internationally competitive centres of excellence • Identified priorities research fields • Instruments involving actors from both industry and academia
Co-ordinating and channelling knowledge demands	• Increasing trend of agencies and councils developing common programmes

3.4 Assessment of policy opportunities and threats

The main opportunities and threats for knowledge demands in Sweden arising from recent policy responses and in the light of the Lisbon Strategy can be summarised as follows:

Main policy opportunities	Main policy-related threats
• In identified prioritised fields Sweden has a strong research base and innovation tradition • Instruments in place target the knowledge demand from both universities and industry	• International global companies reallocating R&D resources because Sweden cannot provide the required knowledge base

Identify the drivers of knowledge demand has been an opportunity for Sweden mainly because prioritised research fields have had a strong knowledge base in both research and innovation. The existing SMEs have had a latent demand of R&D skills, which could indicate that the drivers among these companies have not been fully identified. There is therefore of importance that some instruments specifically target SMEs and their demands.

In Sweden co-ordination and channelling knowledge demand present a risk since there has been limited co-ordination of RTDI measures. The policy bill explicitly highlights this problem and encourages more collaboration between research agencies and councils.

Monitoring demand fulfilment does represent neither a risk nor an opportunity. There is no systematic approach in place but on the other hand do research policy evaluations have a long tradition in Sweden and there are examples of evaluations that have had a significant impact in policy making.

3.5 Summary of the role of the ERA dimension

The importance of EU-integration and participation in European programmes has received increasing attention in recent years. In the most recent policy bill "Research for a Better Life" many references to the ERA can be found. It introduces a reorganised national support system for participation in EU programmes to better respond to the demands brought by the emerging ERA (Government bill, 2005).

Since more knowledge about the framework programmes could increase the chances of EU funding, VINNOVA, the main Swedish National Contact Point for FPs, has set up an information and advice centre concerning all aspects of the FPs. The office also monitors Sweden's progress in the FPs and compiles statistics and performs evaluations and analysis.

Many of the thematic areas in the seventh framework programme do coincide with the national prioritised areas e.g. ICT, health including life sciences, sustainable development and environment, material sciences, and aerospace.

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 Ensuring quality and excellence of knowledge production

The universities in Sweden are the main research performers. In contrast to many other European countries the public research institutes play a rather minor role. The universities account for 20% of the total expenditures while the research institutes only account for less than 5%. The explanation for this is the third mission of universities, to carry out mission oriented research, which in the majority of other European countries is the task of research institutes.

An obligation for each university and college is to formulate their own research strategy. This task makes the universities rather autonomous to decide on what kind of research to focus. However the universities would like to become more independent. Today they are limited by regulations that sometimes impede the degree of collaborations carried out between universities since they fall under governmental authority. Increasing collaboration would probably lead to improved quality, since literature has shown that research collaborations often enhance the scientific outcome.

There are currently three public councils supporting quality and excellence research in Sweden. The main funding council is VR with activities divided into three separate areas: humanities and social sciences, natural sciences, engineering and medicine. The VR distributes some 10% of the total public R&D, mainly to non-oriented basic research. The second council, FAS, supports excellent research in matters related to working life and the understanding of social conditions and processes. The annual budget is some 1% of the total publicly financed R&D. The third major council is Formas promoting scientifically significant research in sustainable development. It distributes 2% of the total public R&D budget. The three councils mainly support individual researchers (ERAWATCH Research Inventory, 2008). The grants are distributed on a competitive basis using peer review as quality criteria. This can include bibliometric indicators such as publication track records and/or use of expert opinions. In the last years foreign expertise has been increasingly used to determine the international quality of the research.

The publication rate in Sweden is among the highest in the world. This does not necessary reflect the quality of the research but does rather say something about the publication culture. Using citation rate as an indicator of quality reveals that Sweden belong to the top cited countries. In terms of scientific specialisation, expressed by the number of publications and using EU15 as a reference, Sweden exhibits high specialisation in the fields of environment, social sciences, and in several medical fields such as immunology, pharmacology, neurosciences, clinical medicine, biology and biochemistry. In addition, by examining the specialisation profile of Sweden measured by citations, it appears that Sweden is highly specialised in the same scientific fields as when using publication data as an indicator (ERAWATCH Network, 2006).

