



ERAWATCH COUNTRY REPORT 2010: Sweden

ERAWATCH Network – Faugert&Co, Technopolis

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The opinions expressed are those of the authors only and should not be considered as representative of the European Commission's official position.

Executive Summary

The Swedish population amounted to 9,354,462 in 2009. The GDP in 2009 (€ per inhabitant) was €31,300 which is higher than the average for the 27 member states of €23,600. The estimated GDP for 2011 is €367,352m. Sweden is the EU country that invests most in R&D relative to its GDP. In 2008, the total R&D expenditure amounted to 3.75% of GDP compared to an average of 1.89% for all Member State countries. However, in contrast to many other countries, the volume of R&D investment has decreased in recent years from a peak in 2001 of 4.25%. It is first and foremost the industry that has decreased its investment in R&D, the BERD as % of GDP was in 2005 2.81% and in 2007 2.65%.

The policy mix in place for promoting private investments in R&D has further developed in 2009 and 2010. The government has invested in strategic research areas amounting to SEK1.8b on a yearly basis. The strategic investments aim at building up a number of new world class research environments in research areas that have been specifically selected because of their strong strategic importance for society. A number of the strategic research areas are also appropriate for partnership programmes with industry, where institutions of higher education, authorities, companies and research institutes make joint investments. In the long-term the aim is to contribute to raising research quality, improving conditions for commercialisation, encouraging cross-disciplinary scientific approaches and increasing opportunities for the system to make use of EU funding.

The strategic areas mentioned above are:

- Energy
- Sustainable exploitation of natural resources
- Effects on natural resources, ecosystems and biological diversity
- Climate models
- Sea environmental research
- Cancer
- Diabetes
- Epidemiology
- Molecular biology
- Neuroscience, incl. brain- and nerve system diseases
- Stem cells and regenerative medicine
- Health
- Nanoscience and nanotechnology
- E-science
- Material science, incl. functional materials
- IT and mobile communication, incl. future solutions for communication and monitoring systems
- Production technology
- Transport research
- Security and crisis management

- Politically important geographical regions

Improved commercialisation and knowledge transfer around universities in relation to the universities' third task is targeted by the research bill, which encourages universities to commercialise to a greater degree the outcomes of research. This is hoped to be achieved by a change in the Higher Education Act, which more clearly lays out the responsibilities of universities to promote commercialisation of research results. Related to this is the establishment of 'Innovation offices' at seven universities, supporting commercialisation, patenting and licensing, etc. The Government has appropriated €6.9m (SEK75m) for these efforts.

Knowledge Triangle

The following table gives a short assessment of the interaction between different policies in place in the knowledge triangle.

	Recent policy changes	Assessment of strengths and weaknesses
Research policy	<p>The government has invested in strategic research areas amounting to SEK1.8b on a yearly basis. The strategic investments aim at building up a number of new world class research environments in research areas that have been specifically selected because of their strong strategic importance for society. The strategic areas include:</p> <ul style="list-style-type: none"> • Energy • Sustainable exploitation of natural resources • Effects on natural resources, ecosystems and biological diversity • Climate models • Sea environmental research • Cancer • Diabetes • Epidemiology • Molecular biology • Neuroscience, incl. brain- and nerve system diseases • Stem cells and regenerative medicine • Health • Nanoscience and nanotechnology • E-science • Material science, incl. functional materials • IT and mobile communication, incl. future solutions for communication and monitoring systems • Production technology • Transport research • Security and crisis management • Politically important geographical regions 	<ul style="list-style-type: none"> • Sweden's economic growth and resilience to the financial crisis will most likely have a positive effect on further public investments in research. Still the crises will most likely result in a decreasing R&D investment from industry. • The increasing importance and investment of infrastructure both internationally and nationally will improve the quality of research and Sweden's role as a strong research actor in the rest of the world. • The interest for students enrolling in S&E studies has decreased over the last years. One of the main reasons why global companies have invested in R&D in Sweden is because of the strong engineering knowledge base. If the number of engineers and strong S&E skills are decreasing there might be a risk that companies relying on these skills will move their activities abroad and invest in other countries. • So far, most R&D has been performed by large companies and to a lesser extent by SMEs. The crisis will most likely result in less R&D investment from SMEs, which will impair the level of research activities even further. The concept "the Swedish Paradox" is still relevant, i.e. High inputs and low output = low productivity

	Recent policy changes	Assessment of strengths and weaknesses
Innovation policy	<ul style="list-style-type: none"> • Establishment of 'Innovation offices' at seven universities, supporting commercialisation, patenting and licensing, etc. The Government has appropriated €6.9m (SEK75m) for these efforts. • Improved commercialisation and knowledge transfer around universities in relation to the universities' third task is targeted by the research bill, which encourages universities to commercialise to a greater degree the outcomes of research. This is hoped to be achieved by a change in the Higher Education Act, which more clearly lays out the responsibilities of universities to promote commercialisation of research results. 	<ul style="list-style-type: none"> • The identified strategic research areas are in line with the industrial priorities. A number of the strategic research areas are also appropriate for partnership programmes with industry, where institutions of higher education, authorities, companies and research institutes make joint investments.
Education policy	<ul style="list-style-type: none"> • In the Government Bill 'Competing on the basis of quality – tuition fees for foreign students' (Govt. Bill 2009/10:65) the Government proposes that higher education should be free of charge for Swedish citizens and citizens of an EU/EEA state or Switzerland but that students from other countries should pay a fee for their higher education as of the autumn term 2011. • The Swedish government has recently presented a bill on greater autonomy for HEIs (Govt. Bill 2009/10:149), which creates further opportunities to transform the organisations. HEIs will still have the status as state agencies, but faculty boards will no longer be mandatory and regulated by the Higher Education Ordinance. 	<ul style="list-style-type: none"> • The decrease of PhD graduates might result in a lack of research competence that can take over after the retirement boom that is to be expected in higher education. • Increased autonomy for HEIs will enable institutions to reconsider their organisations and recruitment procedures. There has been a concern expressed by the Union of University teachers that a deregulated sector might decrease collegial decision-making at HEIs.

European Research Area

Assessment of the national policies/measures supporting the strategic ERA objectives (derived from ERA 2020 Vision).

The ERA concept has gained increasing attention in national strategies and objectives in recent years. It is first and foremost participation in the Framework Programmes that has received stronger focus. The most recent policy bill highlighted the need to extend European collaborations, including increased cooperation between national researchers and programmes, facilitating mobility, and increasing investment in common research infrastructure. National policies addressing the need to open up national research programmes have been addressed in a number of policy documents but have not been practically implemented. Also the modernisation of research organisations has only been carried out to limited extent.

There have been efforts in Sweden trying to adapt national policies to the European Research Area even though many of the criteria have already been lived up to. Regarding a European labour market for researchers a number of initiatives have been introduced trying to facilitate mobility and portability of grants. It is important to keep in mind that these issues are very much interlinked with what is happening at the European level. Regarding social security and providing an attractive employment and working conditions, Sweden is probably one of the better countries in Europe even though many countries have caught up during the last decade. It is especially in regard to salaries were Sweden has to improve. Regarding research infrastructure Sweden has a long tradition and has been investing and prioritised these initiatives for decades. The quality of research has received increasing attention the last years, which is probably related to Sweden losing its position in several fields. To tackle these issues a national quality assurance standard was introduced in 2009. Also the academic autonomy has received increasing attention, due to the fact that many universities in Sweden would like to gain increasing autonomy. This has resulted in a bill on greater autonomy were HEIs will still have the status as state agencies, but faculty boards will no longer be mandatory and regulated by the Higher Education Ordinance. Knowledge transfer has been a prioritised issue on the research agenda for several years, with instruments and activities aiming at increasing collaborations between different sectors and transferring research into commercial activities. Even though new instruments are in place these are not enough especially concerning interactions with SMEs. International research collaborations have always been an important issue, especially since Sweden is a small country with limited number of researcher. This is visible in number of participation in intergovernmental organisations and different type of agreements.

The main challenge for Sweden is to continue performing high quality research and to provide an attractive environment for foreign companies to base their R&D activities in. The ERA is aiming for an integrated research area in which other countries that have not had the national resources to invest in R&D will gain opportunities. This means that Sweden will meet increasing competition from other European countries.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive single European labour market for male and female researchers	<ul style="list-style-type: none"> • Post-doctoral employment scheme; • Investment in quality of mathematics, engineering and science in primary and secondary school. 	<ul style="list-style-type: none"> • Decreasing number of students enrolling for S&E programmes; • Increasing interest from foreign students to study in Sweden.
2	Increase public support for research	<ul style="list-style-type: none"> • Government launch of strategic research areas. 	<ul style="list-style-type: none"> • Sweden's economic growth and resilience to the financial crisis; • Still weak connections between academic research and industry.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
3	Increase European coordination and integration of research funding	<ul style="list-style-type: none"> Increasing importance and support to European initiatives. 	<ul style="list-style-type: none"> Sweden already live up to the 3% target investment; Swedish researchers may be reluctant to share their resources with foreign colleagues as long as the public and private support in other countries do not live up to the Swedish standards; Swedish researchers are not very many, and the best may already be engaged in European initiatives.
4	Enhance research capacity across Europe	<ul style="list-style-type: none"> Building, maintaining and operation of research infrastructure. 	<ul style="list-style-type: none"> Sweden will host several European infrastructures; Investment in research infrastructure is a vital topic among Swedish funding bodies; Decreasing number of PhD graduates; Decreasing number of students enrolling for S&E programmes.
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	<ul style="list-style-type: none"> Current governmental investments in global infrastructures such as ESS and Max Lab 4 in Sweden; Support of 15 ESFRI infrastructures. 	<ul style="list-style-type: none"> Sweden has a long tradition in building, maintaining and operation research infrastructures and have one of the most advanced and developed infrastructures in several fields.
6	Strengthen research institutions, including notably universities	<ul style="list-style-type: none"> Additional funding through strategic research areas; Development of a quality assurance system for evaluating research at universities that will hopefully result in increasing research quality at the same time the system is using traditional indicators which could limit the growth of new research and the interaction with society. 	<ul style="list-style-type: none"> The role of universities is not clear and is complex and there are signs of mission overload; The new distribution model puts more emphasis on performance and quality. This development has been disputed in the academia that wants more autonomy; HEIs feel they are deregulated on the one hand but on the other micromanaged and monitored by the state.
7	Improve framework conditions for private investment in R&D	<ul style="list-style-type: none"> Launch of public-industry joint funding of research, innovation and development (e.g. the likes of FFI at VINNOVA). 	<ul style="list-style-type: none"> The economic crises will most likely lead to even further decrease in private investment in R&D; Increasing globalisation, increasing competition, resulting in MNCs moving their R&D investments abroad; Increasing focus on target research fields, which are in accordance with the economic specialisation.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
8	Promote public-private cooperation and knowledge transfer	<ul style="list-style-type: none"> • Establishment of public private partnership (PPP) programmes that target the knowledge demand from both universities and industry; • Establishment of innovation offices at universities. 	<ul style="list-style-type: none"> • Sweden's long tradition of public-private cooperation; • The low investment in R&D among SMEs.
9	Enhance knowledge circulation across Europe and beyond	<ul style="list-style-type: none"> • Initiatives stimulating the inward mobility of foreign researchers such as tax reductions are in place. 	<ul style="list-style-type: none"> • Increasing inward and outward mobility.
10	Strengthen international cooperation in science and technology and the role and attractiveness of European research in the world	<ul style="list-style-type: none"> • Sweden has introduced a legislation based on the EU's Researchers Visa Directive making it easier for third countries researchers to work. 	<ul style="list-style-type: none"> • Sweden has a long tradition of collaborating with third countries; • Sweden has a number of bilateral agreements with third countries in place; • High level of the populations English and courses thought in English.
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	<ul style="list-style-type: none"> • The research bill includes both research and innovation policies and address private and public actors; • Several different ministries contribute to the formulation of research and innovation policies. 	<ul style="list-style-type: none"> • The tradition of developing research and innovation policies combined; • No formal and obligatory arena for coordination exists in the area of research and innovation policy and operations, and there is also the lack of comprehensive coordination at this level is a recognised weakness.
12	Develop and sustain excellence and overall quality of European research	<ul style="list-style-type: none"> • The Swedish National Agency for Higher Education review the quality of higher education by evaluating subject areas (main fields of study) and study programmes and granting degree awarding powers; • A new performance based funding system for research has been introduced. 	<ul style="list-style-type: none"> • Long tradition of carrying out high quality research and education; • The Swedish National Agency for Higher Education's quality assurance policy has been developed in accordance with the European Network for Quality Assurance's (ENQA) Standards and Guidelines for Quality Assurance in the European Higher Education Area.
13	Promote structural change and specialisation towards a more knowledge - intensive economy	<ul style="list-style-type: none"> • The identification in the research bill of a number of strategic research areas. 	<ul style="list-style-type: none"> • Overlapping high quality of research in fields of importance for industry is a strength; • The identified strategic research areas will support research in fields were Sweden already has a strong R&D position.

