OECD Reviews of Innovation Policy: Sweden 2016

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ABBREVIATIONS AND ACRONYMS

BERD	Business Expenditure on Research and Development;
CDI/ UDI	Challenge-driven innovation (Utmanningsdriven Innovation)
CIIE	Committee for Industry, Innovation and Entrepreneurship
CSTP	Committee for Scientific and Technological Policy
CTH	Chalmers University of Technology
DARPA	Defense Advanced Research Projects Agency
DoE	Department of Energy
EC	European Commission
ERA	European Research Area
ERC	European Research Council
ESFRI	European Strategy Forum on Research Infrastructures
ESS	European Spallation Source
EU	European Union
EUR	Euros
EU-SAM	National Co-ordination Function
FAS/FORTE	Swedish Council for Working Life and Social Research
FDI	Foreign Direct Investment
FHS	Defence College
FIM	Forum for Innovation Management
Formas	Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning
FP	Framework Programme
FTE	Full Time Equivalent
GBAORD	Government Budget Appropriations for Research and Development
GDP	Gross Domestic Product
GERD	Gross Expenditures for Research and Development
GOVERD	Governmental Intramural Expenditures for Research and Development
GSM	Global System for Mobile communications
GU	Gothenburg University
GUF	General University Fund
H2020	European Union's Horizon 2020
HB	Borås College
HEI	Higher Education Institute
HERD	Higher Education Expenditures for Research and Development
HJ	Jönköping College
HK	Kristianstad College
HS	Skövde College

IBM	International Business Machines Corporation
ICT	Information and Communication Technologies
IVA	Royal Swedish Academy of Engineering Sciences (Kungliga Ingenjörs Vetenskaps Akademien)
JPI	Joint Programming Initiative
JPI AMR	Joint Programming Initiative on Antimicrobial Resistance
KBC	Knowledge-based Capital
KI	Karolinska Institute
KKS	Knowledge Foundation (KK-stiftelsen)
KTH	Royal Institute of Technology (Kungliga Tekniska Högskolan)
LiU	Linköping University
LTH	Lund University of Technology
LU	Lund University
MIU	Mid-Sweden University
MNE	Multinational Enterprise
NAE	National Academy of Engineering
NASA	National Aeronautics and Space Administration
NIH	National Institutes of Health
NSF	National Science Foundation
NUTEK	Swedish National Board for Industrial and Technical Development (Närings- och teknikutvecklingsverket)
OECD	Organisation for Economic Co-operation and Development
OSTP	Office of Science and Technology Policy
P2P	Public-to-Public
PhD	Doctor of Philosophy
PRFS	Performance-based Research Funding
PRO/PRI	Public Research Organisation / Institute
R&D	Research and Development
R&I	Research and Innovation
RCN	Research Council of Norway
RI	Research Institute
RISE	Research Institutes of Sweden (before was named IRECO)
RTO	Research and Technology Organisation
SAK	Cooperation, division of labour and concentration (Samarbeid, arbeidsdeling og konsentrasjon)
SBIR	Small Business Innovation Research
SFO	Strategic Research Area
SH	Södertörn College
SHOK	Strategic Centres for Science, Technology and Innovation
SIA	Strategic Innovation Agenda
SIDA	Swedish International Development Cooperation Agency
SIO	Strategic Innovation Area
SIP	Strategic Innovation Programme

SLU	Swedish University of Agriculture
SME	Small and Medium Enterprise
SNSB	Swedish National Space Board (Rymdstyrlsen)
SOU	Swedish Government Report (Statens offentliga utredningar)
SP	Technical Research Institute of Sweden (Sveriges Tekniska Forskningsinstitut)
SRA	Strategic Research Areas
SSF	Swedish Foundation for Strategic Research
STI	Science, technology and innovation
SU	Stockholm University
SWOT	Strengths, weaknesses, opportunities and threats
TFR	Technical Research Council
TIP	Working Party for Innovation and Technology Policy
TNO	Dutch Research and Technology Organisation (Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek)
TPF	Third-party Funding
TRL	Technology Readiness Level
UDI	Challenge-driven Innovation (Utmaningsdriven innovation)
UKÄ	Higher Education Authority
UmU	Umeå University
USAID	United States Agency for International Development
UU	Uppsala University
VINNOVA	The Swedish Governmental Agency for Innovation Systems
VINNVÄXT	Initiatives Supporting Regional Development
VR	Swedish Research Council (Vetenskapsrådet)
VTT	Technical Research Centre of Finland

Country name abbreviations

AUS	Australia	**FIN**	Finland	**MEX**	Mexico
AUT	Austria	**FRA**	France	**NLD**	Netherlands
BEL	Belgium	**GBR**	United Kingdom	**NOR**	Norway
CAN	Canada	**GRC**	Greece	**NZL**	New Zealand
CHE	Switzerland	**HUN**	Hungary	**POL**	Poland
CHL	Chile	**IRL**	Ireland	**PRT**	Portugal
CHN	People's Republic of China	**ISR**	Israel	**RUS**	Russian Federation
CZE	Czech Republic	**ITA**	Italy	**SVK**	Slovak Republic
DEU	Germany	**JPN**	Japan	**SVN**	Slovenia
DNK	Denmark	**KOR**	Korea	**SWE**	Sweden
CZE	Czech Republic	**LTU**	Lithuania	**TUR**	Turkey
ESP	Spain	**LUX**	Luxembourg	**USA**	United States
EST	Estonia	**LVA**	Latvia		

CHAPTER 1 OVERALL ASSESSMENT AND RECOMMENDATIONS

Focus of the *Review*

In 2012, at the request of the Swedish Ministry of Enterprise, Energy and Communications (now the Ministry of Enterprise and Innovation), the OECD performed a review of Sweden's innovation policy. Following the standard methodology for conducting OECD country reviews of innovation policy, the 2012 *Review* provided an independent, comparative assessment of the strengths and weaknesses of the Swedish innovation system, examined its main actors and their interactions, and identified opportunities for improving its overall performance. The resulting recommendations focused on how government policies could contribute to such improvements, drawing on the experience of other OECD countries and existing evidence on innovation processes, systems and policies.

This follow-up – the *OECD Review of Innovation Policy: Sweden 2015* – was commissioned by the Ministry of Enterprise and Innovation. It is intended to deepen the earlier analysis by following up on developments in six key policy initiatives that were central to the Research and Innovation Bills of 2008 and 2012. These involved:

- a significant increase in the "general university funds" (GUF) or "block funding" for university research and the related introduction of a scheme partially linking funding for research to a performance assessment scheme

- the establishment of strategic research areas (SFOs) to enable universities to strengthen capabilities in existing areas of research strength and excellence

- actions designed to enhance the role of research institutes (RIs) in Sweden's innovation system

- the definition and funding of strategic innovation areas (SIOs), whose aim was to strengthen industrial capabilities by supporting collaborations involving new, broad-based configurations of industrial, academic and research institute actors

- the initiation of a Challenge-driven Innovation (UDI) programme focusing on four key areas addressing societal challenges (Information society 3.0; Sustainable attractive cities; Future healthcare; and Competitive production) in which Sweden has both a strategic interest and a good innovation track record

- improved prioritisation and support for Swedish participation in European research and innovation activities, including participation in the European Union's Horizon 2020 (H2020) initiative and involvement in public-to-public (P2P) partnerships aligning research and innovation efforts across Europe, especially in areas related to societal challenges.

In the following, these policy developments are discussed under the following headings:

- strengthening university research

- linking research and innovation
- dealing with societal challenges
- priorities, strategies and governance.

While the focus of this follow-up report is on Swedish policies and institutions, it has a global context in at least two ways. First, it is informed not only by the history and current performance of the Swedish system, but also by lessons and useful practices emerging from international experience. Second, and more importantly, it sets out recent achievements and challenges related to the above-mentioned six policy initiatives that constitute the focus of this report, plus a series of strategic tasks, guiding principles and recommendations vital to Sweden's global competitiveness in research and innovation. These are of the essence if Sweden is not merely to maintain its "good" position in global terms, but also to establish and consolidate excellence and leadership, untrammelled by some of the limitations of its research and innovation system today.

Specific attention is paid to the historical development of the Swedish innovation system as there are signs that institutions, governance and therefore path dependencies tend to limit the system's flexibility, and hence its ability to keep up with the competition. The signs are evident in some of the governance issues associated with current governance structures, arrangements and related policies. Ignoring these signs raises the risk that they will reappear during the development and implementation of future policies. Whatever the strength of the system today, it is clear that it needs to be nimble and flexible in order to keep up with the demands of tomorrow.

The Swedish innovation policy context

The 2012 *Review* of Sweden's innovation policy summarised Swedish achievements and the challenges facing the country prior to identifying a series of strategic tasks, guiding principles and detailed policy recommendations that Sweden might follow. A summary of the results of the *Review* provides a useful starting point for further analysis of the six policy areas listed above.

The 2012 *Review* pointed to Sweden's impressive economic and social development since it began to industrialise in the 19th century. Sweden's development has been characterised by:

- early internationalisation of large Swedish companies
- in certain fields, co-operation between national industry and the state in developing new technologies and making strategic use of public procurement, allowing Sweden to act as a lead market for new product generations
- a framework for "tripartite" interaction among government and social partners, and sharing of productivity gains
- high levels of education, skill and investment in knowledge-based capital (KBC), including research and development (R&D).

Other characteristics of the Swedish system that are key to understanding recent policy developments include:

- The Research Bill process involves wide consultation every four years on policy needs related to research (and in later years also to innovation), and the subsequent publication of a bill setting

out government policies, including justification for proposals and an account of the reasoning behind them. The Ministry of Education and Research leads this process, since its minister takes the lead in government discussions affecting research.

- The existence of a "Swedish model" for universities stems from a recommendation made by the Malm Commission in 1942 not to set up a national technological institute such as those developed by the Netherlands (TNO) or Finland (VTT), but to build the equivalent capabilities into the universities so that they could perform a "third mission" serving the needs of the broader community. The Malm Commission did propose a role for various RIs to serve the needs of industries not dominated by one or more big firms – but they were not to be the major focus of technological efforts. The intention was to avoid fragmenting the research resources of a comparatively small country; it has coloured Swedish research policy ever since.

Innovation has long been at the core of Swedish economic and social development. It has underpinned Swedish enterprises' strong international competitiveness in manufacturing and services, as well as drawn on and fed into the well-educated labour force. It has also generated the revenues to be distributed throughout society and reinvested in innovation activities. This virtuous circle has helped transform Sweden into one of the world's most innovative economies and societies. Innovation has been facilitated through sharing productivity gains and an active labour-market policy mitigating the frictions associated with "creative destruction". By international standards, innovation is comparatively well accepted in Swedish society.

Sweden's development path, however, has not been linear. Like other European countries, the country has experienced a growth slowdown and persistently weak productivity performance following three decades of post-Second World War economic dynamism. As a small, highly open economy, Sweden was not spared by the financial and economic crisis that led to a deep recession in 2009. But earlier fiscal and banking system reforms, as well as industrial restructuring triggered by the recession of the early 1990s, meant that Sweden was better prepared for – and recovered faster from – the recent crisis than many other countries. A less favourable international macroeconomic environment (notably in Europe) has kept growth below pre-crisis levels, although well above growth in other European countries.