The importance of interdisciplinary research and collaborations across traditional scientific fields has been acknowledged both by the policy makers as well as by the funding bodies. In the latest policy bill, inter- and multidisciplinary research is mentioned as one of the major research policy priorities. Several instruments addressing this issue have been implemented. Despite the importance to create multidisciplinary environments where new sciences and opportunities can flourish the Swedish universities are still divided into traditional scientific disciplines organised around departments.

Environments with high attraction potential for investments and the ability to absorb new knowledge have become more important for international competitiveness. A number of centres of excellences have been established between agencies and foundations. The aim is to build up a few research environments in strategic competitive fields. The centres receive long-term funding with the objectives to generate excellent research, increased engagement from industry and society, and increased innovation. Evaluation studies have shown that these environments create high quality research and the societal benefits have been high.

Since 2001, at the request of the Government, the National Agency for Higher Education has been undertaking evaluations of all subjects as well as all programmes leading to the award of a professional qualification at the higher education institutions in Sweden. The National Agency's evaluations have three main aims; control, development, and information. Programmes at basic, advanced and graduate level are evaluated every sixth year.

4.1.2 Ensuring exploitability of knowledge production

Swedish industry invests heavily in R&D and has had a great ability to ensure exploitability of knowledge in product, process and business development. The output of these companies can be observed by different indicators.

If using number of patent applications as an indicator of exploitability of knowledge Sweden shows a high success rate with more than double the number of EPO applications, 185 patents per million inhabitants in 2005, compared to the EU27 average of 106 patents. This is an increase from earlier years and maybe a change in trend since in the last years number of patent applications has been decreasing. If looking at the number of patents issued per million inhabitants in all existing patent systems (EPO, USPTO, and JPO) Sweden ends up as number five in 2003. Similar to the situation in the majority of other countries the number decreased between 1997 and 2003. The major reason for this was the decrease of ICT related patents issued at the USPTO. According to a study carried out by the VR articles involving both academia and industry have an average citation rate of 1.2, meaning that these publications are cited 20% more than the world average.

In Sweden the universities are not only responsible for carrying out basic research but also for providing applied research. Since 1996, universities have a third mission, in addition to research and teaching, to collaborate and interact with society. This is an attempt to bring universities closer to industrial needs but also to collaborate and interact with society. More recently, the White Paper “The Open Higher Education Institutions (HEI)” stated that a prerequisite for the HEI is ‘‘to strengthen its role in lifelong learning and to develop its co-operation with the community’’. To fulfil these requirements universities have developed different kinds of innovation/technology transfer systems aimed at helping researchers in the process of commercialisation.

Since public R&D funding has been decreasing, universities have had to look for other sources of funding, mainly from industry. This has involved a change in research orientation towards more applied and problem oriented projects. It is mainly the technical and medical universities receiving funding from and collaborating with industry.

Using a specialisation index, based on the numbers of patents, with EU15 as reference reveals that Sweden has a specialisation in instruments, electrical equipment, and wood & publishing as industrial sector. The specialisation has been unchanged over the last decade and it is only in pharmaceuticals where there has been a change from minimal specialisation to specialisation in comparison to other EU15 countries. If the share of total patents is used as an indicator of specialisation, Sweden has more than 10% of the total number of patents in the electric equipment, machinery, and pharmaceutical sectors. The public funding of BERD, is directed toward sectors that exhibit strong or relatively strong specialisation such as office machinery, research and the service sectors (ERAWATCH Network, 2006).

A number of studies have shown that innovations are generated in collaborations between two or several actors. There are first and foremost relations between users and producers that are of a central importance. Several funding actors have invested in programmes and initiatives promoting collaborations between academia and other stakeholders. By

involving industry at an early stage the research can be more problem oriented. In Sweden it is mainly VINNOVA, which funds these kinds of activities. Such initiatives are conducted in collaboration with other players in order to achieve the greatest impact for the entire system. The increasing focus on strong research and innovation milieus (centres of excellence) can be seen as a way to further improve the exploitation of research results and improve the innovation process (VINNOVA and IVA, 2008b).