	ERA objectives	Main national policy changes	Assessment of strengths and weaknesses
14	Mobilise research to address major societal challenges and contribute to sustainable development	<ul style="list-style-type: none"> • Strategic research areas and dedicated programmes through sectoral funding agencies; • Involvement of industry and other actors in formulating policies. 	<ul style="list-style-type: none"> • Overlapping high quality of research in fields of importance for industry is a strength.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	<ul style="list-style-type: none"> • Parliament decided in June 2010 that performance based funding should be introduced also for higher education, beginning in 2012. 	<ul style="list-style-type: none"> • The high level of trust in research among Swedish citizens; • The systematic evaluation policy has contributed to a more systematic policy and may facilitate policy learning.

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1 Introduction

The main objective of the ERAWATCH Analytical Country Reports 2010 is to characterise and assess the evolution of the national policy mixes in the perspective of the Lisbon goals and of the 2020, post-Lisbon Strategy. The assessment will focus on the national R&D investments targets, the efficiency and effectiveness of national policies and investments into R&D, the articulation between research, education and innovation, and on the realisation and better governance of ERA. In doing this, the 15 objectives of the ERA 2020 are articulated.

The report builds on the 2009 report streamlining the structure and updating the 2009 policy assessment in the domains of human resource mobilisation, knowledge demand, knowledge production and science-industry knowledge circulation. The information related to the four ERA pillars covered in the 2009 report is also updated and it is extended in order to cover all six ERA pillars and address the corresponding objectives derived from ERA 2020 Vision.

Given the latest developments, the 2010 Country Report has a stronger focus on the link between research and innovation, reflecting the increased focus of innovation in the policy agenda. The report is not aimed to cover innovation per se, but rather the '**interlinkage**' between research and innovation, in terms of their wider governance and policy mix.

2 Performance of the national research and innovation system and assessment of recent policy changes

The aim of this chapter is to assess the performance of the national research system, the '**interlinkages**' between research and innovation systems, in terms of their wider governance and policy and the changes that have occurred in 2009 and 2010 in national policy mixes in the perspective of the Lisbon goals. The analysis builds upon elements in the ERAWATCH Country Report 2009, by updating and extending the 2009 policy assessment in the domains of resource mobilisation, knowledge demand, knowledge production and science-industry knowledge circulation. Each section identifies the main societal challenges addressed by the national research and innovation system and assesses the policy measures that address these challenges. The relevant objectives derived from ERA 2020 Vision are articulated in the assessment.

2.1 Structure of the national research and innovation system and its governance

The Swedish population amounted to 9,354,462 in 2009. The GDP in 2009 (€ per inhabitant) was €31,300 which is higher than the average for the 27 member states of €23,600. The estimated GDP for 2011 is €367,352m. Sweden is the EU country that invests most in R&D relative to its GDP. In 2008, the total R&D expenditure amounted to 3.75% of GDP compared to an average of 1.89% for all Member State

countries. However, in contrast to many other countries, the volume of R&D investment has decreased in recent years from a peak in 2001 of 4.25%. It is first and foremost the industry that has decreased its investment in R&D, the BERD as % of GDP was in 2005 2.81% and in 2007 2.65% (Eurostat).

Main actors and institutions in research and innovation system

Sweden has a scattered governance system and, while policy formulation is carried out largely at a ministerial level, different agencies are responsible for the design and implementation of individual 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. No formal and obligatory arena for coordination exists in the area of research and innovation policy and operations, and the lack of comprehensive coordination at this level is a recognised weakness (Sandstrom, SOU 2008:30).

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, by 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. A third advisory body, the Institute for Growth Policy Studies (ITPS), did report to the Ministry of Enterprise, Energy and Communication with the main tasks to provide analysis and policy intelligence and to evaluate governmental policies, was closed down in April 2009, and replaced by the Swedish Agency for Growth Analysis.

The main agency supporting R&D is the Swedish Research Council (VR), funded by the Ministry of Education and Research. Its main responsibilities include 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), supports research on ecological, conservation, natural resources-related and construction issues. The funding is provided by the Ministry of Sustainable Development and the Ministry of Agriculture, Food and Consumer Affairs (Mattsson P. and Åström T., 2009).

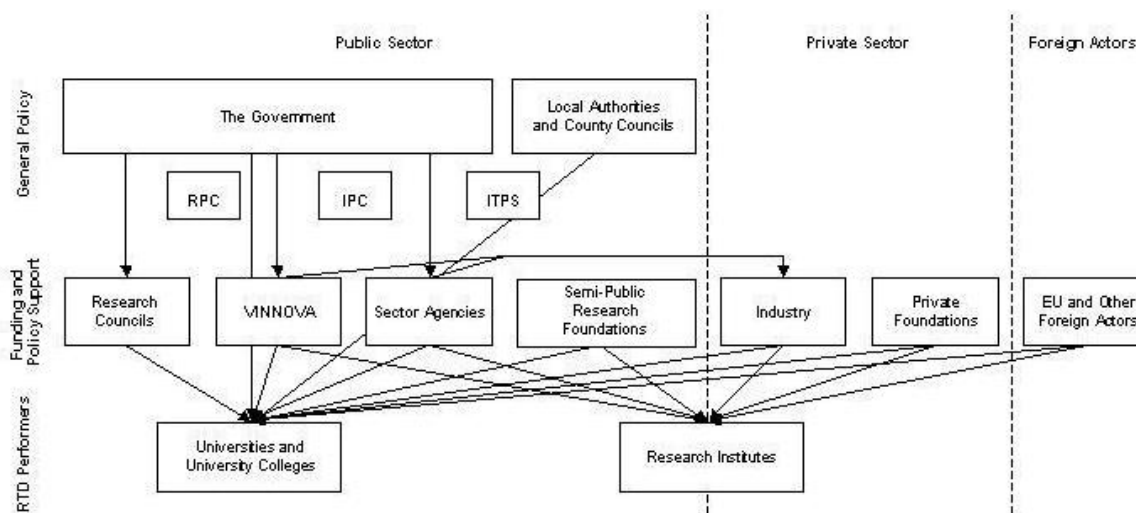
In addition to these agencies there are also six major national semi-public foundations such as the Swedish Foundation for Strategic Research (SSF), which supports research in science and engineering or the Knowledge Foundation (KKS), which promotes basic research carried out at newly established universities. The other foundations include Riksbankens Jubileumsfond (RJ), an independent foundation with the goal of promoting and supporting research in the Humanities and Social Sciences; the Swedish Foundation for International Cooperation in Research and Higher Education (STINT) with the mandate to internationalize Swedish higher education and research; the Foundation for Strategic Environmental Research (MISTRA) supporting research of strategic importance for a good living environment; the Swedish Foundation for Health Care Sciences and Allergy Research (Vårdal

Foundation) stimulates innovative, interdisciplinary Swedish health care science and allergy research (Mattsson P. and Åström T., 2009).

Research of an 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, although it also interacts with the Ministry of Education and Research on research related issues. Swedish Governmental Agency for Innovation Systems' 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 (Mattsson P. and Åström T., 2009).

Design and implementation of research and innovation policies is handled through a well established system of recurring government bills and implementation at higher education institutions as well as through funding agencies, which all have a part of the role of formulating and implementing policy.

Figure 1: Overview of the Swedish research system governance structure



Source: ERAWATCH Research Inventory

At the same time as the implementing bodies are fragmented this also implies a high level of independence from the general policy makers. In general decisions can be made faster reacting to changes that might occur. At the same time the role of different implementing bodies has been questioned and in a report from 2008 the research system governance structure was investigated with the result that a new, coordinated agency should be established. The recommendations in the report did however get a lot of criticism and will most likely not be implemented (Government, 2008a).

The institutional role of regions in research and innovation governance

Overall, research policy is decided on the national level but in the latest government bill on regional policy, “Regional growth – for jobs and welfare” (1997/1998: 62) and “A policy for growth and vitality in the whole country” (2001/2002:4), the coordination of research and regional policy was stressed especially in relation to the development of clusters and regional innovation systems. In the government bill on research policy “Research and renewal” (2001/2002:2), it was emphasised that those universities and university colleges that had not yet established any holding

companies facilitating technology transfer should do this as part of their support to regional development. Further, the latest government bill on research policy “A boost to research and innovation” (2008/2009:50) stresses the necessity to link regional growth initiatives with national research and innovation policy. This includes improving the dialogue with regional actors and national authorities, focusing on how they can develop strategic work on research and innovation issues at the regional level.

The main actors in the regional governance system are the 18 county councils and two regions, who are in fact county councils with an extended development responsibility. The regional development issues are linked closer with innovation and sustainable growth, with county councils in close interaction with agencies like VINNOVA and the Agency for Economic and Regional Growth. They are, often jointly, involved in programme design and funding schemes, of which a portion comes from regional structural funds.

When it comes to spatial spread of the R&D activities, around 72% of all Swedish R&D takes place in either of the Stockholm (32.5%), Vastra Gotaland (23.4%) or Skane (16.3%) regions (Statistiska Meddelanden, UF16 SM 0901, Statistics Sweden).

Main research performer groups

Research in Sweden is mainly carried out by industry and the higher education sector. The business enterprise sector is the main performer with 74.1% of GERD in 2008 (Eurostat). The university sector is the second biggest performer, accounting for 21% of GERD.

2.2 Resource mobilisation

Since 2000, Europe has made evident progress towards ERA but at the same time it is clear that Europe's overall position in research has not improved, especially regarding R&D intensity, which remains too low. The lower R&D spending in the EU is mainly a result of lower levels of private investment. Europe needs to focus on the impact and composition of research spending and to improve the conditions for private sector R&D investments.

This section assesses the progress towards national R&D targets, with particular focus on private R&D and of recent policy measures and governance changes and the status of key existing measures, taking into account recent government budget data. The need for adequate human resources for R&D has been identified as a key challenge since the launch of the Lisbon Strategy in 2000. Hence, the assessment includes also the human resources for R&D. Main assessment criteria are the degree of compliance with national targets and the coherence of policy objectives and policy instruments.

2.2.1 Resource provision for research activities

In 2008 the gross domestic expenditure on R&D (GERD) was 3.75% of GDP in Sweden well above the average of the EU27 of 1.9%. This implies that Sweden already fulfils the Lisbon goal.

Provisions for R&D activities

Every electoral period, the Government presents a research bill, setting the framework for central government-funded research for the coming four years. In the latest bill "A boost to research and innovation" (2008/2009:50), the Government announced a successive increase of public funds to R&D during 2009-2012, with the aim of reaching a permanent increase of €463m (SEK5b) 2012. This implies a total increase of almost €1.3b (SEK14.7b) during the period. This increase during the four year period is more than twice as large as in previous bills. In 2008, public funds to R&D in the central government budget amounted to €2.4b (SEK25.6b). Following the new research bill, public funds to R&D should amount to approximately €2.8b (SEK30.6b) in 2012. The Government estimates that with the additional resources of the Research and Innovation Policy Bill, public sector research funding will be equivalent to 1% of GDP. The increase will partly be an outcome of the abolition of the Research VAT (8%) on external funding, which corresponds to €27.7m (SEK300m) yearly.

There is a growing appreciation in Sweden as in many other countries that there is a need to mobilise research resources in certain areas. For this reason Sweden makes an investment in strategic research areas amounting to SEK1.8b on a yearly basis. This is a new element of Swedish research funding. The strategic investments aim at building up a number of new world class research environments in research areas that have been specifically selected because of their strong strategic importance for society. A number of the strategic research areas are also appropriate for partnership programmes with industry, where institutions of higher education, authorities, companies and research institutes make joint investments. In the long-term the aim is to contribute to raising research quality, improving conditions for commercialisation, encouraging cross-disciplinary scientific approaches and increasing opportunities for the system to make use of EU funding.