Overall, the 2012 *Review* concluded that Sweden had embraced changes in the global economy successfully. It has maintained a strong industrial base with an exceptionally broad range of products, in which it shows a comparative advantage for a country of its size. Swedish manufacturers have successfully integrated sophisticated service components into their products, and market services have grown rapidly. Despite these strengths, the *Review* warned that Sweden's success should not create complacency. Given the intensity of global competition and the continuous need to be at the forefront, new initiatives were needed in order to tap new sources of growth. There was also scope to improve policy formulation and planning.

The 2012 *Review* noted that over the last 25 years, important segments of Sweden's industry have been taken over by non-Swedish multinational enterprises (MNEs) with headquarters outside of Sweden. At the same time, large Swedish firms – which have long relied on international markets – have become more profoundly "global" in reach and orientation. Irrespective of their ownership, these enterprises are guided by their global corporate strategies, including those related to R&D. These changes have had an impact on interactions in the Swedish innovation system and raise questions of how to facilitate adaptation and further internationalisation of Swedish science, technology and innovation (STI). In some cases, actors in the research system have lost important industrial counterparts.

Sweden's R&D intensity (gross expenditure on R&D as a percentage of gross domestic product [GDP]) – long the highest in the world – started to decline in 2000 and stood at around 3.3% of GDP in

2013. This development was driven by a decline in business expenditure on R&D, which is highly concentrated in large MNEs. Many of these MNEs have so far maintained a strong R&D effort in Sweden.

The 2012 *Review* confirmed Sweden's position as an important international centre of scientific excellence and technological leadership. Sweden performs well in the field of science, in terms of both the volume and quality of its scientific publications (as assessed by the share of citations). Sweden can also boast a higher number of international patents per capita than most OECD countries – far above the EU average. The general picture that emerges is that Sweden has maintained a high level of performance, but has done less well in recent years than a number of comparator countries.

The *Review* identified the following key strengths in the Swedish research and innovation system:

- successful economic development
- specialised at high end of global value chains
- good framework conditions
- a strong human resource base
- high investment in R&D, KBC and information and communication technology (ICT)
- a strong science base
- excellent innovation performance
- good positioning in international networks.

Significant weaknesses were:

- some aspects of financing for innovation
- declining educational performance
- a sub-optimal academic intellectual property system
- small academic centres of competence/excellence
- weak links between traditional universities and small and medium-sized enterprises (SMEs)
- weak innovation policy compared to policy in other areas (e.g. education)
- lack of a holistic perspective concerning innovation policy
- many medium-sized funding agencies funding similar things
- unclear governance in regional innovation policies.

The 2012 *Review* identified a series of strategic tasks and guiding principles that Sweden might adopt in order to improve the performance of the overall innovation system.

These strategic tasks included:

- providing world-class framework conditions and infrastructures for business
- improving links between Sweden's strong universities and its relatively small public research institutes (PRIs), with a view to enhancing the links of both with industry
- fostering internationalisation at the forefront of STI
- adopting pioneering approaches to innovation, and the development and implementation of innovation policy.

The guiding principles suggested:

- taking a broad approach to innovation
- highlighting innovation in services
- further strengthening international openness
- ensuring quality, relevance and critical mass in public research.

More detailed recommendations included:

- maintaining supportive framework conditions for innovation and entrepreneurship
- maintaining a world-class human resource base for STI
- improving public governance of the innovation system
- fostering innovation in the business sector
- balancing the policy mix and enhancing the role of demand-side policies
- fostering critical mass, excellence and relevance in public-sector research
- strengthening regional innovation policy and its alignment with national policy
- strengthening public-sector innovation and social innovation
- maximising benefits from the internationalisation of R&D and innovation.

The 2012 *Review* argued that maintaining Sweden's strong long-term economic performance in an increasingly globalised world would depend to a great extent on the country's innovation capacity, i.e. its ability to generate, transfer and assimilate a continuous flow of technological, managerial, organisational and institutional innovation. Meeting this challenge calls for continued high investment in R&D and innovation, as well as a well-functioning innovation system that ensures high returns on investment.

Recent achievements and challenges

Limited success in terms of strengthening the university research base

Sweden attempted to enhance the university research base by increasing GUF and launching the SFO initiative, both aimed at improving the overall research performance of the higher education institutions (HEIs) by allowing them to build on existing strengths. Universities were expected to use the additional GUF money to give researchers greater freedom to follow their own agendas, rather than be committed to some of the agendas of third-party funding (TPF) bodies. Similarly, while a new performance-assessment scheme introduced at the same time was partially based on success in raising competitive TPF, the additional funds gained were also envisaged as a form of compensation that could be used to fund the individual research interests of academics. Finally, the SFO scheme specifically prioritised research endeavours in a very broad range of areas that gave universities an opportunity to bid for funds that would allow them to channel money into areas they deemed "strategic", typically reinforcing areas of strength.

None of these initiatives can be considered truly effective. GUF certainly increased, but the viciously circular link between GUF and TPF that has existed in Sweden for many years was not broken. Rather than using the money to allow individual researchers to follow "non-tied" or "open" lines of enquiry, the funds were often used to hire new recruits whose salaries partly depended on their raising additional "tied" funds from TPF sources. The mechanics of the performance-assessment scheme and the proportion of GUF for research affected by the scheme (10% in the 2008 Bill, rising to 20% after the 2012 Bill) also meant that the relative increases and decreases for individual universities as a result of the scheme's implementation were mostly marginal. Finally, the external evaluation of the SFO concluded that universities with overt strategies had benefited most from the scheme, but that relatively few universities possessed such strategies.

The common thread is the absence of adequate governance mechanisms to ensure that high-level priorities and goals mesh effectively with the lower-level goals of the academic research community. Academics generally value the freedom to conduct research wherever their interests take them, and this sentiment is especially strong in Sweden. By contrast, government often has a civic responsibility to provide a gentle steer to research, sometimes in terms of satisfying broader societal needs, but also often to instigate performance improvements that ensure value for money is realised from the expenditure of public funds. In academic circles, the universities are key institutional intermediates in this process of reconciling often competing top-down and bottom-up priorities. The relative weakness of many Swedish universities in terms of strategic leadership is thus an important impediment to the effective realisation of government priorities and expectations for the university sector.

Commendable efforts to improve research and innovation links, but some concerns

As part of its efforts to improve the links between research and innovation, Sweden has paid increasing attention to the role played by RIs. It has also launched the SIO initiative, which supports joint R&D and innovation-related activities between different sets of actors, including universities, research institutes and industry.

The Swedish innovation landscape originally comprised many small specialised institutes serving specific sectoral needs and (given the "third mission" role of universities) occupying a very marginal position in the national innovation system. Since the 1990s, policy makers have attempted to consolidate and strengthen the role of the research institutes, through the formation of Research Institutes of Sweden (RISE) – announced in the 2008 Bill – and further measures aimed at consolidating and strengthening the role of the RISE institutes – announced in the 2012 Bill. This attempt at consolidation and growth marks the recognition that the functions of RIs are significantly different from those of universities, and that

neither the RIs nor the universities can alone meet all the needs of local and international firms within a flourishing innovation ecosystem.

Progress towards the establishment of a strong RI sector that plays a pivotal, rather than marginal, role in the Swedish innovation system has been slow but steady. There is still some way to go, however, in the transitioning from branch-focused research associations with membership-based governance structures to building a truly polytechnic organisational form for RISE that can address wider industrial and social needs. This may require changes to the existing governance structure of RISE that allow it not only to satisfy the needs of its traditional sectoral interests (the bottom-up needs of its existing customer base), but also to satisfy the top-down needs of the state for an organisation that can play an extended role in the functioning of the Swedish innovation system as a whole.

The SIO initiative set out to prioritise areas considered to be of strategic importance to Sweden and launch support programmes for research and innovation programmes and projects within them. A characteristic was the emphasis put on the bottom-up construction of the strategic innovation agendas (SIAs) formulated in these priority areas and the strategic innovation programmes (SIPs) that were launched under them. New constellations of industrial, academic and research institute stakeholders were expected to play key roles in setting and operationalising these priorities.

There was no overt prioritisation of particular areas from a top-down, governmental perspective. Responsibility for orchestration was handed down to the agency level, first to the Swedish Governmental Agency for Innovation Systems (VINNOVA) and subsequently to VINNOVA and two other funding bodies. VINNOVA deployed funds to support the preparation of the strategic research agendas and encouraged the broad involvement of new configurations of stakeholders spanning multiple disciplines, fields, sectors and organisational types. These stakeholders were then invited to submit proposals for the launch of SIPs, in line with the strategic research agendas that had been developed. External evaluators were used to assess the proposals for these SIPs, and VINNOVA (and the other two agencies) disbursed funds to them.

The effect of funding a portfolio of academic-industrial consortia selected bottom-up is frequently conservative, with the portfolios reflecting areas of existing strengths and interest on both the academic and industrial sides. A bottom-up competition provides a "snap shot" of potentially interesting and strong areas – but it is also to a considerable degree backward-looking and tends to have short-term horizons. Hence, it needs to be complemented by policy instruments that are more forward-looking, addressing less well-established areas of potential future interest, and to have longer-term horizons. The agencies involved appear confident that a determined emphasis on the continued evolution of SIAs within new configurations of actors from different sectors and disciplines will be enough, but additional efforts may be needed to ensure that these are sufficiently forward-looking.

The agencies see their adamant non-involvement in specifying top-down priorities as a strong point of the initiative and a retreat from earlier in-house practices that gave them a much stronger say in specifying top-down policies. . In some respects, however, this can be seen as a high-risk route to take. Ceding control to bottom-up priorities is certainly one way of ensuring that key stakeholders develop a strong interest in the resulting programmes, but it underestimates the importance of maintaining a system of checks-and-balances between top-down and bottom-up priorities, and diminishes the role of the state in maintaining such a balance. The existence of an evaluation scheme that can assess the evolution of strategies every three years constitutes one check, but it may not be enough to ensure that top-down priorities are reflected in future agendas. Without a stronger role for the agencies to ensure such a balance occurs, there is a risk of fragmented portfolios or stronger factions capturing entire portfolios.

Need for more concerted efforts to tackle societal challenges

In response to the prioritisation of societal challenges signalled by the Swedish Presidency of the European Union in the Lund Declaration, Sweden launched the UDI programme, which supported research and innovation activities in areas relevant to societal challenges. It also increased the funds available for greater involvement in European P2P networks of national funding agencies in Europe and the establishment of a co-ordination mechanism across agencies to allow Sweden to take a more strategic approach to aligning of international efforts, especially those tackling societal challenges.

Although many aspects of these responses to the Lund Declaration are laudable, the limited scale of these efforts and their relatively low level of visibility in the 2012 Bill were surprising. Sweden had an opportunity after Lund to place efforts designed to tackle societal challenges at the heart of a very distinctive national research and innovation strategy that would have signalled to the world that it was prepared to lead by example in its response to Lund. It did not do this. The 2012 Bill, like many previous bills, included a broad range of actions designed to improve performance in many of the interdependent domains that constitute a modern, national innovation system. This is fitting and necessary, but the Bill provided no overall vision of how the system as a whole might develop, and the direction it might take. In particular, it gave no indication of how a strong emphasis on societal challenges might fit into an overarching long-term support strategy capable of satisfying the needs of all relevant stakeholders.