4.2 Assessment of strengths and weaknesses

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

Main strengths	Main weaknesses
• Economic strengths and industrial needs coincide with the research focus carried out at universities • High scientific quality according to several indicators	• Universities not able to carry out their third mission in a satisfying way

In Sweden the industry, more specific MNC, is investing heavily in high-tech related research. The access to knowledge in these firms is essential for the innovation process. Since economic strength and industrial needs coincide with research focus carried out at universities, academia can assist industry, MNCs, with human capital.

The quality of the research carried out in Sweden is high. According to bibliometric indicators Sweden belongs to the top countries both with regard to the number of published articles and the citation rate. The Swedish grant system is mainly using peer-review as selection criteria to ensure the quality of the granted projects. There is no national assessment system in place in Sweden like in England or Germany, which could guarantee a similar process of evaluating actors.

The universities are obligated to pursue activities that enhance the probability that the research will have a societal impact. This has not been done in a satisfying way which has resulted in a gap between academia and industry. It is first and foremost the commercialisation process resulting in new start-ups that have been criticised. Despite increasing investment in entrepreneurship there are only a limited number of universities that produce new companies with potential of creating new job opportunities. Despite giving the HEIs increasing responsibility, the government has not allocated any extra funding to this specific task. Existing funding are targeting collaborations between already existing companies and universities rather than trying to create new spin-off companies from universities. Since the majority of governmental funding focus on basic research not enough applied oriented research is carried out in Sweden compared to many other countries. This means that it can often be difficult to justify society involvement when many departments face funding shortages for these specific activities.

4.3 Analysis of recent policy changes

The development of new scientific quality indicators is under way in Sweden. In a proposal from 2007 (Ministry of Education and Research, SOU 2007:81) a new allocation system, in

which quality and results are prioritised, has been suggested. The proposed indicators include international citations, the amount of external funding, the number of graduated PhDs, and the number of female professorships. The proposal also takes into account the importance of freedom for the individual universities. In June 2008 the government commissioned the Swedish National Agency for Higher Education to map and analyse a ranking system for universities and colleges. This is an attempt to increase the information to students regarding quality differences between university degrees and universities. The aim is to report the advantages and the disadvantages that can inform the selection of universities by students (Ministry of Education and Research, SOU 2008:30).

The Swedish National Agency for Higher Education continually evaluates the quality of higher education in Sweden. Its appraisals cover programmes at both basic, advanced and research oriented level. For the six-year period 2007-2012 the National Agency has laid down a new quality assurance system. The change in structure is part of the Swedish process of adapting higher education to conform to the Bologna process. In the new quality evaluation system experiences from the previous system will be combined with new ideas about quality assurance and quality development. The National Agency has also listened to and heeded opinions expressed by the ministry, the higher education institutions, student organisations and other stakeholders. The new quality assurance system comprises five different components: evaluations of subjects and programmes; audits of the quality assurance procedures at the higher education institutions; appraisal of entitlement to award degrees; thematic studies; distinguishing centres of educational excellence.

One of the main goals in the most recent policy bill is to maintain the role of Sweden as a leading research nation. Research must maintain high quality, and research initiatives should provide scope for both breadth and specialisation. In addition to these, further long-term funding was earmarked for centres of excellence in both curiosity-driven and mission-oriented research.

A recurring theme in Sweden has been the demand for R&D environments contributing to the innovation and international competitiveness. The majority of the research agencies have initiated programmes aimed at developing strong research environments. The common characteristic of all programmes is that they focus on a few environments that are selected according to a number of criteria in open competition. Differences between initiatives can be observed in the lengths of funding, the closeness to industry, and the main target groups. The programmes are often not field specific, but projects related to life sciences and ICT have been granted most research money, which is in line with the economic specialisation (VINNOVA and IVA, 2008b).

Entrepreneurship has been an issue in Sweden with decreasing number of patents, start-ups, and medium size companies without R&D activities. A number of new initiatives have been put into place aiming to increase entrepreneurship at universities. Still, there is a concern that these instruments are not enough and more efforts need to be put into place to encourage researchers to commercialise their research.