The Government has used three criteria to determine the strategic areas to be given priority:

- Research that can contribute to finding solutions to important global problems and issues;
- Areas in which Sweden already carries out world class research;
- Areas where companies in Sweden are carrying out their own research and development, and where state investments reinforce the development and competitiveness of the business sector in Sweden.

The areas have been chosen on the basis of strategies that have been drawn up by research funding agents, universities, other research actors, as well as companies and organisations representing industry. The Swedish Research Council has also carried out an assessment of the areas of strength in Swedish research. In addition a total of 8 infrastructures within the strategic areas such as epidemiology, molecular biology, climate research, material science, computer science and biodiversity will be funded.

Strategic areas:

- Energy (SEK160M~€17,2m)
- Sustainable exploitation of natural resources (SEK48m~€5.2m)
- Effects on natural resources, ecosystems and biological diversity (SEK40M~€4.3M)

- Climate models (SEK27m~€2.9m)
- Marine environmental research (SEK18m~€1.9m)
- Cancer (SEK56m~€6m)
- Diabetes (SEK56m~€6m)
- Epidemiology (SEK20m~€2.2m)
- Molecular biology (SEK145m~€15.6m)
- Neuroscience, incl. brain- and nerve system diseases (SEK56m~€6.0m)
- Stem cells and regenerative medicine (SEK59m~€6.3m)
- Nursing research (SEK50m~€5.4m)
- Nanoscience and nanotechnology (SEK60m~€6.5m)
- E-science (SEK56m~€6.0m)
- Material science, incl. functional materials (SEK52m~€5.6m)
- IT and mobile communication, incl. future solutions for communication and monitoring systems (SEK64m~€6.9m)
- Manufacturing technology (SEK48m~€5.2m)
- Transport research (SEK77m~€8.3m)
- Security and crisis management (SEK19m~€2.0m)
- Politically important geographical regions (SEK20m~€2.2m)

Even though these strategic areas are specifically pointed out by the government, calls are to a large extent open and follow the regular procedure where proposals are submitted by the research community. The identified 20 research areas are divided between four different agencies and councils that are responsible for the funding and monitoring of 43 research environments that are carrying out research in the areas. The individual budget for each of the areas in 2012 is highlighted after each area.

Nearly half (46.9%) of the funding of R&D at Swedish higher education institutions is institutional funding. The rest is competitive funding from research councils, other government agencies, companies, municipalities, public research foundations etc. Whether this constitutes an adequate balance is disputed, very much depending on perspective of debating party. Subsidies and tax incentives are also on the agenda, but to a high degree issues waiting to be solved. A great deal of collaborative funding is launched through the programmes for joint funding of research, innovation and development in six industrial sectors, managed by VINNOVA.

Securing long-term investments in R&D

In order to secure long term investment in research the Government is funding strong research environments, e.g. centres of excellence. There are several types of centres of excellence focusing on basic and applied research to different degrees. Centres focusing on basic research are for example, the "Linnaeus Grant" (funded by VINNOVA and VR) and the "Berzelii Centres" (funded by the VR and the VR FORMAS). Examples of centres focusing on applied research are "VINN Excellence Centres" (funded by VINNOVA) and "Institute Excellence centres" (funded by VINNOVA, the KK and the SSF). A common feature of all initiatives is that funding is available for a time period of approximately 10 years.

The emphasis on innovation and commercialisation of research results has as its objective to mitigate the impact of the Swedish paradox¹ (Ejeremo & Kander, 2006). An important part of this effort is to strengthen the industrial research institutes as key actors. Therefore the Government has allocated additional funding of €9.2m (SEK100m) and €18.5m (SEK200m) in 2010-2012. The intention is to improve the institutes' role as an intermediary between academia and industry.

The Government has also decided to invest €11.5m (SEK125m) in 2009 to improve the quality of mathematics, natural science and engineering teaching at primary and secondary level, thus in the longer term providing a good base for students and researchers. This is a response to the decreasing number of S&T (Science and technology) graduates.

Main challenges

As mentioned above one significant recent policy change is the government launching and funding R&D within strategic research areas within universities. The properties of such R&D include, among other things, to address social challenges such as improved health and quality of life. More specifically research related to an ageing population, climate change, structural changes following from globalization etc. are funded. Regarding poverty issues, Sweden continue to fund research focusing on developing countries mainly through the Swedish International Development Cooperation Agency (SIDA).

The identification of a number of strategic areas is a way forward in supporting excellence research in Sweden and it that way also stay competitive in areas were Sweden has competitive advantage and where there is an industrial presence. At the same time it is important to give some space and funding opportunities for "new" science that might have a growth potential. The focus on funding strong research centres has received increasing attention in the major funding agencies to the extent that many traditional research grants have been limited. Several researchers have been critical to this increasing focus upholding that the large universities are more likely to receive these grants. It is important to keep a good mix of funding instruments, at the same time as innovation and excellence should be encourage to a higher degree than before it is also important to provide funding to smaller research groups.

2.2.2 Evolution of national policy mix geared towards the national R&D investment targets

Evolution of BERD

The BERD as a percentage of GDP was in 2008 2.78%, which is an increase compared to 2007 but a decrease compared to 2006 (Statistics Sweden). This means that the industry accounts for 72% of the total R&D investment with the bulk being invested in intramural research.

Policy Mixes towards increased private R&D investment

The Swedish Reform Programme for Growth and Jobs 2008 to 2010, as well as the INNO-Policy TrendChart 2008, point to imbalances in the Swedish system, such as the focus on "knowledge creation" rather than "value creation". In the new research

¹ High inputs and low output = low productivity. First formulated by Edquist/McKelvey in 1991. Then it was expressed in terms of a high R&D intensity in Sweden coupled with a low share of high-tech (R&D-intense) products in manufacturing as compared to the other OECD countries.

bill "A boost to research and innovation" 2008/09:50, a number of policy changes are proposed to help redress this imbalance. Policy instruments promoting the establishment of new indigenous R&D performing firms include increased provision of venture capital, especially in the early stages of the innovation processes, the strengthening of Intellectual Property Rights (IPR) and a new initiative to establish 'innovation offices' at the major universities.

Improved commercialisation and knowledge transfer around universities in relation to the universities' third task is targeted by the research bill, which encourages universities to commercialise to a greater degree the outcomes of research. This is hoped to be achieved by a change in the Higher Education Act, which more clearly lays out the responsibilities of universities to promote commercialisation of research results. Related to this is the establishment of 'Innovation offices' at seven universities, supporting commercialisation, patenting and licensing, etc. The Government has appropriated €6.9m (SEK75m) for these efforts.

Policy instruments mainly focus on keeping a strong performance in terms of knowledge and innovation creation. The main policy instruments are the centre of excellence programmes and the support of strong regional innovation milieus. Since 2005, a number of centres of excellence have been implemented, e.g. the so-called "VINN Excellence" programme, "Berzelii Centres", "Institute Excellence Centres" programme and "Industry Excellence" programme. Common for these programmes is the aim to build bridges between academia and industry by creating excellent academic research environments in which industrial companies actively participate. The "Linnaeus Grant", jointly announced by the VR and FORMAS in 2005, is supporting strong basic-research environments at universities.

Research and Innovation in businesses

In Sweden, Tillväxtverket (Swedish Agency for Economic and Regional Growth) is responsible for supporting entrepreneurship, start-ups and the development of SMEs. The agency has a wide range of measures at its disposal, which target entrepreneurship and SMEs, whereof only a few of them explicitly target firms that do not yet perform R&D. One example of this is the "Product Development in Small Companies" programme which offers direct support to business R&D through grants and loans (INNO-Policy TrendChart, 2008). The overall budget of the programme in 2010 is €5.5m (SEK60m). Grants can be used for supporting external services, including consultancy services, development of prototypes, design etc. They require matching funding by the grant-receiving firm.

Another important actor supporting businesses is ALMI Företagspartner, a government-controlled organisation that aims to stimulate growth and development for SMEs and innovators by providing venture capital. ALMI's strengths as a supportive organisation is its long-term perspective "from idea to profitable business". The business unit ALMI Innovation, funds a number of stages in the innovation process. In 2009, 567 ideas were commercialised, and €5.8m (SEK63m) of funds were earmarked for this type of funding. €5.7m (SEK62m) of these funds were loans and €1.2m (SEK13m) was used to finance preliminary studies.

VINNOVA's programme "Research & Grow", launched in 2005, is targeting SMEs, and aims at funding their needs-driven R&D projects. The background is that 80% of private R&D is performed by large companies while 98% of all Swedish companies are SMEs.

Globalisation with increasing competition from other countries provides an indirect threat towards R&D investment since MNC might consider other countries than Sweden. Still Sweden's industry is investing more than two third of the total R&D investments. Many public investments are already areas in which Swedish MNC are already very active and dominant players and the newly identified strategic research areas are suitable for collaborative programmes. The MNCs are mainly found in sectors such as engineering (accounting for 50% of the production), forestry, ICT, biotechnology and life sciences, environmental industries, and renewable energy. Apart from providing public money for research collaborations between public and private sector one of the most important factor to be able to continue attracting MNCs to invest in R&D in Sweden is to provide an attractive workforce, especially in engineering fields.

Regarding the identified strategic areas these have been chosen since Swedish business sector is carrying out R&D in these areas. Companies were also involved in the selection process to better assure that the areas would fit the need of industry. Even though the money is allocated to universities the business sector is encourage participating in the selected projects. It should be mentioned that many the majority of the selected centres already have extensive collaborations with industry and that these companies directly benefit from the R&D carried out within the centres.

Innovation procurement

The concept of demand driven innovation processes has come into focus also in Sweden, partly following from the discussion on how Europe can become more innovative. According to the recent Innovation Procurement Inquiry (SOU 2010:56), in many situations where there is a manifest demand for new solutions, innovations tend to emerge. However, new knowledge is not automatically transformed into innovations, but a manifest demand for new solutions to specific problems is often the basis for commercially successful innovation processes. On such grounds, the Inquiry finds it important to consider two parallel approaches to create better opportunities for innovation in public procurement, the Innovation-friendly procurement and the Innovation procurement. The former means procurement which is carried out so that new, innovative solutions are not excluded or disadvantaged. The Innovation procurement, on the other hand, regards unknown solutions to a defined problem, or the need for a solution that is not yet established on any market. The report proposes the introduction of a new procurement law, a law on commercial procurement. The law is intended to serve as an optional tool for the contracting authorities or entities that would like to procure research and development services. Further, the Act will ensure that the agencies / entities that would like to procure R&D services are following the fundamental principles under European law. These are equal, transparency, proportionality and mutual recognition.

Other policies that affect R&D investment

The majority of Swedish policy measures are geared towards encouraging interaction (i.e. getting firms to perform some of their extramural R&D either in conjunction with universities and regional actors, or carried out by them). Hence, many of the research programmes launched by VINNOVA and the semi-public research foundations build on co-operation between academia, industry and public actors. These programmes operate on the matching funds principle and require industry to contribute to a project with the same amount of money that is provided by the public funding body. Both sector-specific and non-specific programmes exist and some of the centre of excellence also builds on this model of co-funding.

Barriers and risks for attaining the 2% BERD

In recent years, however, there has been a fall in industry investment. One of the reasons for this decrease in investments is that several of the big global firms have reallocated their R&D to other countries. Also the financial crisis has contributed to decreasing R&D investments. In 2005, industry invested €87m (SEK870m) in research carried out at universities in Sweden. Seventy-five percent of this amount came from firms based in Sweden. This represents about 1% of the industry's total investment, which is rather low compared to international measures. 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). The acquisition of many Swedish large companies by foreign companies' e.g. Saab, Volvo, AstraZeneca have increased the dependence on foreign firms' investment in R&D. This makes it even more important to provide an attractive R&D environment for these firms to be able to compete with the other countries. The last month's economic growth in Sweden is very much linked to Swedish companies' high export, which will hopefully result in an increasing investment in R&D.