The Swedish system of governance for research and innovation does not appear to favour a "challenge" approach. It is characterised by "weak" vertical co-ordination, as ministries have relatively limited ability to steer the large number of government agencies. Instead, agencies are in a position to define and develop their own roles. Horizontally, agencies co-ordinate activities between them, and many concrete programmes are managed and funded by several agencies in collaboration. However, this also results in committing budgets, thereby limiting the agencies' strategic room for manoeuvre. Tackling societal challenges will require new forms of R&D funding governance and co-ordination mechanisms that can prioritise at the societal level. It will also require levels of financial commitment that signal the importance of this policy reorientation.

Prioritisation and strategy development are constrained by weak governance structures and processes

Prioritisation and co-ordination have proved difficult in Sweden in many research and innovation settings. Prioritisation is especially difficult in the absence of a common vision. International experience concerning either the use of foresight exercises or other aids for prioritisation does not suggest a clear way forward, but the need for some kind of vision to guide Swedish research and innovation policy development is becoming increasingly apparent. Swedish policy makers should strive to devise and implement a national visioning mechanism that can build greater consensus around major priorities, without excluding other research and innovation efforts that are necessary in a well-functioning innovation system.

Governance structures and arrangements play a critical role in either enabling or preventing reform and performance improvement in the Swedish system. In the university sector, for example, deeply ingrained concepts of academic freedom, and the autonomy of universities and individual researchers, have conspired with weak internal governance structures within many universities to prevent the university sector from wholly fulfilling its "third mission" – conducting research relevant to many of the needs of society. Similarly, there are concerns about the governance structures of research councils and their dominance by academics; about the level of private-sector stakeholder involvement in the RISE institutes; and about an apparent diminution of the checks-and-balances needed in the relationship between funding agencies (such as VINNOVA) and the research and innovation communities they serve and support, which guarantee they do not take lightly or ignore the interests of the state.

Perhaps the greatest current need, however, is for a systemic overview of the governance structures that Sweden will need, both to improve performance across the whole research and innovation system and to mount a serious response to societal challenges.

Strategic tasks

In the current context of policies and issues, at least seven strategic tasks need to be included in the Swedish policy agenda. Most of them relate to the interplay of policies aimed at different domains within the Swedish innovation system, spanning education and human resource development; the science and research base; innovation-related activities; and links with market development on the demand side. Many of these tasks relate to *balance*. Innovation systems seldom respond well to polarised policies. Rather, they seem to function well where an appropriate balance exists between different policy elements. In this sense, the tendency of the Swedish system towards inclusiveness and moderation will stand it in good stead. It also follows that the order of the strategic tasks in this section, and of the guiding principles and detailed recommendations in subsequent sections, is not important. In a complex system, what matters is the interplay of the components. Interdependence implies that one component is not necessarily more important than another. However, it is sometimes possible to identify where changes in particular components are *preconditions* for improving the others. In this case, the suggested changes covering aspects of governance appear to be preconditions – not least because history shows that existing governance arrangements impede needed changes.

To build on its strength in research and innovation in order to achieve and maintain excellence and a position among the global leaders, Sweden should consider the following strategic tasks:

- address the need to move beyond "good" performance and reach for excellence in Swedish research so that it is attractive, innovative and competitive

- continue to rebalance the roles of the universities on the one hand and the research institutes and research and technology organisations (RTOs – or applied industrial institutes) on the other hand, in order to provide a strong knowledge infrastructure spanning basic research through to innovation – or, in terms of the technology readiness levels (TRLs) increasingly used to describe European R&D policy, from low to the high TRL numbers

- reconsider the balance between state competitive and non-competitive funding for research and in the context of funding provided by the private and public foundations, in such a way as to provide the needed range of incentives for excellence, relevance and co-operation in strategic as well as more routine fields

- consider the extent to which the existing structure and organisation of research funders, including their governance and co-ordination arrangements, provide in the specific context of Sweden the best way to pursue national priorities, promote excellence and encourage change in the research and innovation system more broadly

- examine very carefully the roles played by government agencies in mediating between the needs of the state and the needs of different groups of research and innovation actors

- explicitly articulate clearer research and innovation funding priorities at the national level, especially (but not only) in the context of societal challenges

- as a precondition for success in most of the other strategic challenges, reform the governance of research funding and performing organisations (including universities) and review governance arrangements across the whole innovation system.

Guiding principles

When formulating and implementing the policies needed to undertake these strategic tasks, the following guiding principles should be taken into consideration:

A well-performing research system not only has a high average level of quality, but also a number of "peaks" of excellence. The portfolio needs to respect the requirement for research priorities to address national needs and not only the pursuit of excellence. Hence, an effective funding system must steer towards both these outcomes. Scientometric indicators show that Swedish research is still good, but is missing the handful of "performance peaks" that are desirable in any system. While some have attributed this to university careers or funding, these have not changed in ways that can readily be connected to the rather recent dip in relative performance. There are signs that Swedish academic research is becoming less competitive in comparison to similar countries. One likely factor is that Swedish scientists now face greater worldwide competition. In the life sciences, which are particularly affected, the fall in pharmaceutical R&D has caused a striking loss in industrial impulses. There is room on the one hand for more competition and incentives to allow exceptionally strong universities to reap disproportionately the benefits of Swedish research budgets, and for directing some parts of those budgets to themes of industrial and societal importance on the other.

Funding and task allocations between the university and RI/RTO sectors should reflect their roles and abilities to deliver different types of benefits to the research and innovation system. Different types of universities need to be incentivised and supported to perform different roles. The state research system as a whole will perform best if the different organisations are closely linked and highly co-operative. The "Swedish university model", established during the Second World War, allocated a broader role to the Swedish universities than is usual in other countries. In particular, it entrusted them not only with performing basic and applied research, but also with working close to applications, or in higher TRL numbers. History suggests this task is not really compatible with that of a traditional university, and that a re-division of labour is needed within the RI/RTO sector, which is currently experiencing growing demand for its services under the aegis of RISE. Some regional universities, however, are well linked to their economic and social surroundings, to mutual benefit. Their role and contribution should also be reflected in resource allocation.

The balance between competitive and non-competitive state research funding needs to be based on an understanding of the interplay between incentives and context – not least in terms of university governance and internal allocation rules, which should connect global incentives to micro-behaviour. No "magic number" or "golden ratio" exists between competitive and non-competitive funding that can guarantee success. However, the effectiveness of funding incentives is clearly mediated by the governance structures of both research funders and research performers, as demonstrated by the limited success of recent attempts to strengthen the university research base. Sweden should therefore consider these aspects in designing the funding mix.

Research funding should balance diversity, stakeholder involvement, high standards and relevance on the one hand, and efficiency and effective governance on the other. In particular, it should be asked whether the structure – which has evolved in a context of funding basic research and a number of "sectoral" missions, particularly industrial innovation – is able to address the "societal challenges" launched at Lund in 2009. The structure also needs to contain organisations that can act as change agents, sometimes providing a countervailing force to the short-term interests of the research and industrial

communities. Sweden should therefore review the effectiveness of the funding structure in the context of its current governance and future funding needs.

Successfully translating research and innovation priority-setting at a high level into effective implementation at a lower level critically depends on instituting mechanisms at all intermediate levels that can establish and maintain a consensus on priorities, or reconcile conflicting interests. Sweden has generally followed "bottom-up" approaches rather than powerful thematic strategies to assemble a wide range of activities that may or may not address priority needs. This may not have been the best way to tackle innovation, and the need to address the societal challenges puts it further into question. However, a simplistic "top-down" approach would be equally ineffective, since it would be under-informed about needs and fail to engage relevant stakeholder communities.

Stakeholders such as industry and the research community should inform and have a significant voice in what research funders and performers do. But individual beneficiary communities should not have majority stakes in the governance of these organisations, or otherwise be positioned in management structures in a way that prevents needed change. Both Swedish and international experience shows that when beneficiaries or members govern organisations that allocate resources, they tend to become locked in, struggle to develop strategic priorities, and may fail to keep pace with external needs. Where RISE is concerned, the government has recognised this issue and is preparing to take over the shares owned by member companies in order to give RISE the strategic freedom and flexibility it needs to do its job well. Similar governance and agenda-setting challenges affect the research councils, other funding agencies and the universities.

In an international setting that requires nations to take the lead in demonstrating how research and innovation can help resolve major societal problems and set examples in terms of the structure, organisation and governance of scientific and technological capabilities, recognition of national prowess and potential should not be constrained by natural reticence. Undertaking strategic tasks of the nature described in this *Review* requires a guiding vision, a commitment to change and a considerable degree of confidence in the ability of all relevant stakeholders to rise to the challenge. Sweden has done remarkably well historically in terms of its scientific, technological, economic and societal achievements, attaining levels of success in a broad range of domains that are acknowledged across the world. This qualifies Sweden as a model of good practice and a leader of world opinion, constrained only perhaps by the natural humility of its people. There is a need, however, for strong countries to lead the way and set examples that the international community can follow, especially in terms of tackling societal challenges that confront all nations across the globe. Now, perhaps, is the time for Sweden to step forward.

Key issues and recommendations

The recommendations below are in line with the strategic tasks and guiding principles outlined in the previous section. In general, they are organised around the topics covered in the main chapters of this follow-up *Review*, though some issues are touched upon in several places throughout the report. A concluding set of recommendations cover aspects related to priority-setting, strategy development and governance across the Swedish innovation system as a whole.

Strengthening university research

State research funding is normally provided because private enterprise does not deliver a socially optimal amount of research. In particular, it tends to under-invest in fundamental research. This "market failure" argument for state funding has been its traditional rationale for at least the past 50 years. While Swedish universities have for some decades made it clear that they want to receive a higher proportion of their research income in the form of institutional funding or GUF, evidence from international experience

or statistics does not show any clear way to connect the proportion of university income from this source with overall performance. For example, the Danish and Swiss university systems produce very high levels of research performance (measured in bibliometric terms) while enjoying high levels of GUF for research. British universities record a similarly high performance, based on a much lower proportion of GUF than Swedish universities. However, there is no clear evidence that, if the Swedish universities do have a "research problem", it is caused by the GUF level, or that increasing this level will fix it. Together, the increased GUF provided for in the 2008 Research and Innovation Bill and the SFO programme have significantly increased the institutional funding for universities, but evidence of performance increases is limited. Rather, it appears that Sweden's "good but not sufficiently excellent" scientific performance points to a failure by university management to be selective, combined with sub-optimal mechanisms affecting the allocation of funds (whether from TPF, with its medium-sized instruments, or from the way the universities allocate GUF internally). In this sense, Sweden hovers uneasily between a research-funding policy that focuses on excellence at all costs and research-funding policy that requires a good deal of "fairness" concerning the distribution of funds.

International statistics on the proportion of GUF in university research are hard to collect and compare because of national variations in the way the scope of this funding is defined and implemented. National averages are normally compared. This is also misleading, because in practice the GUF/TPF ratio varies greatly among different types of university – as does the absolute amount of GUF and TPF, compared with the number of teachers or researchers. Good technical universities (KTH Royal Institute of Technology, Chalmers University of Technology, Karolinska Institutet [KI]) tend to have high proportions of TPF. Traditional universities with a lot of social sciences, humanities and natural sciences rely more on GUF. So the "right" ratio depends also upon the role of the university.