Encouraged by the success of the initial competence centre programme, launched by VINNOVA´s predecessor NUTEK in 1995, the VINN Excellence Centres programme was set up in 2005. The Centres provide a forum for collaborations between the private and public sectors, universities and colleges, research institutes and other organisations

conducting research. The ambition is to establish 25 different centres that will be funded for a period of 10 years. The first funding period started 2006, when ten centres were selected, in 2007 additionally ten centres were selected. Together with the Knowledge Foundation and the Swedish Foundation for Strategic Research, VINNOVA has also launched a six-year plan for mission-oriented competence centres (Institute Excellence Centres). The programme was launched in 2005 and is aimed at collaboration between research institutes and universities, colleges, and industrial sectors. The objective is to create leading multidisciplinary, international environments for R&D in fields that are of importance to the future growth and competitiveness of Sweden. The first six centres were selected in 2006. On the same note, VINNOVA and VR have selected four Berzelius centres, focusing on excellence, and curiosity-driven research fields that should always require industry involvement. Ten centres were selected in 2007 and will receive funding until 2016. The largest initiative, according to budget, are the Linnaeus centres initiated by Formas and VR. The aim of these grants is to enhance support for research of highest quality that can compete internationally. The 20 selected environments will receive funding for 10 years (2006-2016) with a budget of 120 mSEK (~12.7 mEUR/environment). The first evaluations, mainly mid-term, have indicated high quality of the research and increasing collaborations and knowledge exchange between industry, academia and other stakeholders (Stenius and Mårtensson, 2008). Other initiatives aimed at improving public-private partnership can be found on the regional level where both public-actor and industry participation are required.

Challenges	Main policy changes
Improving quality and excellence of knowledge production	• Development of new scientific quality indicators
Ensuring exploitability of knowledge production	• Developing strong research environments ensuring quality and international competitiveness

4.4 Assessment of policy opportunities and threats

The main opportunities and threats for knowledge production in Sweden arising from recent policy responses and in the light of the Lisbon Strategy can be summarised as follows:

Main policy opportunities	Main policy-related threats
• Increasing collaboration with industry and international attractiveness through centres of excellences. • Focus on quality which might increase the competitiveness	• Not living up the international demand of knowledge production • Low level of entrepreneurship at Swedish universities

The challenge related to improving quality and excellence of knowledge production is an opportunity in Sweden since research has a high international reputation.

Ensure exploitability of knowledge production is a risk in Sweden since MNCs are moving their activities abroad but is also reflected in the decreasing number of spinoffs and

patents. More efforts need to be put into commercialisation and entrepreneurship activities.

4.5 Summary of the role of the ERA dimension

The increasing internationalisation of science has resulted in an environment where competitiveness plays an important role for the success rate. To be able to compete with other countries Sweden need to provide high quality and attractive research. Since Sweden is a small and country dependent on global integration the need to focus on a number of strong, internationally distinguished R&D milieus is a critical factor in the effort to promote growth. The centres of excellence are means to foster high quality research in a collaborative environment (VINNOVA and IVA, 2008b).

With decreasing public funding Swedish researchers have to apply for other sources of money. The biggest international funding source is the EU framework programme. Since most of the international funding bodies are using open competition with peer review as a means to secure quality, it is crucial to support excellence in research on a national level.

Participation in international funded projects has become part of the Swedish evaluation process used as an indicator of international recognised excellence.

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;
- Benefiting from access to international knowledge by reducing barriers and increasing openness; and
- Enhancing absorptive capacity of knowledge users to mitigate 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

The importance of collaborations between academia and industry has received increasing attention mainly due to the stagnating and in some sectors decreasing R&D investment. The need to interact between research institutions will continue to increase not least for high tech companies that constantly have to upgrade their knowledge base. This implies that mobility between sectors will get more important. Since many of the existing big companies are dependent on research it is important that Sweden continues being an attractive country, providing industry with valuable research and knowledge.

In 2005, the industry invested 87 mEUR in research carried out at universities in Sweden. 75% of this amount came from companies based in Sweden. This represents about 1% of the industry's total investment, which is rather low compared to international measures. When considering the percentage of HERD financed by business it can be concluded that Sweden is below the EU17 average with 5% compared to 6.7%. Karolinska Institutet is the university in Sweden generating most money from both Swedish and foreign companies. If studying the share of GOVERD financed by business the number is lower 1.5%.

The R&D centres of excellence described in chapter 4 are also means to increase and facilitate knowledge circulation between academia, industry and the public sector. These environments are often regionally based and represent a physical space for both industry and academia to interact and exchange ideas. Many of the projects in which industry participates are of a problem-based character and therefore require a dialogue between the involved partners.