In the "A boost to research and innovation" (2008/2009:50) the importance of strengthening and continuing the restructuring of the industrial research sector to improve firms' R&D investment in highlighted. By allocating additional funding of some €64.8m (SEK700m) to industrial research institutes in 2009-2012 the Government is trying to ensure long-term funding for research institutes. The intention is to improve the institutes' role as links between academia and industry. The institutes are particularly important for SMEs that otherwise might have difficulty accessing academic knowledge. This has been a continuing problem for Swedish R&D investments, that the majority comes from a few MNCs while SME have had problems to grow and not been investing sufficiently in R&D.

The strategic areas prioritised by the government in the research bill were selected not only because Sweden has a high quality research in those fields but also because these areas are very much interlinked with the industrial specialisation.

2.2.3 Providing qualified human resources

To develop international competitive research it is important to support the development of skilled human resources at all levels in the education system. At the university level, the government has introduced a two-year post-doctoral employment scheme to make it easier for those with a doctoral degree to continue their research.

In October 2009 25,000 full time equivalents were hired as teachers and researchers in Swedish higher education institutions, an increase with 4% in a year. More than one third (35%) of the teaching and researching personnel have employment limited in time, and 34% of them are 55 years or older (Statistiska Meddelanden, UF 23 SM 1001, Statistics Sweden).

In recent years, there have been concerns regarding the low number of engineers and students studying natural sciences. The Government decided in 2009 to invest €11.6m (SEK125m) to improve the quality of mathematics, natural science and engineering teaching at primary and secondary level, and provide a knowledge base that is of importance for high tech companies carrying out R&D (Mattsson P. and Åström T., 2009).

The period 2005-2008 saw a steady increase in research graduates at Swedish universities from 2,750 to 2,900. In 2009 that figure decreased to 2,690 (Statistiska Meddelanden, UF 21 SM 1001, Statistics Sweden).

2.3 Knowledge demand

In its most recent publication (July 2010) The Government's Research Policy Council lists a number of challenges that Swedish research faces. Most industrialised countries are currently making large investments in R&D. The research front is thus moving must faster than before, and Sweden should clearly be a part in that development. The Research Policy Council consequently proposes a general expansion of R&D in Sweden, that distinct driving forces for quality are developed, that the innovation force in Swedish research is strengthened, and that the role of research institutes as a link between academic research and the corporate needs of research results is enforced. The Council also recommends a clear strategy for investments in research infrastructure, further development of the innovation procurement system, increase wild card-ventures in research, improve conditions for graduate students, create transparent career paths and establish a national elite programme for young, talented researchers. Among the rest of proposals from the Council there is also one on greater autonomy for higher education institutions

Characteristic of the research priorities in Sweden is that they very much coincide with the business sector's demand. It is mainly the MNCs that have been in demand of R&D, rather than the SMEs, even though the picture is changing. The MNCs are mainly found in sectors such as engineering (accounting for 50% of the production), forestry, ICT, biotechnology and life sciences, environmental industries, and renewable energy.

2.4 Knowledge production

The production of scientific and technological knowledge is the core function that a research system must fulfil. While different aspects may be included in the analysis of this function, the assessment provided in this section focuses on the following dimensions: quality of the knowledge production, the exploitability of the knowledge creation and policy measures aiming to improve the knowledge creation.

2.4.1 Quality and excellence of knowledge production

The main policy change in relation to the domain of knowledge production is the introduction of a new system for allocation of research funding outlined in the "A boost to research and innovation" (2008/2009:50). The distribution of funding between university or higher education institutions will be determined by quality - measured by two criteria – publications/references to publications and external research funds.

In the National Reform Programme 2008, it is stated that Sweden needs to prioritise and improve management of intellectual property rights. Some measures have been taken in this regard, which will make it easier and less costly for firms to protect their inventions, e.g. in relation to patents applied for through the European Patent Office.

2.4.2 Policy aiming at improving the quality and excellence of knowledge production

Monitoring and review are performed within each funding agency's system, taking both scientific excellence and relevance criteria into account where applicable or appropriate. The strategic research areas are subject to a monitoring approach common to government, funding agencies and universities. How international evaluation procedures are utilized in allocation of funds varies, but clearly there are several examples where international evaluation groups have had a large impact, not least in the strategic research areas.

2.5 Knowledge circulation

Tackling the challenges that European society faces in the 21st century will require a multi-disciplinary approach and coordinated efforts. Many debates and conferences, e.g. the Lund Declaration recognise that such complex issues cannot be solved by single institutions, technology sectors or MS acting alone. Hence strong interactions within the "knowledge triangle" (education, research and innovation) should be promoted at all levels. Moreover, in the context of increasing globalisation, cross-border flows of knowledge are becoming increasingly important. This section provides an assessment of the actions at national level aiming to allow an efficient flow of knowledge between different R&D actors and across borders.

2.5.1 Knowledge circulation between the universities, PROs and business sectors

Knowledge circulation between academia, industry and the public sector has increasingly been stressed in Swedish research and innovation policy. This is reflected in the number of programmes, especially launched by VINNOVA, that build on the triple-helix rationale. Ongoing programmes range from sector-specific programmes, to programmes facilitating the development of regional innovation milieus. Another example is the focus on the establishment of R&D centres of excellence. These environments are often regionally based and represent a physical space for both industry and academia to interact and exchange ideas. Industry PhDs and different types of joint affiliations are another way of ensuring exploitation of knowledge generated in academia. The focus of these types of triple helix initiative has been a measure to improve the level of collaborations between industry and universities. According to a number of evaluation studies, analysing the impact of these initiatives, the majority of initiatives have resulted in new and stronger collaborations between the triple-helix actors. Even though SMEs have been encouraged to participate in these initiatives the participation rate has been moderate. It is expected that, due to the financial crisis, many SMEs might have had to reprioritise their activities and rather focus on short term financial goals rather than investing in long-term research activities. Therefore there is a need to further support SMEs access to research.

In order to strengthen technology transfer at universities, new innovation offices are currently being set up at eight universities: Uppsala University, Lunds University, Umeå University, Linköpings University, Karolinska Institute, Royal Institute of Technology, Chalmers Technical University, Mittuniversitet (coordinating an office also including Karlstad University, Örebro University and Linnaeus University). The offices are supposed to advise on for instance patenting, licensing and contract research.

2.5.2 Cross-border knowledge circulation

The importance of international cooperation in research is highlighted in “A boost to research and innovation” (2008/2009:50). It stresses the development of a national strategy to determine with which countries Sweden should arrive at an agreement with, see section 3.5.2. In the majority of evaluations of Swedish R&D funding programmes and activities is the international dimension of high importance.

Another example of accessing international knowledge and thereby promoting knowledge circulation is the effort the Government has put into hosting the large research facility, ESS (European Spallation Source), located to Lund, see section 4.2. In the research bill the importance of Swedish participation in international research infrastructure is highlighted. A number of research fields are listed that took part in the development of European Infrastructure efforts in FP7 e.g. metabolic diseases, epidemiological research and specific biobanks, e-science. The Swedish Research Council is responsible for Swedish international infrastructure participation and has also funded a number of participations in inter-governmental Research Infrastructures.

VINNOVA has the national responsibility for providing information and advice on EU's Framework Programme for Research and Technical Development, and is the national co-ordinator (NCC) for COST, EUREKA and Eurostars. VINNOVA is also responsible for special grants for project co-ordinators in order to support the development of applications for the FPs. In order to promote participation of SMEs, VINNOVA also award grants intended for preliminary studies that should eventually lead to an application.

2.5.3 Main societal challenges

In the strategic research areas launched by the government in the latest research and innovation bill, cross-sectoral and multi-disciplinary approaches are expected to arise to deal with especially one or another of the described societal or grand challenges. These global challenges include for example environmental issues such as climate change, security issues and public health, such as the consequences related to an ageing population and other diseases such as diabetes that has been increasing and that bring high costs to the society. As for climate related topics especially energy, use of natural resources, climate models, and deep sea research are especially prioritised and will receive an increase of €33m (SEK310M) in the period 2009-2012. As for security issues the increase will be €4.3m (SEK40M). These three areas corresponding directly to main societal challenges will get increasing funding over the coming years.

2.6 Overall assessment

Sweden's economy has come rather well out of the recent economic crisis. However, due to receding markets companies are expected to still act somewhat cautious for a while, which will probably result in further decreasing R&D investment from industry. Governments can choose to compensate for these losses and allocate funding not only to universities but also to industry and stimulates inter-sector collaborations.

In the new policy bill the government allocates more additional resources to research, which is a sign of the increasing importance of research in the national agenda. Even if the importance of research has been clearly visible in earlier policy documents, the GBAORD as a percentage of the total governmental expenditure has decreased,

indicating that R&D played a less important role in the last years. In 2008, GBAORD was 1.53% which is somewhat above the EU27 average of 1.52% (Eurostat).

In “A boost to research and innovation” (2008/2009:50), a new type of funding is introduced, so-called strategic research areas. As mentioned above, the areas for strategic investment have been chosen based on three criteria taking into account both research quality and relevance to society and industry. The strategic investments are targeting areas in which Swedish MNC are already active.

There is still room for further policy initiatives focusing on creating new SMEs and targeting existing SMEs. This includes both R&D programmes targeting SMEs and provision of venture capital. Entrepreneurship could be encouraged at an early stage of education in order to change the risk-averse attitudes towards entrepreneurship. One of the few positive effects of the financial crisis may be to inspire a culture of resourcefulness and openness for new ideas, which in turn might lead to the establishment of new firms.

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

Table 1: Summary of main policy related opportunities and risks

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	<ul style="list-style-type: none"> • Increasing globalisation ensuring international funding opportunities; • Provide an attractive knowledge base, more specifically in engineering and science, for foreign researchers to collaborate with; • Sweden has done relatively well through the economic crisis. 	<ul style="list-style-type: none"> • Increasing globalisation, increasing competition, resulting in MNCs moving their R&D investments abroad; • Decrease of S&E skills which might result in MNCs reallocating R&D resources.
Knowledge demand	<ul style="list-style-type: none"> • Establishment of PPPs will target the knowledge demand from both universities and industry. 	<ul style="list-style-type: none"> • Sweden cannot live up to the international demands, quality standards and increasing competition with other countries that are increasingly investing in R&D.
Knowledge production	<ul style="list-style-type: none"> • Increasing collaboration with industry and international attractiveness through higher participation rate and in FPs; • Increasing focus on target research fields, which are in accordance with the economic specialisation; • Increasing focus on quality research through new allocation systems. 	<ul style="list-style-type: none"> • The low level of R&D activities in SMEs with a lack of industry-university links; • Introduction of fees for foreign students at undergraduate level.

Domain	Main policy opportunities	Main policy-related risks
Knowledge circulation	<ul style="list-style-type: none"> • Focus on activities supporting mobility between sectors and countries; • The establishment of innovation offices at eight universities will hopefully result in further technology transfer. 	<ul style="list-style-type: none"> • Decreasing number of S&T graduates, which are the main workforce for international companies; • Decreasing industry R&D investment.

Table 2: Main barriers to R&D investments and respective policy opportunities and risks

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
The crises will most likely imply further decreasing industry R&D investment	Identified strategic investments correspond to industry demand and make sure to provide a competitive knowledge base
Low level of R&D investments in SMEs	Will mostly decrease further with re-prioritised activities due to the crises
Risk-averse attitudes towards entrepreneurship	Globalisation introduces new R&D funding sources that is also invested in universities
Lack of venture capital of in the earlier stages of the innovation process	
Financial crisis has result in even further decreased R&D investment by business sector	

The analysis of the Swedish research system's strengths and weaknesses shows that the research carried out is of high quality, as demonstrated by a number of indicators. The main research performers are the universities, mainly carrying out basic research, and industry, carrying out applied research. Both actors are internationally recognised for performing excellent research. Sweden does already meet the Lisbon objectives with high R&D investment from both public and private sectors. Another important strength is the fact that economic specialisation and industrial needs coincide with the research focus carried out at universities. This is a result of strong public funding in fields corresponding to industry demands.

The main weakness in the system is often said to be related to inadequate return on public investments in R&D, the so-called Swedish paradox (Ejermo & Kander, 2006). This situation can be explained by several possible factors related to the industrial structure, the entrepreneurial climate and traditions in public R&D expenditure. With an industrial structure characterised by a few MNC and many small firms, there is a risk that the institutional framework has become adapted to the dominant business model. Much of the research is conducted in the larger firms, which is partly related to limited resources among SMEs and a lack of venture capital sources resulting in limited growth opportunities. The increasing focus on co-financing in public funded research activities puts limits on which firms are able to make use of public R&D investments. Moreover, the entrepreneurial climate in Sweden is poor in comparison with many other European countries, which is reflected in its position in the lower half of the Entrepreneurship index.