Swedish universities will find it difficult to be effective as long as GUF funding creates a paradox. The universities claim they have too little core funding over which they can exercise strategic control, because academic posts cannot be fully funded out of limited institutional funds, and researchers must depend on TPFs for their own support. Furthermore, increases in core funding are used to hire more academics whose jobs depend upon TPF, exacerbating the problem that the increased core funding was supposed to solve. The only way out of this impasse is for the universities to use core funding to pay the full salaries of a greater proportion of their faculty.

Breaking the vicious cycle of GUF/TPF dependence is linked to a lack of clarity concerning career paths in Swedish universities. On the one hand, the limited number of clear tenure tracks, and the paucity of well-specified criteria and procedures governing access to permanent positions, can act as a barrier to recruitment of top-quality researchers from both Sweden and elsewhere. On the other hand, an apparent reluctance on the part of university management to make "hire, fire or reassign" decisions limits their flexibility when adjusting to the volatility of TPF and constrains their influence over the balance between research and teaching. Strong centres can be built with large TPF inputs, but these then have to be able to adjust staffing levels to some degree in response to variations in their income. However, academic top management seems to have problems introducing and executing the necessary recruitment and career policies.

This calls for the basis of university funding and governance to be investigated with a view to allowing management to introduce real tenure tracks, as well as to be more flexible in hiring, dismissing and reassigning staff based on their organisational strategies and individual performance, and to fund the majority of their faculty through institutional money. Such changes would help universities combine funding and human-resource policies more effectively in their pursuit of excellence. It would also make it easier to implement strategic changes. The necessary transition will need to take place over an extended period and will not be easy. However, the current investigation in Sweden into academic careers and the basis of tenure may provide a useful first step in this direction.

The new performance-assessment scheme introduced after the 2008 Research and Innovation Bill was meant both to raise scientific productivity and to reward and incentivise success in raising TPF, allowing the additional funds gained to act as a form of compensatory addition to GUF. The proportion of GUF affected by the scheme (10% in the 2008 Bill, rising to 20% after the 2012 Bill) and the mechanics of its implementation, however, meant that the relative increases and decreases for individual universities as a result of the scheme's implementation were mostly marginal.

The SFO scheme was innovative and was intended to have a double effect by increasing university specialisation (or launching new activities) while gradually increasing core funding over time. It appears to have suffered from a lack of focus, so that it made only a limited difference to universities' degrees of specialisation. It was well used by universities able to articulate and implement strategy, and less well used by those that did not. Its failure to involve industrial and other societal stakeholders to any significant extent undermines the societal relevance and applicability of the funded work. Its role as a potential change agent is doubtful. Its evaluation focused on judging the performance of the individual centres and universities funded by the scheme, and devoted little attention to addressing the question of whether it succeeded in its policy purposes. The policy lesson from the SFO scheme appears to be that this is not an instrument that can be used successfully in the current context.

Increases in GUF, the associated performance-assessment scheme and the SFO were all meant to improve university research performance, and all rested on the premise that universities would make sensible, strategic decisions concerning the utilisation of this additional income. Increased funding for research will always be welcomed by universities, and there is always the danger of adverse impacts on research performance if additional funding for academic researchers to undertake self-determined research is stifled, but genuine improvements in performance cannot truly be expected until barriers related to university governance, strategy formulation and internal policies for funding faculty members have been removed.

Although the focus here is specifically on measures stipulated in the 2008 and 2012 Research and Innovation Bills designed to strengthen university research, many factors and structural facets of the Swedish university and research systems that have affected the ability of universities to respond adequately to these measures were explored, especially the implications of the "Swedish model" for universities, which allocates an unusually large share of state-funded research activity to a widely competent university sector.

The idea of a "knowledge triangle" is a useful reminder that research, innovation and education are intimately interconnected, and that related policies should be similarly interconnected. A historical strength of the Swedish model has been its focus on higher education and training, thereby providing the people and skills needed not only to maintain the higher education sector, but also other parts of society. In principle, the insistence on research-based teaching in universities has probably helped ensure that higher education is up-to-date, but higher education's focus on more basic research knowledge means that industry faces the challenge of transforming graduates' general skills into the specific skills valued by companies.

The expansion of PhD education since 1994 was partly intended to support increased PhD employment in industry, since Swedish firms were employing fewer PhDs than major foreign competitors. The expansion took place partly through instruments such as new graduate schools, industry PhD programmes and schemes such as the competence centres, which established a more direct link between industry's skill needs and PhD training. Growing numbers of PhDs have therefore been trained in applied and problem-driven areas, and not only in basic research. TPF also provided a major impulse to shift from the old continental model of mid-academic career PhDs towards the modern four-year cycle, with a taught component as well as research.

The Swedish model developed at a time when the national research and innovation system was much smaller than today. In 1942, the Malm Commission's desire to avoid fragmenting a small system between universities and technological institutes made sense in context. Even at that time, there existed a clear division of labour between technological and traditional universities. Since then, the system's increasing size has fostered a finer division of labour, with traditional (non-engineering) universities, technical universities, "omniversities" and regional universities carving out different roles – though considerable scope persists for more thematic and functional specialisation.

The economic consequence of "massification" – which would make it impossibly expensive for all universities to be research universities if around one-half of each generation attends university – has not been fully addressed in the Swedish system. As elsewhere, the new regional universities will probably need to align both their research agendas and their teaching on specific regional and "professional" education needs, in order to allow higher education to remain research-based. Whether these universities can afford to do research in the full range of subjects they teach is not clear, and selective strategies are probably needed. The benefits of specialisation can only be secured, however, if university governance is changed so that rectors have more freedom to develop and manage their universities' strategies. This requires significant reform on the part of the universities, as well as a willingness among policy makers and funders to concentrate research resources in larger centres that can reap the benefits of specialisation.

A corollary of greater specialisation and scale is the availability of funding able to support a significant increase in the size of individual research groups or centres. A characteristic of Swedish research-funding programmes is the small size of individual awards. For example, the Swedish Competence Centres are much smaller than their Austrian counterparts or the National Science Foundation's Engineering Research Centres on which they are partly modelled. Achieving the necessary advantages of scale and specialisation, whether to pursue academic excellence or fulfil industrial and societal missions, is difficult without larger grants and centres. While not all research funding is about scale, some Swedish funding schemes need to provide significantly larger grants to significantly fewer beneficiaries. There will be losers, but without losers you also cannot have winners. The number of research councils, funding agencies and other sources is very high in international comparison and for a small country. This has historical reasons, as well as consequences for the size and the level of ambition of funding interventions. There are reasons to consider the rationalisation of funding organisations, together with re-alignment of missions and governance structures.

The EU Framework Programme has the potential to support strategy-building by research-performing organisations, including universities. It offers a wide range of thematic choices for researchers seeking funding. However, it operates essentially by enhancing national strengths, and is too short-term and competitive in most cases to support long-term capacity-building. Like their counterparts in the United Kingdom, the Swedish universities are very successful in obtaining funding from the Framework Programme. But while the evidence suggests it is a useful source of additional income for universities, it has little effect on research directions. Universities generally welcome all contributions to their research income, but until they develop more focused strategies, the Framework Programme will have little strategic impact on the Swedish research sector.

Recommendations

- *Address the governance and leadership weaknesses of the Swedish university system that undermine the universities' abilities to define and implement strategies, especially those that require the reallocation of internal resources.*

- *Ensure that any increases in GUF are accompanied by other measures that enhance the possibility of sustainable improvement in research-performance*.

- *Avoid extending the SFO programme unless and until there is clearer evidence that (a) most of the universities are able to make use of such resources to develop and implement strategies, including change strategies, and (b) university governance is reformed in ways that enable university rectorates to exercise effective strategic leadership.*

- *Either amend the way the existing research performance-assessment scheme for allocating GUF is implemented so that it can have a real, rather than marginal, impact on performance and rewards, e.g. by increasing the percentage of GUF that can be affected by it, or consider the use of alternative schemes.* In so doing, consider also the need to incentivise and reward research outputs that go beyond excellence and satisfy "third-mission" criteria.

- *Encourage university management to introduce a real tenure track, as well as to be more flexible in hiring, dismissing and reassigning staff based on clear organisational strategies and individual performance, and to fund the large majority of their faculty out of institutional funding. This may require changing the rules on how universities can spend their money.*

- *Encourage the universities to specialise in their research to a greater extent than today, underpinning excellence in selected areas of research and teaching, and strengthening their individual differentiated functions in the research and innovation system*. Such focus is needed in order to be present at the very top ranks of global research. It does not follow that the same pattern of specialisation adopted in research should always apply in teaching, where societal needs are often broader.

- *Examine the usefulness and the options for strengthening the desired effects of TPF to universities, RIs and industry*. In particular, options should be considered for:

  - *re-orienting some funding schemes to provide significantly larger grants to significantly fewer beneficiaries*

  - *rationalising the number of funding organisations, together with re-aligning missions and governance structures*.

Linking research and innovation

Ensuring that research links effectively with technologically based innovation is a prerequisite for a well-functioning innovation system. Two policy initiatives in the 2008 and 2012 Research and Innovation Bills that were relevant to this task were particularly scrutinised during this follow-up *Review*: efforts to strengthen the position of research institutes in the Swedish innovation system and their role in linking the worlds of research and innovation; and the launch of the SIO initiative, designed to provide support for new, cross-sectoral configurations of research and innovation actors.

While the Malm Commission's principle that the universities should perform some of the tasks undertaken by applied institutes was reflected in the decision not to set up a big national institute of technology, it was never strongly reflected in the shape or activities of the universities themselves. Partly as a result, the applied industrial research institutes – now RISE – continue to expand within the "sectoral" space previously allocated to universities, arguably because they were designed for sectoral tasks, and especially to interact with industry in ways that the universities were not doing.

The steady growth of RISE, working in areas of market and systemic failure related to industrial innovation, testifies to its relevance. While it may conceivably represent a loss in human-capital development compared with the intended "Swedish model", large numbers of PhD students do their

practical work in institutes while registered at universities. At present, RISE provides over 70 adjunct professors to the university system. Thus, while there is scope for greater interaction (which would benefit both sides), university and institute research are often already linked. The present arrangement provides a good basis for simultaneously supporting innovation and developing human capital through research in the institutes and linkages to the wider Swedish research community. While RISE meets industrial needs that are in general differentiated from those tackled in the universities, there is no evidence that it offers services to industry that could be provided by unsubsidised private companies, such as engineering consultancies.

The experience of the UDI programme – in which research institutes play a significant role – underscores the ability of the RISE institutes not only to meet industrial and societal needs, but also to bring solutions to a higher stage of technological readiness than the universities. It follows that the RISE institutes should be instrumental in a greater and more focused research and innovation effort, tuned towards the societal challenges.

However, like other parts of the research system in Sweden, RISE institutes are subject to path dependencies driven by their governance, and sometimes even by their ownership. Branch associations still own a considerable share of individual institutes and have a large say in their governance. While maintaining close links with stakeholders is important, it is also a source of lock-in and inflexibility. In order to tackle both industrial innovation and societal challenges, the institutes should be able to change direction more quickly. This requires simpler and more unified governance and ownership. This could involve the industrial co-owners of the RISE institutes relinquishing their shares to the state – a development that is highly desirable and has in fact recently begun to take place.

A change in ownership structure, however, will not be enough. To address the societal challenges, the institutes need signals and incentives about Swedish policy on the societal challenges that supplement the existing inputs they get from the industrial and higher education systems about industrial needs and scientific opportunities. These signals can take the form of programme funding or additional core funds earmarked for developing the new capabilities required by RISE to tackle some of the challenges. The funding and steering system for the Dutch TNO institute provides a useful example of how to achieve this.