There are currently 12 to 14 holding companies at selected universities in charge of the commercialisation of academic research. These companies are supposed to help the universities carrying out their third mission (commercialise R&D and promote knowledge transfer). In 2006 the total investment of these companies amounted to around 4.3 mEUR. In order to achieve a more efficient system of knowledge transfer, the government would like to reduce the number of holding companies while at the same time expanding their services to all Swedish universities.

The Key Actor's Programme, initiated by VINNOVA, aims to develop competence, methods, processes and structures to enhance the professionalism of key actors in the Swedish innovation system. It focuses on increasing the amount and efficiency of co-operation between research performers, industry and other actors in the broader society, as well as activation of knowledge (i.e. knowledge transfer and commercialisation of research results).

Industry PhDs and different types of joint affiliations is another way of ensuring exploitation of knowledge production generated in academia. According to a questionnaire, by the industry committee in 2005, 700 PhDs at ten different universities were employed by the industry. The number of professors financed by the industry was 2000. This does not say much in an European context since comparable numbers are not available. It is mainly the technical universities that have these kinds of arrangements and the concept has been encouraged both by existing funding programmes as well as policy documents.

5.1.2 Profiting from access to international knowledge

The participation of Swedish organisations in EU Framework Programmes (FPs) has been increasing for every programme and accounted for 3.6% of all participation in FP6. Swedish organisations collaborate most with organisations based in Germany followed by United Kingdom and France. Other Nordic countries have the highest share of collaborations with Swedish organisations (VINNOVA, 2008).

Sweden has a long history of international research collaborations. This is a crucial factor to gain access to knowledge especially in a small country as Sweden. A number of bilateral and networking agreements are already in place to stimulate international collaborations. VR is responsible for a number of bilateral agreements. These arrangements intend to support joint research projects, workshops and researcher exchange. Also Formas has ongoing bilateral collaboration supporting research in agricultural and forestry. Several initiatives supporting collaborations with Japan are in place. The Swedish Foundation for Strategic Research has focused most of its international support on collaboration with Japanese researchers. In addition, VINNOVA is supporting international exchange with Japan in collaboration with the Japan Society for the Promotion of Science. Since 1971 the Sweden-Japan Foundation has tried to help promoting relations between Sweden and Japan. Research collaborations between the Nordic countries are present in most funding organisations programmes and can be found in most sectors. Apart from the specific initiatives mentioned above, VR provides grants for exchange programmes, conference fees and travel allowances. Even though most Swedish programmes do not directly finance foreign organisations they encourage international collaborations and these are often used as an indicator of quality when programmes are evaluated.

5.1.3 Absorptive capacity of knowledge users

Statistics on the aggregate level imply that industry has a high knowledge absorption capacity since companies invest heavily in R&D. However, most of the investments are done by MNCs and the absorptive capacity among SMEs is rather low in Sweden compared to European standards. The SMEs invest less than 20% of the total R&D business investments, which place Sweden on the lower half of countries. Companies with more than 250 employees are responsible for 79% of the R&D carried out in Sweden. In 2002-2004 almost half, 49%, of all enterprises were engaged in both product and process innovative activities. In a European comparison Sweden has five countries that perform better with Germany in first place having 65% of the industry involved in innovation (Eurostat). Among SME companies 44% are carrying out innovative activities compared to 77% of the MNC. These facts are very much linked to the Swedish paradox (Edquist, 2002), inadequate return on public investment in R&D (Åström and Mattsson, 2007).

The main promoter of entrepreneurship and enhancing SME participation in R&D is NUTEK. Despite the focus on SMEs only a few programmes targeted towards enhanced R&D activities exist. The University & SME cooperation programme aims at facilitating the development of collaboration between enterprises and other actors with a view to joint innovation and activities, as well as knowledge exchange. A programme directly addressing the low R&D rate in SMEs is the Research & Innovation in SMEs programme also initiated by VINNOVA. It aims at identifying R&D needs among SMEs and finance need-driven R&D projects.

The Knowledge Foundation is working to increase competence in Swedish industry based on company needs. The goal is to have the business and academic communities work together so that Swedish companies have access to the knowledge that is available at the country's institutes of higher learning.