Taking together Sweden needs to continue providing an attractive workforce and make sure that research is of highest quality. With an increasing global world and increasing competition this is probably best done by focusing on a number of fields where Swedish research can be of world-class quality. At the same time the strong

presence of MNC in the research agenda need to be shifted also to include SMEs and make sure that these companies also have access to research and public funding. Finally the entrepreneurship needs to be further strengthen probably already at an early age.

3 Interactions between national policies and the European Research Area

3.1 *Towards a European labour market for researchers*

The [Communication Better careers and more mobility: A European Partnership for Researchers](#) proposed by EC in May 2008 aims to accelerate progress in four key areas:

- Open recruitment and portability of grants;
- Meeting the social security and supplementary pension needs of mobile researchers;
- Providing attractive employment and working conditions;
- Enhancing the training, skills and experience of researchers.

The Commission has also launched concrete initiatives, such as dedicated information services for researchers, in particular through the activities grouped under the name of [EURAXESS – Researchers in Motion](#). Based on the assessment of the national situation in the four key dimensions detailed above, this section will conclude if national policy efforts are supporting a balanced ‘brain circulation’, with outward mobility levels matching inward mobility levels. High levels of outward mobility coupled with low levels of inward mobility often signal an unattractive national labour market for researchers and unsuitable research infrastructures. This may trigger, despite the policy efforts supporting the mobility the ‘brain drain’ rather than brain circulation.

3.1.1 Stocks and mobility flows of researchers

Researchers in Sweden made up 0.98% of the total active population in 2008. This is a decrease from earlier years when the same number was over 1%. The most important sector for employing researchers is the business sector, accounting for 0.68% of the total active population. The higher education sector is the second most important sector with 0.26% representing a total of 25,000 persons, excluding PhD students.

In 2009 17,200 persons engaged in postgraduate studies in Sweden. For the first time in more than fifteen years, the number of examined PhDs decreased. The number of enrolled PhD students has in the last years been relatively stable over the years (3,400) and the proportion of foreign students remained about one third (31%). It should be pointed out that between 2000 and 2009 the proportion of foreign doctoral students has increased from 19 to 31%. The areas of medicine and engineering sciences accounted for more than half of the newly enrolled and examined PhDs. According to information from the different universities almost 1,100 PhD students, in 2009, participated in international mobility

programmes that lasted for at least three months. According to earlier statistics, this is the highest number of outward mobility since 1999, when the first data was collected. Regarding senior researchers, the outward mobility was 670 individuals in 2009. Professors and lecturers accounted for one third of this number. Inward mobility was around 800 foreign researchers in 2009.

Initiatives stimulating the inward mobility of foreign researchers such as tax reductions are in place. Such tax incentives include the provision that foreign experts, executives, scientists, researchers only pay tax on 75% of their income during the first three years in Sweden, a benefit that again applies to both EU and non-EU researchers.

3.1.2 Providing attractive employment and working conditions

The Swedish universities have an international reputation for providing high quality education and in recent years the number of foreign students applying to universities has increased substantially. The most common and secure way of funding postgraduate study is through appointment to a PhD studentship. Approximately 50% of research students have studentships. This represents the most advantageous form of funding since it also comes with social benefits and applies to both EU and non-EU researchers. 12% are funded by study grants and 17% receive some other form of funding through their institution of higher education. 16% of the PhD students are externally funded.

According to the 2007 EC report "Remuneration of Researchers in the Public and Private Sectors" Swedish researchers are located in the middle band of EU15 countries, when comparing average yearly salaries in Europe. Researchers working in the higher education sector have higher salaries than in other sectors.

Researchers' salaries should theoretically be individually determined but are often decided centrally on faculty or research-council level. Researchers in similar positions do often have the same salaries. Most universities and university colleges are in some form of financial difficulty due to reduced funding per student, reduced base funding for R&D, and increased costs. This has resulted in universities employing researchers that are able to attract external funding.

The Association of Swedish Higher Education (SUHF), which organises the 42 Swedish universities and university colleges, signed "The European Charter for Researchers" and "The Code of Conduct for the Recruitment of Researchers" in 2007. Most of the issues covered in these initiatives had by then already been implemented in Sweden.

Parental leave in Sweden is probably the most generous in Europe and has served as a model for many other countries. All working parents are entitled to 16 months of paid leave per child. To encourage greater involvement by both parents a minimum of 2 months is required to be used by the parent that takes the more limited involvement in childcare, usually the father. This has resulted in more fathers staying home and employers being more tolerant towards parental leave. Still, since the women usually stay home longer and take a greater responsibility for childcare, they face professional disadvantages compared to their male counterparts. Non-permanent contracts are normally extended by up to one year in case of maternity leave or for a time commensurate to how long the parent decides to stay home. This is partly due to the fact that it is the social security system paying the parental benefit and not the employer.

Even though Sweden has a reputation of being a country with high standards of gender equality, there are still major inequities between men and women. Only a small percentage of high-level academic posts are occupied by women. In order to achieve more gender equality in higher education, positive discrimination can be used when recruiting staff for graduate schools and other positions. In addition, supervisors in graduate studies can be given training in gender equality and gender perspective issues.

A number of funding activities are aimed only at female researchers. The long-term objective is to increase the number of female postgraduates with the potential of becoming research leaders.

3.1.3 Open recruitment and portability of grants

Since 2006 EU/EEA citizens do not need any work permit to stay in Sweden. If their stay is longer than three months researchers need to register with the Swedish Migration Board. Citizens of a Nordic country (Norway, Finland, Iceland, and Denmark) do not need a residence permit. As for third country citizens a new legislation came into force on first of July 2008, which is based on the EU's Researchers Visa Directive. According to these rules no work permit is needed, if the purpose is to teach or lecture during a period of time shorter than three months. If the purpose is to be hired as a researcher for any period of time a work permit is required before arrival. One of the main problems has so far been that the time foreign researchers can be affiliated with universities is limited to two years. According to a new legislation on improved conditions for foreign recruitment this might be changed to four years.

The Swedish National Agency for Higher Education is the public agency responsible for recognising qualifications from abroad. Sweden as a member state is following the directive 2005/36/EC that stipulates the terms for the mutual recognition of diplomas, certificates and other evidence of formal qualifications. The agency evaluates most foreign higher education programmes. The foreign education is compared to undergraduate and postgraduate programmes from other countries with those provided in Sweden. The comparison is expressed in terms of Swedish degree levels. The evaluation does not involve any award of a Swedish degree. All decisions regarding admissions and transfer of credits from prior learning abroad are made by the universities and higher educational institutions themselves.

In the case of getting a profession recognised in Sweden, the competent authority responsible for the profession makes the decision. There is a clear system how to get a profession recognised with a list of documents that have to be submitted with the application. After the application has been submitted the agency has three to four months to assess the application and notify the applicant. The authority may decide to admit the application directly, ask for further information about the professional experience, ask about undertaking compensation measure, or deny the admission to the profession. Sweden has few regulated professions in comparisons with other countries.

Swedish universities and industry are publishing research related positions on the European Researcher's Mobility Portal. These positions can either be covered by public funds or private funds depending on the organisation with the free position.

VR is working towards making it easier for funded researchers to transfer the grants awarded to other countries in case of relocation. VR has therefore, on the initiative of

the European Heads of Research Councils (EUROHORCs), signed the Money Follows Researcher (MFR) agreement. According to this agreement, a researcher moving to a country in which there is an organisation that has also signed the MFR agreement, can take along the remaining part of a grant. Project Research Grants and Research Equipment Grants (<SEK2m) are eligible. Grants for Postdoctoral Positions cannot be transferred to another country.

3.1.4 Meeting the social security and supplementary pension needs of mobile researchers

The national pension system is made up of two contributions: the Income Pension which comprises 18.5% of the salary and is paid monthly by the employer into the national pensions account and the Premium Pension (2.5%) to be invested into a fund of choice.

All researchers that have a salary or a residence permit for a year or more have access to social and health insurance on the same terms as Swedish citizens. This implies that medical care is subsidised and that the individual is eligible for state-sponsored compensation in case of sickness for a prolonged period. If the stay is limited to one year but the salary is provided by a Swedish employer, individuals might still be eligible for a certificate that entitles them to medical care. If researchers are on a scholarship and not paying tax, they will not be eligible for healthcare and other benefits.

3.1.5 Enhancing the training, skills and experience of European researchers

There are no formal admission requirements for doctoral studies with regard to Swedish language skills, since many courses are given in English. This makes it easier for foreign students to study in Sweden. In addition, both graduate and postgraduate studies are for free. In 2011 the Swedish government has introduced tuition fees for students who are not citizens of the EU, EEA or Switzerland. Tuition will apply to bachelor's and master's programmes and courses, while PhD programmes remain tuition-free.

Both mobility between sectors and international mobility have gained increasing importance for career development in the last decade. This has further been highlighted in the research bills. The majority of both private and public foundations and agencies have programmes funding outward mobility at different research career stages. VINNOVA has also introduced measurements that facilitate and encourage mobility between different sectors such as VINNMER that has the long-term objective to help to increase the number of postgraduates that can become the leaders of the future at universities/colleges, centres, research institutes and companies.

3.2 Research infrastructures

Research infrastructures (RIs) are a key instrument in the creation of new knowledge and, by implication, innovation, in bringing together a wide diversity of stakeholders, helping to create a new research environment in which researchers have shared access to scientific facilities. Recently, most EU countries have begun to identify their future national RI needs, budgets and priorities in the so called National Roadmaps for Research Infrastructures. These strategic documents also set out a strategic view on how to guarantee and maintain access to research facilities.

Although some countries invest heavily in RIs, none can provide all the required state-of-the-art facilities on a national basis. Several large RIs have already been created in Europe. While optimising the use and development of existing RIs remains important, new infrastructures are needed to respond to the latest research needs and challenges. European Strategic Forum for Research Infrastructures ([ESFRI](#)) was established in April 2002 to support a coherent approach to policy-making on RIs in Europe and to act as an incubator for international negotiations on concrete initiatives. This section assesses the research infrastructures national landscape, focusing on the national RI roadmap and national participation in ESFRI.

3.2.1 National Research Infrastructures roadmap

Access to infrastructure is becoming increasingly important within many research fields and plays an important role in international collaborations. In a small country like Sweden it is a crucial task to nationally coordinate and finance the most expensive research infrastructures. This is highlighted in the research bill where an entire section is dedicated to infrastructure issues. VR is expected to spend €13.4m on research infrastructure over the period 2009-2012. In addition to this amount the government contributed with €13.4m in 2009, parts of which are meant to be used for the ESS, since Sweden will be the acting host.

Issues related to research infrastructure are mainly handled by the VR's Committee for Research Infrastructure that was established by the Board of VR in 2005. It formulates long-term strategies and handles resource allocation for expensive scientific equipment, large research facilities and extensive databases.

The first roadmap for research infrastructure, "The Swedish Research Council's guide to Infrastructure", was published in 2006 and has since then been updated once in 2007. The next rapport is expected in 2011 and as process of this work universities will contribute with input regarding future needs of infrastructure. The earlier roadmaps were prepared by VINNOVA and the three research councils: VR, FAS, and FORMAS. This roadmap covers all research areas and provides a basis for discussions on financing future infrastructure in Sweden as well as for participating in joint international research infrastructure. It takes a perspective of about 10-20 years. The roadmap report recommends that an investment fund should be established for large international infrastructure investment. An alternative would be to develop forms of financing that utilise investment loans from the Nordic Investment Bank or its European counterpart. In summary the following conclusions can be drawn:

- Sweden should participate actively in the development of common international infrastructures — primarily by contributing to the 15 projects from the ESFRI Roadmap.
- Research infrastructures should be coordinated at the national level to increase the quality of research and utilise resources more efficiently. Current examples include systems for managing environmental and climate data and the coordination of biobanks.
- National nodes should be developed to collaborate with international infrastructures. Resources are also needed on the home front to develop technology, expertise, and methods.
- Sweden should offer to host one or more international infrastructures, for example, ESS (European Spallation Source). Other possibilities would be the

MAX IV synchrotron radiation facility and the upgrading of EISCAT (European Incoherent Scatter Facility).