One key mission, which was not clearly discussed when the Swedish model was established, is how to provide general support to innovation in SMEs, especially low-to-medium technology SMEs that need to strengthen their technological capabilities. The institutes have sometimes been awarded extra funding to provide an "SME service", but it must be recognised that from the institutes' perspective, SMEs are often not attractive customers. They may have trouble identifying their needs, they tend to need small things done, generating unattractive projects, and they are frequently reluctant to pay the price that an institute needs to charge in order to help them. To some degree, the regional universities have stepped into the breach, but this whole area of SME support appears disorganised.

The SIO initiative was an important innovation in research and innovation policy, building on a growing practice across Europe of encouraging public-private partnerships to establish and implement research agendas over an extended period of time, and then partially funding these. It is simply too early to say whether this approach has been successful in Sweden. The long Nordic experience with technology programmes suggests that the balance between academia and industry in the governance of such initiatives is crucial to success: too much academic influence, and the work becomes overly fundamental and industry loses interest; too much industrial influence, and the agenda becomes incremental and short-term, undermining the case for state and academic involvement. The Finnish experience with its SHOK competence centres well illustrates this second danger, which led the Academy of Finland to refuse to support the centres and eventually resulted in the termination of the SHOK programme.

As in other aspects of governance, the experience from this type of programming is that excess stakeholder influence has the potential to limit the scheme to conventional and often short-term work. Funding consortia rather than individual projects means focusing on things that are sufficiently established to have developed an interested community. A call for proposals is an extremely useful way to identify such areas. For example, the Swedish Competence Centres Programme – launched in 1994 and still operating as Vinn Excellence Centres – used an open call (with no specified themes) to generate information about which research and innovation areas in Sweden would benefit from a combination of industrial strength and academic capability. The centres that were funded together more-or-less comprised a "snapshot" of Swedish strengths in 1994-95, without necessarily capturing newer developing areas that might prove more disruptive and challenging in scientific and competitive terms. In the SIO, efforts have been made to ensure the continued evolution of forward-looking strategic research agendas, but participants may require additional assistance if this is to occur.

The SIO succeeded in attracting a broad range of research and innovation stakeholders to construct strategic research agendas and bid for SIPS within them. In so doing, it raised expectations among a broader set of potential stakeholders than normal – expectations that were not realised for many – and even those making successful bids received relatively small amounts of money. The challenge now is to manage future expectations, which will require raising budgets and giving more thought to risk-reward ratios if interest in the initiative is to be maintained.

Recommendations

- *Further develop the RISE institute system to strengthen its contribution to national research and innovation*:
  - *Continue to fund the growth of RISE, aiming to maintain its core funding at about 20% of the institutes' total income*.
  - *Approve current plans to take full ownership of the RISE institutes in order to effect this*.
  - *Provide signals and incentives about Swedish policy on the societal challenges that supplement the existing inputs they get from the industrial and higher education systems about industrial needs and scientific opportunities.*
- *Consider both the role of RISE and the regional universities in supporting innovation in traditional SMEs*, with a view to considering whether and how to establish a more formal and longer lasting SME service.
- *Increase funding for initiatives such as the SIO* to facilitate both broader participation by new cross-sectoral configurations of research and innovation actors, and projects of greater critical mass.
- When extending SIO-like funding, *consider the balance between this sort of funding, which is frequently governed by industry and essentially strengthens existing industrial activity* in areas of established importance if left unchecked, *and additional efforts and activities aimed at identifying new trajectories and, as necessary, disrupting existing ones.*
- At an appropriate stage, *perform a meta-analysis of the strategic research agendas developed by participants in the SIO as a means of devising higher-level programme strategies*.

Dealing with societal challenges

In the development of a new model of "societal-challenge" research funding in Europe, Sweden occupied centre-stage when, during its presidency of the European Union in 2009, the Lund Declaration called for a new focus on "grand challenges" that would move away from narrow thematic approaches, and involve both the public and private sectors in concerted efforts to tackle them. At the level of the European Union, this led to a significant new emphasis on societal challenges in the Horizon 2020 programme. In Sweden, it swiftly led to the launch of the UDI programme, led by VINNOVA, and enhanced efforts to increase Sweden's participation in European co-operative research and innovation initiatives, many of them focused on societal challenges.

The UDI programme represented a timely first step. It shifted policy attention onto the demand side and its coupling with the innovation process, going beyond the Nordic technology programme tradition by involving users who are downstream of the innovating organisations. This is a legitimate extension of what might be thought of as "normal" research and innovation policy. The budget for the programme is relatively small, however, and the projects supported by it are correspondingly modest. These are grouped into four broad categories, not all of which appear overtly focused on societal challenges as conventionally understood, though an important selection criterion for projects proposed by potential participants is that they have a distinct societal-challenge orientation. In future, however, programmes such as these will need to be complemented by action at a higher, systemic level if Sweden is to address societal challenges adequately.

Nonetheless, this "lower" level of instrument evolution poses challenges to governance. Traditionally, R&D funding agencies have set tight conditions for funding projects, leaving little scope for the project performers to define or redefine them. A new set of instruments – such as competence centres and the SIO programme – shift the design and management of a project portfolio from the agency to the beneficiary level, with a distinct diminution in the ability of the agencies to ensure an effective compromise between the needs of the state and those of the research and innovation communities. This is something to be avoided in the UDI programme if a co-ordinated, cross-sectoral, cross-agency effort to tackle societal challenges through a "systems-innovation" approach is to be attempted.

At the European level, Sweden has increased the budgets available for participation in P2P networks that attempt to align national research efforts with topics of mutual interest, many of them pertinent to societal challenges. Whereas Sweden had previously been involved in many of these networks of national funding bodies, participation tended to be ad hoc and Sweden had not led any of them, in contrast to many other EU countries of a similar standing. Sweden now leads one Joint Programming Initiative on Antimicrobial Resistance (JPI AMR) and partakes in 31 out of 37 P2Ps directly related to societal challenges. Thanks also to the establishment of an office to co-ordinate participation across government agencies, Swedish involvement now seems to be more strategic than previously.

However, despite Sweden's role in the formulation of the Lund Declaration and the endorsement of its aims by the Education Minister at the conference that launched it, there is still no overall strategy at the national level or even at the level of organisations (such as VINNOVA) for addressing societal challenges. The 2012 Bill provided no overall vision of how the Swedish research and innovation system might develop, and the direction it might take in order to mount an effort in response to societal challenges, or how such an orientation could satisfy the research and innovation needs of multiple stakeholders. Without such a "higher-level" perspective and a commitment to the governance changes it would involve across the Swedish innovation system, it is difficult to envisage an effective mobilisation of resources to tackle societal challenges.

Furthermore, even though Sweden – and VINNOVA in particular – has increased its efforts to encourage greater participation in European initiatives on the part of both national agencies in P2Ps and research and innovation actors (in universities, research institutes and industry) in Horizon 2020 programmes and projects, without a basis in a national position or strategy, it will be harder to lobby for future changes to the Framework Programme.

Recommendations

- *Develop a national strategy regarding societal challenges, integrating these elements with the wider research and innovation strategy*.

- *Integrate research and innovation strategy for the societal challenges with wider policies, such as energy and transport*, in order to enable the needed systemic shifts or transitions in the development and use of technologies.

- *Increase agency efforts to play a leadership role in research and innovation to addresses societal challenges at a European and even global level, by stepping up Sweden's involvement and leading P2P networks that align national efforts to achieve mutually desirable benefits*.

- *Expand the scale of the UDI programme and refine its scope so that its potential contribution to particular societal challenges is well defined*.

- *Devise more and broader policy instruments capable of simultaneously addressing more fundamental and more applied aspects of the societal challenges, rather than dividing them into initiatives separately focusing on research and innovation*.

- *Consider the way in which not only research and innovation funders, but also policy programmes and instruments, are governed, in order to ensure on the one hand that they are not "captured" by interest groups and on the other hand that they are capable of involving a broad mix of non-R&D and innovation stakeholders, who will play essential roles in operationalising the results of research and innovation projects related to the societal challenges*.

Priorities, strategies and governance

Many research and innovation debates in Sweden have concerned the relative prioritisation of funding for basic research versus funding for mission or problem-oriented research, typically oriented towards innovation and, frequently, economic outcomes and impacts. Often this debate appears to consider these funding modes as straight alternatives, rather than as complementary approaches that can co-exist happily. Now, with the rise of a funding mode that prioritises research related to societal challenges, the debates are likely to become even more lively, especially since it is not immediately obvious that this third form of funding can just be added as an additional layer to the existing basic research and problem-oriented research strata. First, it would increase overall levels of expenditure on research at a time where parsimony reigns; second, it introduces a new level of complexity into the funding system, because it requires significant levels of co-ordination, and increased mobilisation of research and innovation resources, if societal challenges are to be tackled effectively. At the same time, it will also be important to leave sufficient space for the continued provision of funding for basic research, and more conventional problem-oriented research and innovation geared towards economic returns.

Prioritisation and co-ordination have proved difficult in Sweden in many research and innovation settings. Prioritisation is especially difficult in the absence of a common vision. Sweden has attempted foresight exercises in the past, specifically in 2000 and 2004, but these were generally not received with

much enthusiasm and their impact was slight. International experience concerning either the use of foresight exercises or other aids for prioritisation does not suggest a clear way forward, but the need for some kind of vision to guide Swedish research-and-innovation policy development is becoming more and more apparent. Swedish policymakers should devise and implement a national visioning mechanism that can build greater consensus around major priorities, without excluding the range of other research and innovation efforts that are necessary in a well-functioning innovation system.

One thing that history does teach us about prioritisation in the research and innovation world, however, is not to bet on single firms, or otherwise try to oppose market forces. It has therefore become common practice to define priorities in terms of enabling technologies, challenges, clusters and networks, without trying to pre-judge the outcome of competition. Moreover, as in other parts of research and innovation policy, governance is very important. While stakeholder involvement in research-and-innovation prioritisation exercises is very important, it must be sufficiently balanced to avoid capture of priorities and agendas by any one stakeholder or group.

Prioritisation, strategy development and implementation take place within the context of specific governance systems, and these governance structures and arrangements play a critical role in either enabling or preventing reform and performance improvement in the Swedish system. These are not new issues in Sweden. In the university sector, for example, deeply ingrained concepts of academic freedom, and the autonomy of universities and individual researchers, have conspired with weak internal governance structures within many universities to prevent the university sector from wholly fulfilling its "third mission" concerning the conduct of research relevant to many of the needs of society. Forms of governance that impede universities from developing strategies addressing these needs are clearly problematic.

Similarly, there are concerns in a Swedish context about the governance structures of research councils and their dominance by academics, the prime beneficiaries of their activities; about the level of private-sector stakeholder involvement in the RISE institutes; and about an apparent diminution of the checks-and-balances needed in the relationship between funding agencies (such as VINNOVA) and the research and innovation communities they serve and support, which guarantee that the interests of the state are not taken lightly or ignored by these communities.