A highly qualified labour force has been Sweden's main advantage in attracting foreign R&D investments. According to the International Standard for Classification of Education more than 20% of the workforce (25-64 years old) has a higher education degree. The portion of scientists and engineers is rather high in Sweden and accounts for 25% of all people with higher education. Since the industry is dependent on these skills there is a great demand of these competences from the high tech companies. Also the number of researcher graduates is relatively high in international comparison. However, the number of S&T graduates has decreased over the last years and it is an increasing concern that Sweden will loose its position as a knowledge-absorptive country.

5.2 Assessment of strengths and weaknesses

The main strengths and weaknesses of the Swedish research system in terms of knowledge circulation can be summarised as follows:

Main strengths	Main weaknesses
• Research intensive industry sector • Instruments in place targeting academic – industry collaborations	• Difficulties in transforming research results into products

• Attractive research environment for international researchers e.g. tax incentives and social benefits	

The Swedish industry is the main R&D investor. It is mainly the big MNCs that perform in-house research and that require human capital with research skills. These companies are the major employees for researchers outside universities. The challenge for Sweden is how to enhance SME participation in R&D. The number of start-ups involved in innovation activities is low and academic spin-offs have been decreasing over the last decade. A major reason is the lack of incentives for researchers to create their own companies and the unfavourable economic environment for start-ups.

To be able to get access to international knowledge Sweden has introduced tax incentives for foreign researchers. These include the provision that foreign experts, executives, scientists, researchers only pay tax on 75% of his/her income during the first three years in Sweden.

5.3 Analysis of recent policy changes

In Sweden research and innovation policies are overlapping. In 2004, the first national strategy for innovation "Innovative Sweden" was presented. The document is an attempt to improve the circulation of knowledge between sectors and improve the innovation performance. Four specific areas are prioritised namely: knowledge base for innovation; innovative trade and industry; innovative public investment; and innovative people (Government White Paper, 2004).

Since the implementation of centres of excellence the number of collaborations between public and private sectors has increased. The first evaluations also indicate that the research carried out in these environments is of high quality (Stenius and Mårtensson, 2008).

Another way to increase the circulation of knowledge is to support mobility between different sectors. The Swedish research Council is supporting industrial doctoral students and postgraduate education for employees in industry. The Swedish Foundation for Strategic Research is supporting researchers that want to work in a different sector for a limited period of 12 months.

In 2007 the Government decided to set up the Globalisation Council consisting of experienced people from a number of sectors of society. The aim is to analyse how Sweden can address the challenges of the future and to suggest a strategy how to benefit from the potentially welfare gains generated by globalisation. It is intended to deepen our knowledge of the effects of globalisation and to broaden the public conversation on them.

VINNOVA provides special grants for project co-ordinators in order to co-fund the work on drawing up applications for the FPs. In order to promote participation of SMEs, VINNOVA also award grants for feasibility or preliminary studies that should eventually lead to an application.

The National Reform Programme confirmed the diffused border between innovation and research by the government deciding to merge the two guidelines put forward by the

Commission and treat them on an aggregated level. The Swedish NRP does not identify any specific priorities in contrast to many other countries. The document rather promotes a number of measures in support of a knowledge based society which are very much in line with the "Innovative Sweden" (Government White Paper, 2004) and "Research for a better life" (Government bill, 2005) documents. The NRP emphasizes the need to create a healthy business environment; improve the competitiveness; and support R&D, innovation and diffusion of ICT. It should be mentioned that the document has not received much attention in the general public policy debate probably because of its similarity with the national innovation strategy "Innovative Sweden" (Government White Paper, 2004).

In Sweden it is mainly the MNC that are carrying out and investing in research. This can partly be explained by the increasing costs and risks of R&S activities. This means that it is more difficult for SMEs to conduct their own R&D operations than for large companies. VINNOVA has initiated several activities aimed for SMEs to increase their R&D activities examples include the "Research&Grow" first launched in 2005 and still ongoing. The "Key Actor Programme" aims at develop key players in the Swedish innovation system and to make them more professional in their roles with regard to collaboration between research players, companies and other players in society at large as well as to the utilisation of knowledge and the commercialisation of research results. The first part of the programme started in 2006 and focused of universities "Higher Education Infrastructure for Collaboration for Growth", five projects were selected in 2007. Additional measures are planned where the focus will be on research institutes and companies.