- Advancements in eScience are revolutionising many disciplines. eInfrastructures for large-scale computing, communication, and storage of data should be strengthened to benefit all research fields.

In planning research infrastructures it is essential to consider the full lifecycle — from concept and construction to operation and phase-out. Hence, the Swedish Research Council recognises the need for new types of grants that facilitate long-term planning and promote long-term projects and competition in operating and using infrastructures. For instance, establishment of a long-term investment fund has been proposed for large investments in research infrastructures.

In parallel to the development of the Swedish roadmap the ESFRI roadmap was developed and did not have a direct impact on the Swedish decision to invest in infrastructure.

3.2.2 National participation in the *ESFRI roadmap*. Updates 2009-2010

The above mentioned national roadmap also provides a priority list of the infrastructure elements that are of most value for the Swedish research community, industry and society as a whole. This type of list was one of the first ones of its kind in Europe. The bulk of the research infrastructure is found in natural and engineering fields with a focus on research in environment and climate areas, PRACS computing facilities, biomedicine and life sciences, but also the humanities and social sciences are of interest. The roadmap recommends that Sweden should primarily contribute to 15 out of the total 35 projects identified by the ESFRI Roadmap for Research Infrastructures. VR is participating in the planning of seven projects judged to be of particular interest. They are: ELIXIR (European Life Sciences Infrastructure for Biological Information), ESS (European Spallation Source), PRACE (Partnership for Advanced Computing in Europe), FAIR (Facility for Antiproton and Ion Research), Infrafrontier (Infrastructure for phenotyping and archiving of model mammalian genomes), LifeWatch (e-science and technology infrastructure for biodiversity data and observations), and XFEL (X-ray Free Electron Laser). Furthermore, the following projects were given a letter of support: European Biobanking and Biomolecular Resources Infrastructure (BBMRI), Council of European Social Science Data Archives (CESSDA), Common Language Resources and Technology Infrastructure (CLARIN), European Advanced Translational Research Infrastructure in Medicine (EATRIS), European Multidisciplinary Seafloor Observatory (EMSO), European Social Survey (ESS), Integrated Carbon Observation System (ICOS), Free Electron Laser Network for Infrared to Soft X-rays (IRUVX-FEL). In 2009 the Committee for Research Infrastructure decided to support planning grants for participation in the FP7 funded infrastructure project EISCAT_3D.

In 2009, VR invested SEK421m (€45m) in international infrastructure this is a higher than the investments done in national infrastructure (SEK348m=€37m). Since 2005 the investments in both national and international infrastructure have increased.

3.3 *Strengthening research institutions*

The ERA green paper highlights the importance of excellent research institutions engaged in effective public-private cooperation and partnerships, forming the core of research and innovation 'clusters', mostly specialised in interdisciplinary areas and

attracting a critical mass of human and financial resources. The Universities/research institutions should be embedded in the social and economic life where they are based, while competing and cooperating across Europe and beyond. This section gives an overview of the main features of the national higher education system, assessing its research performance, the level of academic autonomy achieved so far, dominant governing and funding models.

3.3.1 Quality of National Higher Education System

The institutions run by central Government are formally administrative agencies subject to the Government. The higher education and research within the institutions is financed predominantly out of central government funds. These institutions consist of 14 universities and 22 university colleges of which 7 are colleges of fine, applied or performing arts.

Chalmers University of Technology, the Stockholm School of Economics and the University College of Jönköping are private institutions. The private institutions are also to some extent funded by government funds. The differences between universities and university colleges are not always substantial. Below is a description of the two forms:

Universities

Universities have degree awarding powers at:

- First cycle (University diplomas and Bachelors' degrees);
- Second cycle (one-year and two-year Masters' degrees);
- Third cycle (licentiate and doctoral degrees).

In addition, they have:

- Entitlement to direct government funding for research.

University colleges

University colleges have degree awarding powers at:

- First cycle (University diplomas and Bachelors' degrees);
- Second cycle (one-year Masters' degrees).

Tuition at higher education institutions in Sweden is free of charge. This means that all Swedish students and students from the EU/EEA are educated free of charge, as well as students from outside this area. However, in the Government Bill 'Competing on the basis of quality – tuition fees for foreign students' (Govt. Bill 2009/10:65) the Government proposes that higher education should be free of charge for Swedish citizens and citizens of an EU/EEA state or Switzerland. The Parliament decided that citizens from other countries – 'third country students' – should pay a fee for their higher education as of the autumn term 2011.

Sweden ranks highly according to several of the indicators used in the OECD:

Well-educated population: 30% of the Swedish population between 30 and 64 years has taken a minimum of 120 higher education credits, equivalent to two years of full-time study.

Entrants: At 76%, Sweden has a large proportion of students beginning higher education in relation to its population.

Disciplines: Sweden awards a high proportion of qualifications in medicine and health sciences.

Third cycle (doctoral) studies: Sweden awards a high number of doctorates: 2.2% in relation to the size of a typical age cohort.

In the latest Shanghai university ranking, three Swedish universities were ranked among the top 100: Karolinska Institute number 42, Uppsala University number 66 and Stockholm University number 78.

It is the task of Högskoleverket (Swedish National Agency for Higher Education) to review the quality of higher education. This work includes:

- Evaluating subject areas (main fields of study) and study programmes;
- Granting degree awarding powers.

The purposes of quality assurance are the following:

- Individual students have the right to demand that their course or study programme is of a high standard;
- Employers in the public, private and voluntary sectors have a need for highly trained graduates;
- The general public is entitled to be assured that high levels of taxation result in high standards.

In a global world, Swedish higher education must retain a high standard therefore the Swedish National Agency for Higher Education's quality assurance policy has been developed in accordance with the European Network for Quality Assurance's (ENQA) Standards and Guidelines for Quality Assurance in the European Higher Education Area (ENQA 2009).

3.3.2 Academic autonomy

The Swedish government has recently presented a bill on greater autonomy for HEIs (Govt. Bill 2009/10:149), which creates further opportunities to transform the organisations. HEIs will still have the status as state agencies, but faculty boards will no longer be mandatory and regulated by the Higher Education Ordinance. In brief, this is the main conclusions of the bill.

- HEIs shall have a Board and a rector but are otherwise free to develop their own organisation.
- Decisions requiring a particular, qualified assessment must be taken by people with scientific or artistic qualifications.
- The students must have the right to representation when decisions are taken or preparations are made that significantly affect the education or the situation.
- Staff in the categories Professor and Senior Lecturer will continuously be regulated in the Higher Education Ordinance. Otherwise, HEIs can choose their own career structures and categories of staff. They can also recruit key persons to a professorship without the need for the traditional open competition.
- Education will be regulated at a less detailed level and some of the state regulated examination goals shall be abolished.

The Government Bill A Reformed Constitution (Govt. Bill 2009/10:80) also includes two amendments to the Instrument of Government that increase the freedom of higher education institutions. Under the proposal, the amendments will enter into force on 1 January 2011. A new provision is to be introduced in the Instrument of Government that establishes that the freedom of research is protected under statutory provisions. Such a provision is currently found in the Higher Education Act. Since many years, according to the Higher Education Act, researchers are free to design their own research agendas and they are also free to choose how to publish their results.

University boards include internal representatives, staff and students, and external members. The requirement that heads of government agencies and members of government agency boards must be Swedish citizens will be removed from the Instrument of Government but can instead be included in an act of primary legislation. The Government does not intend to impose such requirements in the area of higher education. It should be possible for a non-Swedish citizen to be a vice-chancellor or member of the board of a higher education institution.

Rectors and deans as well as other HEI managers can either be recruited through an open tender process or elected among peers. So far, the dominant pattern has been election, especially at older universities. Increasingly, however, an open tender process has been used in the recruitment of rectors. Formally, rectors are appointed by the Government.

One of the main reasoning behind this increasing autonomy is that universities want to decide to an increasing degree over funding sources. The “third task” to cooperate and inform society about universities activities has put increasing pressure on universities to interact with other actors. Increasing autonomy will make it easier for universities to develop their own strategies and implementation plans and will hopefully lead to increasing funding. At the same time one of the aims is that universities should further specialise in specific fields, which would result in increasing international competitiveness but also national competition between universities with the aim of increasing research quality. The debate has also raised the question about private universities since external funding plays an increasing important role. Especially universities that have been able to raise a large amount of external money have been proponents for this option.

Even though the debate on university autonomy has become increasing intensive the actual changes in the Swedish system has been rather few in comparison to some other European countries such as Denmark and Finland.

3.3.3 Academic funding

Direct government funding for research and third-cycle programmes amounted to SEK12.6b (€1.3b) in 2008. In comparison to 2007 direct government funding has risen by SEK800m (€86m) in current terms, including adjustments for prices and salaries of 0.3%.

In 2008 the revenues of the higher education institutions from external funding totalled SEK14.1b (€1.5b). In comparison to 2007 this external funding has risen by just over SEK400m (€43m) or 3%. This means that external funding accounted for 53% of the revenues of the higher education institutions in 2008.

In addition to the direct government funding received by the higher education institutions, most of their external funding also comes from the public sector. In 2008 82%

of the revenues of the higher education institutions came from public sources, the majority from the government.

The revenues of the higher education institution from public external funding have on the whole risen every year since 1999, except for two years, 2001 and 2005. The reduction in 2001 was largely due to a drop in funding from the research councils with the implementation of a new research funding organisation. The decline in 2005 can be explained by a drop in funding from the public research foundations.

The relations between education and research at Swedish HEIs vary considerably between HEIs. The proportion of undergraduate education varied in 2009 between 96.7% and 18.9%.

In the latest Research and Innovation Bill, a total of SEK11.5b (€1.2b) was allocated in 2008. Direct appropriations to universities and other higher education institutions will increase by SEK1.5b (€0.16b) over the period 2009-2012. The new funds and 10% of the previous appropriations will be distributed on the basis of a quality assessment. Quality will be assessed based on the ability of the higher education institution to attract external funding and the number and quality of scientific articles published by each institution.

The Government has also introduced investments in areas considered strategically important to Swedish society and the business sector. The Parliament decided in June 2010 that performance based funding should be introduced also for higher education, beginning in 2012. The Government considered (Focus on knowledge – quality in higher education, Government Bill 2009/10:139) that those higher education institutions that attain high quality in their study programmes are to be encouraged and receive acknowledgement through increased resource allocation. Those higher education institutions offering study programmes at first and second cycle that receive the highest appraisal when a quality evaluation is carried out should be rewarded by means of an extra funding. The quality-based resource allocation aims at increasing quality by creating incentives for universities and higher education institutions to try to achieve higher quality in their study programmes.

3.4 Knowledge transfer

The importance of knowledge dissemination and exploitation in boosting competitiveness and contributing to the effectiveness of public research has been increasingly recognised by EC and EU Member States. Following the publication of the [ERA Green Paper](#) in April 2007, the EC Communication "[Improving knowledge transfer between research institutions and industry across Europe](#)" was issued, highlighting the importance of the effective knowledge transfer between those who do research, particularly HEIs and PROs, and those who transform it into products and services, namely the industry/SMEs.

Several Member States have taken initiatives to promote and facilitate knowledge transfer (for instance new laws, IPR regimes, guidelines or model contracts) and many others are planning to intensify their efforts in this direction. However, these initiatives are often designed with a national perspective, and fail to address the trans-national dimension of knowledge transfer. This section will assess the national policy efforts aimed to promote the national and trans-national public-private knowledge transfer.

3.4.1 Intellectual Property Policies

The number of Swedish patent applications has remained constant over the last years. There is great potential to strengthen Sweden's competitiveness and increase growth by stimulating the output parameters in terms of more patents, more new products, more new businesses and more jobs in high-and medium-technology companies. Efforts in the latest research bill contribute to a strengthening in the field of high technology products and jobs, which is the parameter for which Sweden is performing worst.