Sweden has recently established an Innovation Council. Bodies such as innovation councils are frequently set up to formulate strategies and co-ordinate at the national level. Other mechanisms exist, however, and there is no strong body of evidence that one mechanism is better than another. Co-ordination mechanisms do seem to work best when there is a real willingness to strategise and co-ordinate. The most important recommendation that can be made in the Swedish context, therefore, is that the remit and the authority given to the new Innovation Council truly reflect a commitment to contemplate changes at the level of the whole research and innovation system. The greatest current need in Sweden is for a systemic overview of the governance structures that Sweden will need to both improve performance across the whole innovation system and mount a serious response to societal challenges

Recommendations

- *Recognise that while policy, planning and governance structures and processes in Sweden might appear adequate in different parts of the Swedish research and innovation system, across the system as a whole they lack coherence and hinder the realisation of "whole system" performance improvements.*

- *Strive to devise and implement a national visioning mechanism (such as foresight) that can build greater consensus about major priorities, without simultaneously excluding the range of other research and innovation efforts that are necessary in a well-functioning innovation system.*

- *Set priorities in terms of challenges, areas of technology, clusters and value chains rather than attempt to pre-judge market outcomes as part of research and innovation policy*.

- *Devise an effective mechanism for co-ordinating challenge, innovation and research policies across different sectors of the state and society*.

- *Initiate a study by a team or committee that is not dominated by past or present members of the Swedish academic community to explore what university reforms are needed in order to enable them to act in more flexible and strategic ways than is the case today*. Reform needs are likely to include:

  - *Continuing the recently established requirement for the majority in university boards to comprise people external to the university*.

  - *Strengthening the hand of government in appointing rectors who are not hamstrung by the collegiate to such a degree that they cannot initiate significant changes or effective strategies*.

  - *Strengthening the rights and power of the individual rectorates to make strategy and to (re)allocate resources*.

- *Follow international practice in retaining academic competence in the governing bodies of the research councils but, at the same time ensure that academia does not form the majority.* The point of this reform is to ensure that the research councils are the servants of society, rather than just answering to the scientific community.

- *Require that both the research councils and VINNOVA seek ways to balance the use of internal expertise as an impulse to change with the impulses (both change-oriented and conservative) that come from the beneficiaries, thereby producing a more robust and change-oriented way to implement their programming and funding roles*.

- At the overall level, *review Sweden's current research and innovation policy governance and co-ordination mechanisms with a view to creating a new co-ordination structure able not only to span research and innovation, but also to co-ordinate responses to societal challenges*.

CHAPTER 2. FINDINGS OF THE OECD REVIEW OF INNOVATION POLICY: SWEDEN 2012

2.1 Achievement and challenges

2.1.1 A highly successful economic and social-development trajectory

Taking a long-term perspective, the 2012 *Review* pointed to Sweden's extraordinarily successful economic and social development. Sweden started the industrialisation process in the mid-19th century as a relatively poor and resource-based peripheral country. It overcame the limitations of a small domestic market through internationalisation – specifically the emergence and growth of export-oriented, large Swedish-based enterprises – and successfully took part in the Second Industrial Revolution.

The Swedish development model, which became prevalent over the course of the 20th century and has profoundly influenced Swedish society, has been characterised by elements such as:

- early internationalisation of large Swedish companies
- high levels of education, skills and investment in knowledge-based capital (KBC), including research and development (R&D)
- a framework for "tripartite" interaction among government and social partners, and sharing of productivity gains
- in certain fields, co-operation between national industry and the state developing new technologies and making strategic use of public procurement, allowing Sweden to act as a lead market for new product.

Innovation has long been at the core of Swedish economic and social development. It has underpinned Swedish enterprises' strong international competitiveness in manufacturing and services, as well as drawn on and fed into Sweden's well-educated labour force. It has also generated the revenues to be distributed throughout society and reinvested in innovation activities. This virtuous circle has helped transform Sweden into one of the world's most innovative economies and societies. Innovation has been facilitated through sharing productivity gains and an active labour-market policy mitigating the frictions associated with the "creative destruction" the economist Joseph Schumpeter has famously associated with innovation processes. By international standards, innovation is comparatively well accepted in Swedish society.

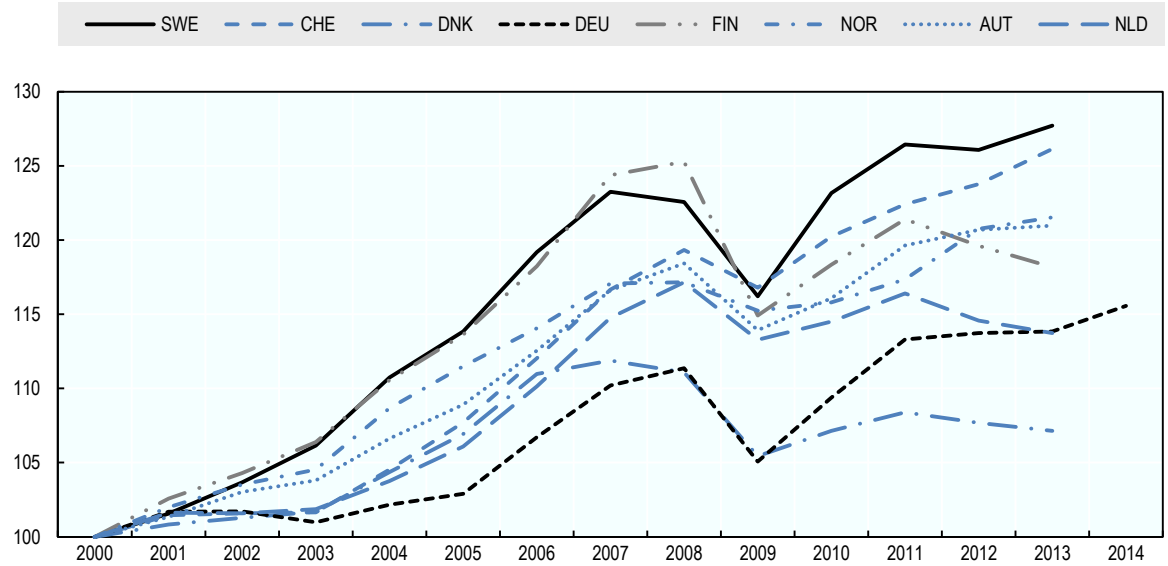
Public procurement played an important part in the emergence of large, globally operating Swedish firms and was a major driver of innovation and economic development for decades of Sweden's modern history. This is evidenced by the so-called "development pairs" involving business enterprises and public-private partners, some of them engaged in long-term relations, e.g. ASEA-Vattenfall for electricity transmission, AXE digital switches and the Global System for Mobile communications (GSM) standard (Ericsson-Televerket).

Sweden's development path has not been linear, however. Like other European countries, the country has experienced a growth slowdown following three decades of post-war economic dynamism. It has been beset by persistently weak productivity performance, which has sometimes been contrasted with Sweden's

high investment in human capital, R&D and other types of knowledge-based capital. Previously powerful modes of co-operation in the national innovation system have become obsolete under the contemporary framework governing the European Union and the world economy at large, and Sweden has found it difficult to replace this engine of innovation.

As a small, open economy, Sweden was affected by the financial and economic crisis that led to a deep recession in 2009. Nevertheless, earlier fiscal and banking system reforms, as well as industrial restructuring triggered by the recession of the early 1990s, meant that Sweden was better prepared for – and recovered faster from – the recent crisis than many other countries (Figure 2.1). A less favourable international macroeconomic environment (notably in Europe) has kept growth below pre-crisis levels, although well above that recorded in other European countries. Overall, Sweden has weathered the crisis well and has shown remarkable resilience.

Figure 2.1. GDP growth performance before and after the crisis



Source: OECD (2015a), National Accounts Statistics, http://www.oecd-ilibrary.org/economics/data/oecd-national-accounts-statistics_na-data-en.

2.1.2 Succeeding in a globalised world

Overall, the 2012 *Review* (OECD, 2013) found that Sweden has done well in embracing globalisation and the profound changes it has brought about. Unlike other high-income countries, Sweden has maintained a strong industrial base with a broad range of products in which it shows comparative advantage. In line with its endowment of high-skilled labour and high wage levels, Sweden has specialised in manufacturing products at the high end of the quality ladder. Increasingly, many Swedish manufacturers (e.g. Ericsson) have transformed themselves by integrating sophisticated service components into their products and product portfolios, and market services have grown rapidly.

Despite these achievements, the *Review* warned that Sweden's success should not create complacency. The intensity of global competition – including from emerging economies – and the continuous need to be at the forefront mean that new initiatives are needed to achieve sustainable high growth.

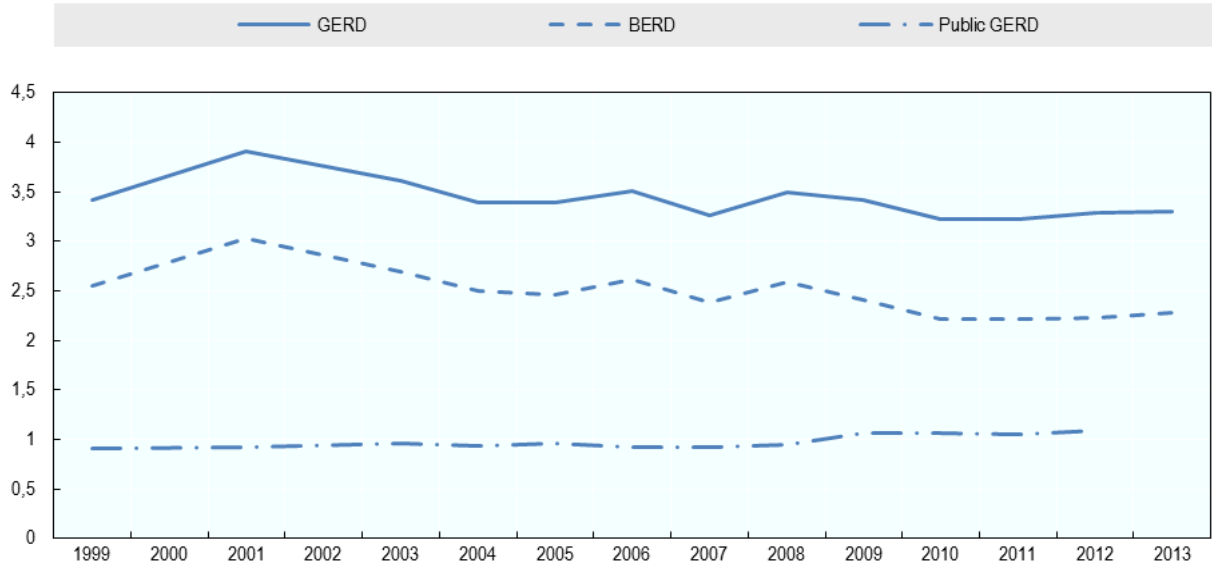
2.1.3 Challenges for the Swedish innovation system

The 2012 *Review* noted that over the last 25 years, important segments of Sweden's industry have been taken over by non-Swedish multinational enterprises (MNEs) with headquarters outside of Sweden. At the same time, large Swedish firms – which have long relied on competing successfully on international markets – have become more profoundly "global" in reach and orientation. Irrespective of their ownership, these enterprises are today guided by their global corporate strategies, including on R&D and innovation. These changes have had a profound impact on interactions in the Swedish innovation system. In some cases, actors in the research system have lost important industrial counterparts.