Challenges	Main policy changes
Facilitating knowledge circulation between university, PRO and business sectors	• Creation of holding companies • Centres of Excellence involving universities, industry and research institutes • Support to individual mobility programme
Profiting from access to international knowledge	• Establishment of Globalisation Council • Reorganisation of national support system for participating in EU programmes
Absorptive capacity of knowledge users	• Instruments in place targeting R&D in SMEs

5.4 Assessment of policy opportunities and threats

The main opportunities and threats for knowledge production in Sweden arising from recent policy responses and in the light of the Lisbon Strategy can be summarised as follows:

Main policy opportunities	Main policy-related threats
• The first evaluations of the centres of excellence indicate increasing collaborations between private-public sector	• Decreasing industry R&D investment

The challenge of facilitating knowledge circulation between university, PRO and business sector represents neither a clear risk nor an opportunity. Collaborations between public and private sector needs to be improved and enhanced at the same time do prioritised

research fields and the focus of existing industry overlap, which should facilitate knowledge exchange.

Profiting from access to international knowledge should be seen as an opportunity for Sweden. Swedish researchers have for many decades been collaborating with foreign researchers and are used to acting in an international research area.

Absorptive capacity of knowledge users can be seen as both an opportunity and risk. On one side does industry invest heavily in R&D which indicates a high research activity but it is mainly MNCs that account for these spending. The absorptive capacity among SMEs is rather low in Sweden compared to other European countries.

5.5 Summary of the role of the ERA dimension

Universities are today competing for both researchers and students from all over Europe with the underlying aim of staying competitive. As a result Swedish research organisations have become more open to international researchers. Since the research carried out at universities has a good international reputation there have not been any difficulties to attract foreign scholars. In recent years the number of graduates applying for Swedish undergraduate degrees has increased rapidly and there is a discussion to introduce fees for foreign students.

The majority of national programmes are aimed at Swedish researchers and organisations. Still, most programmes also encourage collaborations with foreign organisations and recognise this as a sign of quality and excellence. Several instruments are also in place for preparing researchers to apply for participation in European R&D programmes.

6 - Overall assessment and conclusions

6.1 Strengths and weaknesses of research system and governance

The analysis in this document has shown that the Swedish research system is of high quality identified by a number of indicators. The main research performers are the universities, mainly carrying out basic research, and the industry, carrying out applied research. Both actors are internationally recognised for performing excellent research. The main weaknesses, in the system, are related to the Swedish paradox (Edquist, 2002), inadequate return on public investments in R&D and transferring basic research into applied. The main explanatory factors are the government's focus on financing basic research and the problem of universities not being able to carry out their third mission in a satisfying way (commercialise R&D and promote knowledge transfer with society).

Domain	Challenge	Assessment of strengths and weaknesses
Resource mobilisation	Justifying resource provision for research activities	Meeting the Lisbon objectives, which gives Sweden a competitive advantage in comparison to other EU-countries

	Securing long term investment in research	High R&D investment
	Dealing with barriers to private R&D investment	Swedish paradox: inadequate return on public investments in R&D
	Providing qualified human resources	Highly skilled R&D personnel
Knowledge demand	Identifying the drivers of knowledge demand	Strong public funding specialisation in fields corresponding to industry demand. Limited R&D demand from SMEs
	Co-ordination and channelling knowledge demands	Fragmented innovation system which makes demands from different actors unclear
	Monitoring of demand fulfilment	Lack of systematic evaluation approach
Knowledge production	Ensuring quality and excellence of knowledge production	High scientific quality according to publication and citation rate
	Ensuring exploitability of knowledge	Economic strengths and industrial needs coincide with the research focus carried out at universities Universities not able to carry out their third mission in a satisfactory way
Knowledge circulation	Facilitating circulation between university, PRO and business sectors	Instruments in place targeting academic – industry collaborations
	Profiting from international knowledge	Attractive research environment for international researchers e.g. tax incentives and social benefits
	Enhancing absorptive capacity of knowledge users	Research intensive industry sector Difficulties in transforming research results into products

The governance system is well-known for its limited horizontal coordination between ministries and little or no formal horizontal coordination between implementing authorities. The Swedish system with small ministries and relatively independent implementing authorities has resulted in weak vertical coordination, slow policy implementation, and policymakers having limited influence over how policies are implemented.