The basic principle in Sweden is that the individual (as well as employed) researcher owns the result of his or her research. This applies to what one writes or draws as well as any technical invention. The "exemption for teachers", applicable in university and college situations, is in place with regard to patentable inventions. As a starting point, a researcher therefore has full ownership rights to his or her research result of this kind, if another agreement has not been reached. According to custom, this exemption has been extended to cover copyright-protected material. The Swedish government recently investigated the need for and consequences of an abolishment of the exemption for teachers. Abolishment would give a college the right to a teacher's invention against a reasonable compensation. The study also looked into universities' and colleges' obligation to support the commercialisation of research results and considered introducing an obligation on the part of teachers to report inventions to their employer. The government has decided to keep the exemption but to consider introducing an obligation on the part of teachers to report inventions to their employer.

A number of universities have established technology transfer offices (TTOs) as a mean to support commercialisation and entrepreneurship. Despite elaborative efforts to establish these offices, the academic support system for commercialization has been rather fragmented with many different players besides the inventor and the investor involved. In addition, it has been claimed that most of these university technology transfer activities have been informal and that the outcomes are not systematically organised (Stankiewicz, 1997; Etzkowitz et al., 2005; Jacob and Orsenigo, 2006).

In the latest research bill the government identified seven universities that would be given the opportunity to develop so called "innovation offices". These offices are supposed to provide support in issues related to commercialisation, patenting and licensing, knowledge exchange and principles for contract research. In addition they are supposed to inspire, inform, and stimulate researchers to innovate. The rationale behind the establishment of these innovation offices is to increase the utilisation of research results and thus create benefits for the society and industry.

3.4.2 Other policy measures aiming to promote public-private knowledge transfer

Spin-offs

As mentioned in the above section the newly established innovation offices are intended to support researchers that would like to commercialise their research results and further to establish spin-off companies. In the research bill the government highlighted the importance to increase the access to venture capital through the Innovationbron, a national company formed by the Teknikbrotstiftelsen, Industrifonden and the State with the support of VINNOVA in spring 2005. Innovationsbron is active all over Sweden to create a basis for internationally

competitive companies by commercialise innovations. It supports this development by providing seed financing, combined with industry related business development as active owners and helps developing incubators. Even though there is an established mechanism to support spin-offs there is a need for further support and increased venture capital.

Inter-sectoral mobility

Inter-sectoral mobility should increase and be facilitated according to the government. Three different possibilities to encourage mobility have been identified and include hiring of professors in industry, accepting industry PhDs, and to establish graduate schools with elements of industry collaboration and innovation. There are also a number of programmes especially initiated by VINNOVA and other agencies. In programmes supporting interaction between academia and industry the use of industry PhDs is a common way to improve the knowledge exchange and interaction. It is in general more common with inter-sectoral mobility when researchers are at the beginning of their career than for senior researchers and professors. VINNOVA has introduced a number of instruments supporting inter-sectoral mobility of more senior researchers.

Promoting research institutions - SME interactions

The majority of programmes and activities aimed at collaborations between industry and academia are also meant for SMEs. Unfortunately the participation rate of SMEs has not been satisfactory. The number of activities targeting specifically SMEs and academia are few and the issue has not been further addressed on a policy level. In Sweden, SMEs that are not spin-offs from universities are on average involved to a limited degree in research. The research institutes have a rather limited role as research institutions, in comparison to many other countries, but have on average a better interaction with SMEs than universities. There is a need to further strengthening and developing interactions between research institutions and SMEs with the aim of facilitating the growth and competitiveness of SMEs.

EU cohesion policy

Regional questions have received increasing attention in Sweden partly because of the EU's Cohesion Policy. The government has in a national strategy "National strategy for regional competitiveness, entrepreneurship and employment", covering the period 2007-2013, identified the importance of creating more competitive regions in Sweden. This is done through instruments encouraging innovative and entrepreneurial regions.

The duty to collaborate with societal actors has increased universities interactions with outside partners such as private actors. Also the role of chairman of the board has been given to an outsider, which at some universities includes people from private sector. In contrast, there is a concern that the increasing amount of external funding at universities will affect the autonomy of researchers to pursue their own research agendas. The decreasing amount of direct public funding has put pressure on universities to look for other, external, sources of funding. Since the latest research bill budget more public funding to universities has been allocated so this concern might be less of an issue in the years to come.

3.5 Cooperation, coordination and opening up national research programmes within ERA

The articulation between the R&D Framework Programmes, the Structural Funds and the Competitiveness and Innovation Programme is still underdeveloped in terms of coordination, synergies, efficiency and simplification. The policy fragmentation at EU and national level, and between EU and national policies can hinder the build of critical masses of research excellence, leads to the duplication of efforts, sub-optimal impacts of the different instruments and unnecessary administrative overheads. Differences between research selection procedures and criteria can also be an obstacle to the overall spread of excellence. This section assesses the effectiveness of national policy efforts aiming to improve the coordination of policies and policy instruments across the EU, all part of the drive to create an integrated ERA.

3.5.1 National participation in intergovernmental organisations and schemes

Participation in international collaboration initiatives have received increasing importance over the years and are a priority for all main research councils and agencies. Even though Sweden's participation in these initiatives has increased, the government is encouraging further engagement not the least for SMEs. VINNOVA is the responsible agency for inter-governmental participation in European programmes such as EUREKA, COST and FPs. Sweden remains among the top ten countries in terms of participation in EU's Seventh Framework Programme, FP7. The latest figures from the EU-Commission (October 2009) shows that Sweden has contracted close to SEK4b (€387m) since the start of FP7 in 2007. The contracted funds from FP7 represent about 25% of the total R&D funding in Sweden. 1,100 participations in 771 approved projects puts Sweden in 8th place among the countries in FP7. The Swedish success rate in FP7 is over 24% which gives a fifth position among the 27 EU member states. Swedish participation in approved project applications was 6,349 of which 1,535 applications were eligible for funding.

In the "Swedish Research Council's guide to Infrastructure" the prioritised inter-governmental Research Infrastructures and the strategy for the coming years are outlined. It is stated that Sweden should participate actively in the development of common international infrastructures and that it should be coordinated at the national level to increase the quality of research and utilise resources more efficiently. The VR's Committee for Research Infrastructure represents Swedish interests in various national and international research infrastructures. Sweden is participating in several international infrastructure initiatives and has been a long time member of CERN, EFDA, ESO, IceCube, JET, EMBL, ESRF, IARC, ILL, ISIS, PRACE, GBIF, IODP/ECORD, ESS, EUI, INCF and ITER. Furthermore, a number of Nordic initiatives exist such as NORDSIM, NDGF, NORDUnet, and NOT. The overall aim of these participation efforts is to provide better conditions for Swedish researchers by ensuring access to high quality infrastructures.

3.5.2 Bi- and multilateral agreements with other ERA countries

Sweden has rather established formal bilateral agreements with third countries, see 3.6.1. Collaborations on the European level either take place through infrastructure, but have mainly focused on Nordic collaborations through the Nordic Council and Nordic Council of Ministers for Education and Research where Denmark, Finland, Iceland, Norway and Sweden participate. The Nordic Council participates in the

Baltic Sea co-operation in the [BSPC](#) both by sending a delegation to the annual meeting and by representing its member countries in the organisation's permanent committee. The Nordic Council has Observer status in the permanent [Standing Committee of Parliamentarians of the Arctic Region](#) (SCPAR), which is the parliamentary counterpart to the [Arctic Council](#). The Nordic Region is aiming at establishing a coherent area in which knowledge can move freely across national borders. This area will appear internationally attractive as compared to the surrounding world, and act as a flagship for the Nordic Region. As a step in this direction a strategy has been developed where the main goals are to: further develop the Nordic Research and Innovation Area (NORIA) which aims to develop the Nordic region in Europe (ERIA) and other parts of the world; improve research and innovation through increased efforts in the joint Nordic research and innovation institutions, as well as intensify co-operation between the national research funding bodies; develop and strengthen NordForsk's central role for the co-ordination of Nordic research activities; identify the Nordic positions of strength in the area of research and innovation; and to promote co-operation around the research infrastructure.

3.5.3 Other instruments of cooperation and coordination between national R&D programmes

Sweden has two NCP (National Contact Points) for ERA-NET: one based at VINNOVA and one at VR. The latter is involved in eight ERA-NET programmes. VINNOVA is involved in five ERA-NET projects that fall into Theme 2, "Technology for the Information Society" and one ERA-NET project, Cosine 2, that belong to Theme 2, "Technology for the Information Society".

Sweden participates in the ESF through six member organisations: the Swedish Research Council, the Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning (Formas), the Council for Working Life and Social Research (FAS), the Royal Academy of Sciences, the Swedish Governmental Agency for Innovation Systems (VINNOVA), and the Royal Academy of Letters, History, and Antiquities. Sweden contribute with a total of SEK3m (€0.32m) in membership fee per year.

Swedish organisations, both universities and industry representatives, are represented in both ETPs and JTIs. One example is the IMI, where both Swedish researchers and companies have had leading roles in the initiation and implementation of different projects. In addition, the JPIs have been a prioritised initiative among both private and public actors as well as among policy makers.

3.5.4 Opening up of national R&D programmes

The majority of research councils and agencies have for the last couple of years worked with an international action plan which states goals and strategies related to international activities. The main goal is to make it easier for Swedish researchers to act in an international environment and for non-national researchers to work and interact with Swedish researchers. Even though international cooperation is a central part of the activities, funding is rarely available for foreign based researchers.

In the most recent research bill it is highlighted that the international dimension of research policy needs to be strengthened. As part of this the Ministry for Foreign Affairs prepared an international strategy for Swedish foreign policy "Underlag för internationell strategi i svensk forskningspolitik" (dnr U2008/2555/F). The document

recommends that clear goals regarding international research collaborations should be developed at central level, as well as among universities. The long-term objective should be to allocate a specific budget earmarked for collaborations with prioritised countries. The document further discusses a number of barriers in the formulation of laws and regulations that limit international collaborations. It is not clear to what extent public research funding can be used outside the Swedish borders. On the one hand the funding is supposed to promote Swedish research, but at the same time funders are supposed to engage and develop international collaborations. According to the international strategy, international collaborations would benefit from clearer legislations that could help research funding agencies in their work towards more extensive and long term international collaborations. In the most recent research bill this issue is further elaborated. With a trend towards encouraging international collaborations, opening funding programmes to external collaborators and funding international actors may become a viable option. According to the bill such efforts will be carried out to a limited extent and the conditions on how to best implement such activities is still examined by the Government.

VR is working towards making it easier for funded researchers to transfer the grants awarded to other countries in case of relocation. VR has therefore, on the initiative of the European Heads of Research Councils (EUROHORCs), signed the Money Follows Researcher (MFR) agreement. According to this agreement, a researcher moving to a country in which there is an organisation that has also signed the MFR agreement, can take along the remaining part of a grant. Project Research Grants and Research Equipment Grants (<SEK2m) are eligible. Grants for Postdoctoral Positions cannot be transferred to another country.

3.6 *International science and technology cooperation*

In 2008, the European Commission proposed the [Strategic European Framework for International Science and Technology Cooperation](#) to strengthen science and technology cooperation with non-EU countries. The strategy identifies general principles which should underpin European cooperation with the rest of the world and proposed specific orientations for action to: 1) strengthen the international dimension of ERA through FPs and to foster strategic cooperation with key third countries through geographic and thematic targeting; 2) improve the framework conditions for international cooperation in S&T and for the promotion of European technologies worldwide. Having in view these aspects, the following section analyses how national policy measures reflect the need to strengthen the international cooperation in S&T.

3.6.1 International cooperation

The Swedish government has since several years had several agreements with third countries. The co-operations are an important aspect of Sweden's strategic priorities where Sweden can exploit its comparative advantages. In the latest research bill Brazil (bioenergy and biofuels), India (life sciences, IT, environment, transport), Israel (IT), Japan (Biotechnology, ICT, e-Health), China (material, ICT, biomedicine, research- and innovation policy, environment, energy and climate change, healthcare), South Africa, USA (several different fields with a focus on renewable energy) are identified as ongoing agreements. In addition the individual research councils and agencies have established bilateral agreements with a number of countries. In addition Sweden has established a number of foreign offices in third

countries with the aim to further strengthening collaborations and Swedish research and innovation interests abroad.