This also raises the question of how to anchor globally oriented MNEs in their Swedish innovation environment, as well as maintain and promote a world-class Swedish research and innovation system that is able to contribute effectively to this task. It also raises the question of how to best reposition Swedish STI capacity in the face of these changes in the economic environment and provide the strategic guidance, support and incentives to achieve this.

Sweden's leading role in global research and innovation appears to be eroding. Sweden's aggregate R&D intensity (gross expenditure on R&D as a percentage of gross domestic product [GDP]) – long the highest in the world – started to decline after 2000 and stood at 3.3% in 2013 (Figure 2.2). While Sweden still stands at a high level, it is losing ground compared to most countries (Figure 2.3).

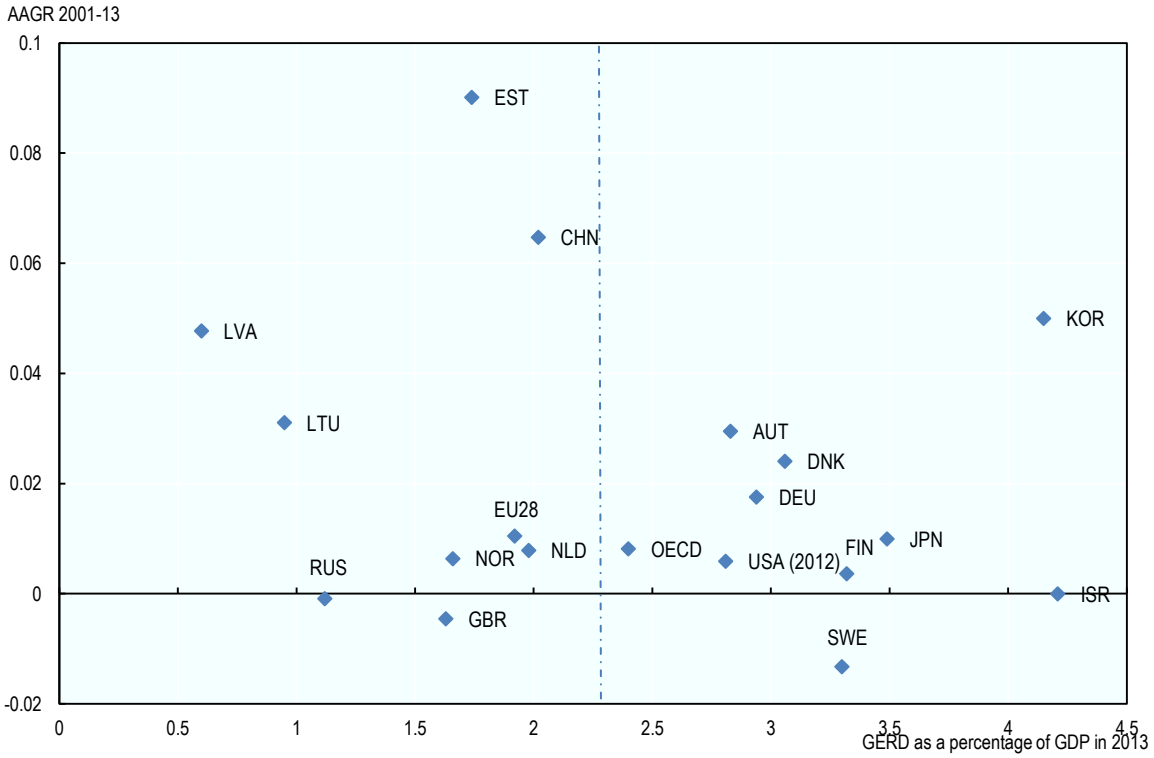
Figure 2.2 Evolution of Sweden's R&D intensity: GERD, BERD and public GERD (HERD+GOVERD) as a percentage of GDP, 1999-2013



Source: OECD (2015b), *Main Science and Technology Indicators 2014/2,* http://dx.doi.org/10.1787/msti-v2014-2-en.

Note: GERD= gross domestic expenditure on research and development; BERD= business expenditure on research and development; HERD= higher education research and development; GOVERD= government expenditure on research and development

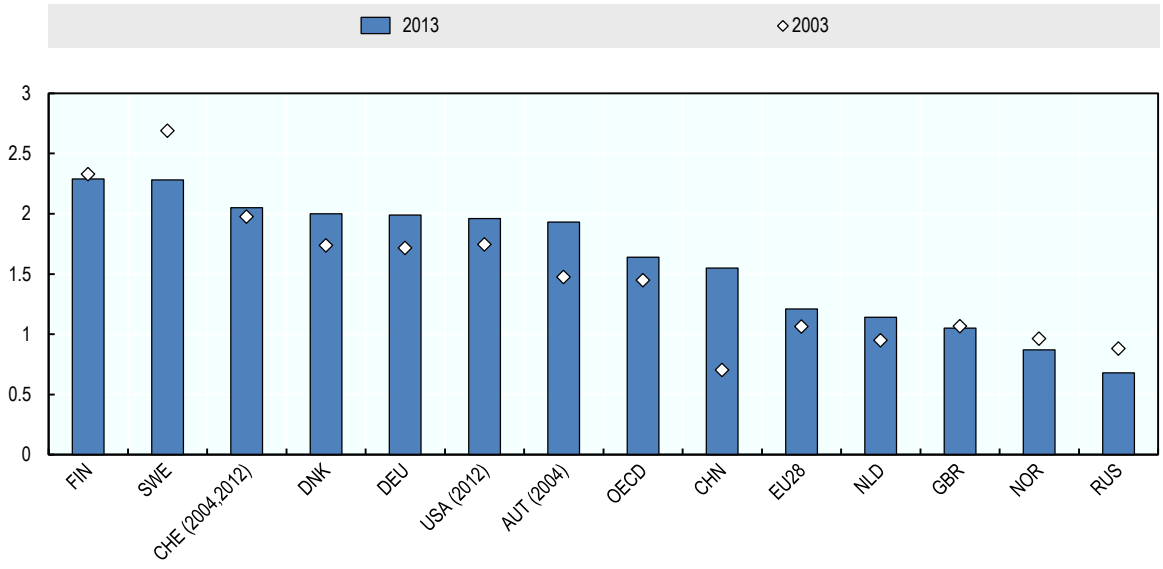
Figure 2.3. R&D intensity, 2013, and average annual growth rate, 2001-13



Source: OECD (2015b), Main Science and Technology Indicators 2014/2, http://dx.doi.org/10.1787/msti-v2014-2-en; Eurostat (2015), Science, Technology, Innovation database, http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

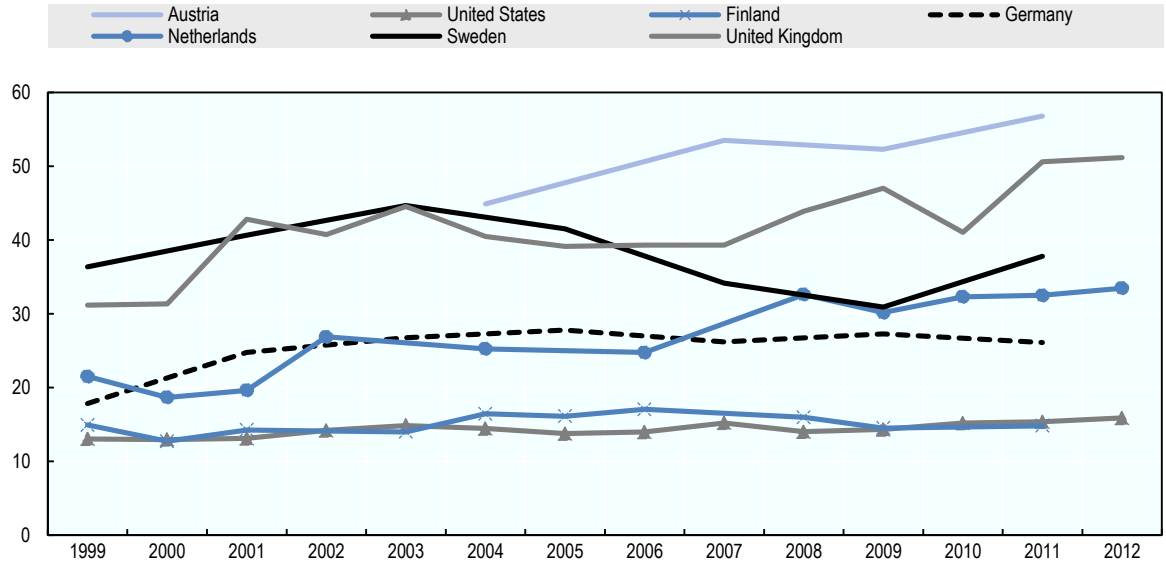
The negative trend in aggregate R&D intensity was driven by a decline in BERD (Figure 2.4). Sweden's BERD is traditionally concentrated in large MNEs. Although many of these have so far maintained a high level of R&D activity, significant cuts have also occurred. A pronounced trend has been the fall of the share of foreign affiliates in Sweden's BERD over much of the 2000s, resulting in the downsizing of R&D activity in Sweden (Figure 2.5).

Figure 2.4. BERD as a percentage of GDP in selected countries, 2003 and 2013 (or latest year available)



Source: OECD (2015b) Main Science and Technology Indicators 2014/2, http://dx.doi.org/10.1787/msti-v2014-2-en.

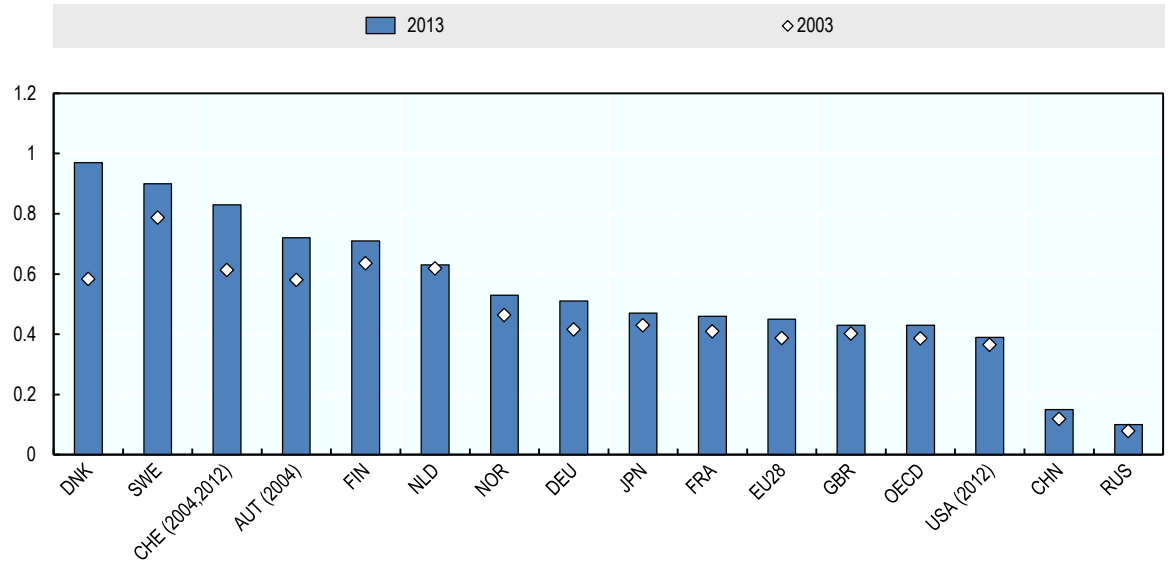
Figure 2.5. R&D expenditure of foreign affiliates as a percentage of R&D expenditures of enterprises in selected countries, 1999-2012



Source: OECD (2015b), *Main Science and Technology Indicators 2014/2,* http://dx.doi.org/10.1787/msti-v2014-2-en.