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

Sweden is one of the few European countries already fulfilling the goals of the Lisbon agenda. The 3% research intensity target has already been reached with Sweden investing 3.73%. The importance of internationally competitive research environments has been addressed in a number of policy documents. Several centres of excellence have been established by a number of research agencies and foundations, often in cooperation. The first half-time evaluations indicate that there have been improved collaborations between sectors and that the quality of research performed is of high international standard (Stenius and Mårtensson, 2008).

The main threats are related to globalisation and MNCs moving their activities abroad. Sweden has been an attractive country providing a high skilled knowledge base for international companies carrying out R&D activities. Since the number of S&T graduates has been decreasing and other countries provide different economic benefits for companies there is a concern that Sweden will loose out on foreign R&D investments and existing MNCs will move their activities elsewhere.

Domain	Main policy opportunities	Main policy-related threats
Resource mobilisation	• Increasing globalisation ensuring international funding opportunities	• Increasing globalisation resulting in MNCs moving their R&D investments abroad • Decrease of competent research knowledge base
Knowledge demand	• In identified prioritised fields Sweden has a strong research base and innovation tradition • Instruments in place target the knowledge demand from both universities and industry	• International global companies reallocating R&D resources because Sweden cannot provide the required knowledge base
Knowledge production	• Increasing collaboration with industry and international attractiveness through centres of excellences. • Increasing focus on target research fields, which are in accordance with the economic specialisation • Focus on quality which might increase the competitiveness	• Not living up the international demand of knowledge production • Low level of entrepreneurship at Swedish universities
Knowledge circulation	• The first evaluations of the centres of excellence indicate increasing collaborations between private and public sectors	• Decreasing industry R&D investment

Current policy priorities identified by the research policy bill “Research for a better life” (Government bill, 2005) and the White Paper “Innovative Sweden” can be summarised into four points 1) increasing and facilitating SME access to R&D 2) improved commercialisation and knowledge transfer around universities 3) increased long-term funding for research institutes 4) funding to internationally competitive centres of excellence (Government White Paper, 2004). These priorities are in line with the Lisbon agenda. A number of instruments are in place but there is an uneven distribution between priorities. The initiatives meant to stimulate R&D in SMEs are not implemented in a satisfying way and more efforts need to be put into place to enhance the absorption capacity within SMEs.

6.3 System and policy dynamics from the perspective of the ERA

The increasing importance of progress towards an ERA was highlighted in the latest policy bill “Research for a Better Life” (Government bill, 2005). The majority of the strategies and references identified are in line with the ERA approach. The document also introduces a

reorganisation of the national support system for participating in EU programmes to better respond to the demands brought by the ERA.

In the Swedish National Reform Programme (NRP) a number of action plans how to reach the Lisbon goals are put forward. The plan was prepared with stakeholders' involvement and discussed at national, regional and local level and presented to the public in late 2005. It contains several measures about Sweden's plans to improve competitiveness by 2010. The measures highlighted in the document include excellence centres, "Industry Branch Talks", and tech-transfer offices at universities. It also emphasizes the importance of financial support to SMEs, increasing protection of IPR, strengthening of the industrially oriented research institutes, and strengthening of availability to seed capital (Government Offices of Sweden, 2007).

The impact in the form of Europeanization is visible in the number of programmes already targeting the mobility of researchers within Europe. Also, the openness towards other European organisation has increased, even though the majority of national founding schemes are targeting Swedish organisations.

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List of Abbreviations

FAS: Swedish Council for Working Life and Social Science

FORMAS: Swedish Council for Environment, Agricultural Sciences and Spatial Planning

NUTEK: Swedish Agency for Economic and Regional Growth
VINNOVA: Swedish Governmental Agency for Innovation Systems
VR: Swedish Research Council

European Commission

EUR 23766 EN/27

Joint Research Centre – Institute for Prospective Technological Studies
Directorate General Research

Title: ERAWATCH Country Report 2008 - An assessment of research system and policies: Sweden
Authors: Pauline Mattsson and Tomas Åström
Luxembourg: Office for Official Publications of the European Communities
2009
EUR – Scientific and Technical Research series – ISSN 1018-5593
ISBN 978-92-79-11956-9
DOI 10.2791/XXXX

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 Sweden.

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LF-ZB-23766-EN-C

ISBN 978-92-79-11956-9

9 789279 119569

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