3.6.2 Mobility schemes for researchers from third countries

The bilateral agreements mentioned in the above section also aim at establishing and increase the mobility of researchers from the different countries. The government is highlighting the importance of international mobility in the most recent research bill. In addition research councils, agencies and foundations are funding both inward and outward mobility. Examples of existing programmes include the Sweden-Korea Research Cooperation funded by the Swedish Foundation for International Cooperation in Research and Higher Education. The SSF have a number of specific mobility grants aimed for mobility to both European and non-European countries. Mobility grants for exchange with Japan exist in a number of different forms and programmes organised by SSF and VINNOVA. The increase of especially inward mobility could be a result of these initiatives but specific analysis regarding the impact of the different programmes and activities has been made.

4 Conclusions

4.1 *Effectiveness of the knowledge triangle*

The policy mix in place for promoting private investments in R&D has further developed in 2009 and 2010. The government has invested in strategic research areas amounting to SEK1.8b on a yearly basis. The strategic investments aim at building up a number of new world class research environments in research areas that have been specifically selected because of their strong strategic importance for society. A number of the strategic research areas are also appropriate for partnership programmes with industry, where institutions of higher education, authorities, companies and research institutes make joint investments. In the long-term the aim is to contribute to raising research quality, improving conditions for commercialisation, encouraging cross-disciplinary scientific approaches and increasing opportunities for the system to make use of EU funding.

Improved commercialisation and knowledge transfer around universities in relation to the universities' third task is targeted by the research bill, which encourages universities to commercialise to a greater degree the outcomes of research. This is hoped to be achieved by a change in the Higher Education Act, which more clearly lays out the responsibilities of universities to promote commercialisation of research results. Related to this is the establishment of 'Innovation offices' at seven universities, supporting commercialisation, patenting and licensing, etc. The Government has appropriated €6.9m (SEK75m) for these efforts.

The following table gives a short assessment on the effectiveness of policies in the knowledge triangle.

Table 3: Effectiveness of knowledge triangle policies

	Recent policy changes	Assessment of strengths and weaknesses
Research policy	<p>The government has invested in strategic research areas amounting to SEK1.8b on a yearly basis. The strategic investments aim at building up a number of new world class research environments in research areas that have been specifically selected because of their strong strategic importance for society. The strategic areas include:</p> <ul style="list-style-type: none"> • Energy • Sustainable exploitation of natural resources • Effects on natural resources, ecosystems and biological diversity • Climate models • Sea environmental research • Cancer • Diabetes • Epidemiology • Molecular biology • Neuroscience, incl. brain- and nerve system diseases • Stem cells and regenerative medicine • Health • Nanoscience and nanotechnology • E-science • Material science, incl. functional materials • IT and mobile communication, incl. future solutions for communication and monitoring systems • Production technology • Transport research • Security and crisis management • Politically important geographical regions 	<ul style="list-style-type: none"> • Sweden’s economic growth and resilience to the financial crisis will most likely have a positive effect on further public investments in research. Still the crises will most likely result in a decreasing R&D investment from industry. • The increasing importance and investment of infrastructure both internationally and nationally will improve the quality of research and Sweden’s role as a strong research actor in the rest of the world. • The interest for students enrolling in S&E studies has decreased over the last years. One of the main reasons why global companies have invested in R&D in Sweden is because of the strong engineering knowledge base. If the number of engineers and strong S&E skills are decreasing there might be a risk that companies relying on these skills will move their activities abroad and invest in other countries. • So far, most R&D has been performed by large companies and to a lesser extent by SMEs. • The crisis will most likely result in less R&D investment from SMEs, which will impair the level of research activities even further. • The concept “the Swedish Paradox” is still relevant, i.e. High inputs and low output = low productivity.

	Recent policy changes	Assessment of strengths and weaknesses
Innovation policy	<ul style="list-style-type: none"> • Establishment of 'Innovation offices' at seven universities, supporting commercialisation, patenting and licensing, etc. The Government has appropriated €6.9m (SEK75m) for these efforts. • Improved commercialisation and knowledge transfer around universities in relation to the universities' third task is targeted by the research bill, which encourages universities to commercialise to a greater degree the outcomes of research. This is hoped to be achieved by a change in the Higher Education Act, which more clearly lays out the responsibilities of universities to promote commercialisation of research results. 	<ul style="list-style-type: none"> • The identified strategic research areas are in line with the industrial priorities. A number of the strategic research areas are also appropriate for partnership programmes with industry, where institutions of higher education, authorities, companies and research institutes make joint investments.
Education policy	<ul style="list-style-type: none"> • In the Government Bill 'Competing on the basis of quality – tuition fees for foreign students' (Govt. Bill 2009/10:65) the Government proposes that higher education should be free of charge for Swedish citizens and citizens of an EU/EEA state or Switzerland but that students from other countries should pay a fee for their higher education as of the autumn term 2011. • The Swedish government has recently presented a bill on greater autonomy for HEIs (Govt. Bill 2009/10:149), which creates further opportunities to transform the organisations. HEIs will still have the status as state agencies, but faculty boards will no longer be mandatory and regulated by the Higher Education Ordinance. 	<ul style="list-style-type: none"> • The decrease of PhD graduates might result in a lack of research competence that can take over after the retirement boom that is to be expected in higher education. • Increased autonomy for HEIs will enable institutions to reconsider their organisations and recruitment procedures. There has been a concern expressed by the Union of University teachers that a deregulated sector might decrease collegial decision-making at HEIs.

4.2 ERA 2020 objectives - a summary

The ERA concept has gained increasing attention in national strategies and objectives in recent years. It is first and foremost participation in the Framework Programmes that has received stronger focus. The most recent policy bill highlighted the need to extend European collaborations, including increased cooperation between national researchers and programmes, facilitating mobility, and increasing investment in common research infrastructure. National policies addressing the need to open up national research programmes have been addressed in a number of policy documents but have not been practically implemented. Also the modernisation of research organisations has only been carried out to limited extent.

The main challenge for Sweden is to continue performing high quality research and to provide an attractive environment for foreign companies to base their R&D

activities in. The ERA is aiming for an integrated research area in which other countries that have not had the national resources to invest in R&D will gain opportunities. This means that Sweden will meet increasing competition from other European countries.

Table 4: Assessment of the national policies/measures supporting the strategic ERA objectives (derived from ERA 2020 Vision)

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive single European labour market for male and female researchers	<ul style="list-style-type: none"> • Post-doctoral employment scheme. • Investment in quality of mathematics, engineering and science in primary and secondary school. 	<ul style="list-style-type: none"> • Decreasing number of students enrolling for S&E programmes • Increasing interest from foreign students to study in Sweden
2	Increase public support for research	<ul style="list-style-type: none"> • Government launch of strategic research areas 	<ul style="list-style-type: none"> • Sweden's economic growth and resilience to the financial crisis • Still weak connections between academic research and industry.
3	Increase European coordination and integration of research funding	<ul style="list-style-type: none"> • Increasing importance and support to European initiatives 	<ul style="list-style-type: none"> • Sweden already live up to the 3% target investment • Swedish researchers may be reluctant to share their resources with foreign colleagues as long as the public and private support in other countries do not live up to the Swedish standards • Swedish researchers are not very many, and the best may already be engaged in European initiatives.
4	Enhance research capacity across Europe	<ul style="list-style-type: none"> • Building, maintaining and operation of research infrastructure 	<ul style="list-style-type: none"> • Sweden will host several European infrastructures • Investment in research infrastructure is a vital topic among Swedish funding bodies. • Decreasing number of PhD graduates • Decreasing number of students enrolling for S&E programmes
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	<ul style="list-style-type: none"> • Current governmental investments in global infrastructures such as ESS and Max Lab 4 in Sweden. • Support of 15 ESFRI infrastructures 	<ul style="list-style-type: none"> • Sweden has a long tradition in building, maintaining and operation research infrastructures and have one of the most advanced and developed infrastructures in several fields

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
6	Strengthen research institutions, including notably universities	<ul style="list-style-type: none"> • Additional funding through strategic research areas. • Development of a quality assurance system for evaluating research at universities that will hopefully result in increasing research quality at the same time the system is using traditional indicators which could limit the growth of new research and the interaction with society 	<ul style="list-style-type: none"> • The role of universities is not clear and is complex and there are signs of mission overload. • The new distribution model puts more emphasis on performance and quality. This development has been disputed in the academia that wants more autonomy • HEIs feel they are deregulated on the one hand but on the other micromanaged and monitored by the state.
7	Improve framework conditions for private investment in R&D	<ul style="list-style-type: none"> • Launch of public-industry joint funding of research, innovation and development (e.g. the likes of FFI at VINNOVA). 	<ul style="list-style-type: none"> • The economic crises will most likely lead to even further decrease in private investment in R&D • Increasing globalisation, increasing competition, resulting in MNCs moving their R&D investments abroad • Increasing focus on target research fields, which are in accordance with the economic specialisation
8	Promote public-private cooperation and knowledge transfer	<ul style="list-style-type: none"> • Establishment of public private partnership (PPP) programmes that target the knowledge demand from both universities and industry • Establishment of innovation offices at universities 	<ul style="list-style-type: none"> • Sweden's long tradition of public-private cooperation • The low investment in R&D among SMEs
9	Enhance knowledge circulation across Europe and beyond	<ul style="list-style-type: none"> • Initiatives stimulating the inward mobility of foreign researchers such as tax reductions are in place 	<ul style="list-style-type: none"> • Increasing inward and outward mobility
10	Strengthen international cooperation in science and technology and the role and attractiveness of European research in the world	<ul style="list-style-type: none"> • Sweden has introduced a legislation based on the EU's Researchers Visa Directive making it easier for third countries researchers to work. 	<ul style="list-style-type: none"> • Sweden has a long tradition of collaborating with third countries • Sweden has a number of bilateral agreements with third countries in place • High level of the populations English and courses thought in English

	ERA objectives	Main policy changes	Assessment of national strengths and weaknesses with regard the specific ERA objective
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle	<ul style="list-style-type: none"> • The research bill includes both research and innovation policies and address private and public actors • Several different ministries contribute to the formulation of research and innovation policies 	<ul style="list-style-type: none"> • The tradition of developing research and innovation policies combined • No formal and obligatory arena for coordination exists in the area of research and innovation policy and operations, and there is also the lack of comprehensive coordination at this level is a recognised weakness
12	Develop and sustain excellence and overall quality of European research	<ul style="list-style-type: none"> • The Swedish National Agency for Higher Education review the quality of higher education by evaluating subject areas (main fields of study) and study programmes and granting degree awarding powers • A new performance based funding system for research has been introduced. 	<ul style="list-style-type: none"> • Long tradition of carrying out high quality research and education • The Swedish National Agency for Higher Education's quality assurance policy has been developed in accordance with the European Network for Quality Assurance's (ENQA) Standards and Guidelines for Quality Assurance in the European Higher Education Area
13	Promote structural change and specialisation towards a more knowledge - intensive economy	<ul style="list-style-type: none"> • The identification in the research bill of a number of strategic research areas 	<ul style="list-style-type: none"> • Overlapping high quality of research in fields of importance for industry is a strength • The identified strategic research areas will support research in fields were Sweden already has a strong R&D position
14	Mobilise research to address major societal challenges and contribute to sustainable development	<ul style="list-style-type: none"> • Strategic research areas and dedicated programmes through sectoral funding agencies. • Involvement of industry and other actors in formulating policies 	<ul style="list-style-type: none"> • Overlapping high quality of research in fields of importance for industry is a strength
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	<ul style="list-style-type: none"> • Parliament decided in June 2010 that performance based funding should be introduced also for higher education, beginning in 2012 	<ul style="list-style-type: none"> • The high level of trust in research among Swedish citizens • The systematic evaluation policy has contributed to a more systematic policy and may facilitate policy learning

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List of Abbreviations

BERD	Business Expenditures for Research and Development
CERN	European Organisation for Nuclear Research
COST	European Cooperation in Science and Technology
ERA	European Research Area
ERA-NET	European Research Area Network
ERP Fund	European Recovery Programme Fund
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EU-27	European Union including 27 Member States
FDI	Foreign Direct Investments
FP	European Framework Programme for Research and Technology Development
FP7	7th Framework Programme
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
GUF	General University Funds
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
HES	Higher education sector
IP	Intellectual Property
OECD	Organisation for Economic Co-operation and Development
PRO	Public Research Organisations

R&D	Research and development
RI	Research Infrastructures
RTDI	Research Technological Development and Innovation
S&T	Science and technology
SF	Structural Funds
SME	Small and Medium Sized Enterprise
VC	Venture Capital