By contrast, HERD gained ground in the decade following 2003, although not at the same rate as in Denmark (which overtook Sweden in the second half of the 2000s; see Table 2.1) or Switzerland, two of Sweden's major comparators (Figure 2.6).

Figure 2.6. HERD as a percentage of GDP in selected countries, 2003 and 2013 (or latest year available)



Source: OECD (2015b), *Main Science and Technology Indicators 2014/2,* http://dx.doi.org/10.1787/msti-v2014-2-en.

Table 2.1. Higher education expenditure on R&D (HERD) as a percentage of GDP

	2005	2008	2009	2010	2011	2012	2013
Austria	0.59	0.65	0.68	0.71	0.69	0.72	0.72
China	0.13	0.12	0.13	0.15	0.15	0.15	0.15
Denmark	0.59	0.76	0.85	0.89	0.92	0.95	0.97
Finland	0.63	0.61	0.71	0.76	0.73	0.74	0.71
Germany	0.40	0.43	0.48	0.49	0.50	0.51	0.51
Netherlands	0.63	0.63	0.68	0.70	0.62	0.62	0.63
Norway	0.46	0.50	0.55	0.53	0.51	0.51	0.53
Russian Federation	0.06	0.07	0.09	0.09	0.10	0.10	0.10
Sweden	0.74	0.74	0.85	0.85	0.85	0.89	0.90
Switzerland	..	0.66	..	0.73	..	0.83	..
United Kingdom	0.42	0.45	0.49	0.46	0.44	0.44	0.43
United States	0.36	0.37	0.40	0.40	0.40	0.39	..
Total OECD	**0.38**	**0.40**	**0.43**	**0.43**	**0.43**	**0.43**	**0.43**
EU28	0.38	0.41	0.45	0.45	0.44	0.45	0.45

Source: OECD (2015b), *Main Science and Technology Indicators 2014/2,* http://dx.doi.org/10.1787/msti-v2014-2-en.

The 2012 *Review* confirmed Sweden's position as an important international hub of scientific excellence and technological leadership. Sweden is among the global science leaders, both in terms of the volume and the quality of its scientific publications (as assessed by the share of citations). Sweden can also boast a higher number of international patents per capita than most OECD countries, far above the EU average.

While Sweden has maintained a high level of performance, the general picture that emerged from the comparative analysis in the 2012 *Review* was that it has evolved less dynamically than a number of comparator countries (including Denmark and Switzerland, and in some respects the Netherlands, not to mention the most dynamic emerging economies). This matter deserves the utmost attention, as the global R&D landscape is changing rapidly and Swedish enterprises (e.g. in the telecommunications industry) are finding themselves in direct competition with enterprises from emerging economies -– notably China.

The 2012 *Review* argued that maintaining Sweden's high long-term economic performance in an increasingly globalised world would strongly depend on the country's innovation capacity, i.e. its ability to generate, transfer and assimilate a continuous flow of technological, managerial, organisational and institutional innovation. Meeting this challenge calls for continued high investment in R&D and innovation, as well as a well-functioning innovation system to ensure high returns on the investment.

2.4 Strengths, weaknesses, opportunities and threats (SWOT)

The 2012 *Review* undertook a SWOT analysis of the national innovation system. In particular, it identified the following key strengths in the Swedish research and innovation system:

- successful economic development
- specialised at high end of global value chains
- good framework conditions for innovation
- a strong human resource base
- high investment in R&D, KBC and information and communication technology (ICT)
- a strong science base
- excellent innovation performance
- good positioning in international networks.

It also identified the significant weaknesses:

- some aspects of financing for innovation
- declining educational performance
- a suboptimal academic intellectual property system
- small academic centres of competence/excellence
- weak links between traditional universities and small and medium-sized enterprises
- weak innovation policy compared to policy in other areas (e.g. education)
- lack of a holistic perspective concerning innovation policy
- many medium-sized funding agencies funding similar things

- unclear governance in regional innovation policies.

For the full SWOT, see Annex A1.

2.5 Strategic tasks

Building on the summary SWOT analysis and detailed assessments of specific aspects of the innovation system, the 2012 *Review* identified a series of strategic tasks that Sweden might adopt in order to improve the overall performance of the innovation system, including:

- providing Swedish business with world-class framework conditions, as well as a world-class business environment and infrastructure, including in information and communication technology, one of Sweden's major assets

- increasing the economic and social benefits derived from R&D performed at Sweden's strong and well-endowed universities and comparatively small research-institute sector, helping to anchor Swedish and foreign-owned enterprises in the Swedish innovation environment

- further fostering internationalisation in order to be at the forefront of STI, and attract and retain the best students, researchers, enterprises and research centres

- adopting and pioneering new approaches to innovation and innovation policy, including in services.

The first of these strategic tasks aims to take the lead regarding the fundamental conditions for innovation – e.g. the regulatory and competition framework, as well as access to finance and infrastructure (including ICT and transport) essential to a highly-developed, globalised, knowledge-based economy. The three other strategic tasks relate directly to topics covered by this *Review*: enhancing the contribution of Sweden's universities and research institutes; keeping Swedish science competitive and reversing its tendency to fall behind compared to other dynamic economies; and developing new approaches to innovation and innovation policy.

2.6 Recommendations of the 2012 Review

The 2012 *Review* provided a set of recommendations on how Swedish innovation policy could support the strategic tasks mentioned above. The recommendations focused on the following areas for improvement:

- maintaining supportive framework conditions for innovation and entrepreneurship

- maintaining a world-class human resource base for STI

- improving public governance of the innovation system

- fostering innovation in the business sector

- balancing the policy mix and enhancing the role of demand-side policies

- fostering critical mass, excellence and relevance in public-sector research

- strengthening regional innovation policy and its alignment with national policy

- strengthening public-sector innovation and social innovation
- maximising benefits from the internationalisation of R&D and innovation.

Table 2.2. provides a detailed overview of these recommendations.

Table 2.2. Recommendations of the 2012 *Review*

Maintain supportive framework conditions for innovation and entrepreneurship
• Maintain sound macroeconomic conditions, including sustainable public finances, one of the most important prerequisites for dynamic private and public investment in innovation. • As part of an ongoing effort to give due attention to their impact on innovation, the government should continuously screen key framework conditions to ensure their alignment with best practice. • Undertake a comprehensive examination of how the tax system affects equity finance for growth companies, including the scope for tax deductions for investment in growth companies and the taxation of stock options. • Examine the legal framework for specialised business (association) forms to ensure that the absence of suitable legal structures does not create a barrier to early-stage equity finance. • Ensure that the evaluation of publicly supported venture funds is fully independent. • In line with what is generally considered global best practice, examine where direct public support for equity finance could be provided through a fund-of-funds approach. More generally, examine where more commercially oriented approaches – with *more co*-financing from private investors – can be included in overall public support for venture finance. • Examine the overall balance of supply- and demand-side measures for early-stage equity financing.
Maintain a world-class human resource base for STI
• Continue to pay attention to problematic developments in early stages of education. • Monitor reported mismatches between supply and demand in the labour market for engineers and other skilled personnel required for innovation. • Consider whether there are adequate employee placement schemes for graduates targeted at small and high-technology firms. • In monitoring entrepreneurship education initiatives, seek to encourage programme assessments that take account of selection effects in student intake. • *Foster international academic openness through stronger inward internationalisation.* • *Make better use of universities' role in hosting foreign students and researchers.*
Improve public governance of the innovation system
• *Enhance the strategic direction of innovation policy across government.* • *Improve inter-ministerial co-ordination of innovation policy.* • *Generate and utilise more strategic policy intelligence.* • *Reduce the fragmentation of funding support.* • *Introduce a few high-profile, large-scale initiatives, in addition to the many, often parallel medium-sized activities in policy making and funding.* • *Use the innovation strategy and successive planning activities to formulate a small number of large initiatives to promote innovation.* • *Create larger centres and contribute to the build-up of real critical mass in scientific as well as collaborative research.* • *Consider doubling the budget of the Swedish Governmental Agency for Innovation Systems (VINNOVA) if current ambitions for this agency are maintained.*

Foster innovation in the business sector
• *Provide a world-class innovation environment in order to attract and retain innovative firms* • *Use all available means to anchor large firms and their activities in production and research in a world-class Swedish innovation environment* • *Make the growth of innovative SMEs a main focus of a revamped and strengthened innovation policy.* • Consider raising the amount and level of direct innovation funding to SMEs. • If new fiscal incentives for R&D are considered, they should be targeted at SMEs, including those not currently profitable. • Extend attention from traditional R&D-based innovation to non-R&D-based innovation in firms, including innovation in services and creative industries. • Foster design competencies.
Balance the policy mix: The role of demand-side policies
• *Enrich the traditional set of instruments with demand-side instruments.* • *Consolidate the lessons and recommendations stemming from the many inquiries and pilot activities pertaining to pro-innovation procurement and proceed to implementation.* • *Examine ways to ensure standardisation and structured learning in pro-innovation procurement across sub-national governments.* • *Ensure that comprehensive information and guidance are available for procurement bodies, including at regional level.* • Consider whether the introduction of a full-blown SBIR-type initiative would add significantly to the existing suite of innovation support instruments.
Foster critical mass, excellence and relevance in public-sector research
• *Help make universities stronger and more proactive players in the innovation system.* • *Continue to increase R&D support to university colleges while maintaining their distinctiveness vis-à-vis the leading research HEIs.* • *Reward research excellence by submitting HEIs to stronger accountability regimes through research assessment.* • *Improve the attraction and retention of top researchers from abroad, particularly in universities.* • *Revisit the "professor's privilege" arrangements.* • *Retain the existing policy focus on collaborative partnerships while drawing lessons from experience to improve some of the instruments.* • *Strengthen links between HEIs and the business sector on teaching and curriculum design.* • *Keep the RISE structure stable and let it grow moderately if it directly serves the needs of SMEs/SME-dominated sectors.* • *Screen possibilities of mergers between institutes and (smaller) universities if such a move could lead to strong regional actors with a clear thematic focus.*
Strengthen regional innovation policy and its alignment with national policy
• Explore ways to better adapt European and national initiatives to regional specificities. • Encourage a broad set of actors beyond universities and colleges to take leading roles in regional innovation programmes. • Nurture a learning culture around innovation policy interventions at the regional level.
Strengthen public sector innovation and social innovation
• *Broaden the framework of innovation policy to ensure that it covers public sector and social innovation.* • *Continue to support a better conceptual and empirical basis for measuring and promoting public-sector innovation.* • Develop and implement experiments in the public sector to nurture innovation.

• Ensure that know-how regarding public-sector innovation reaches the regional and municipal levels. • *Develop business models for sustainable social innovation, taking note of international practices in the area.*
Maximise benefits from the internationalisation of R&D and innovation
• *Consider developing an explicit internationalisation strategy for R&D and innovation.* • *Consider developing an explicit national strategy targeted at EU research and innovation.* • *Actively explore various avenues to intensify the internationalisation of SMEs.* • *Continue strengthening links to established and emerging global centres of innovation.*

Source: OECD (2013), OECD Reviews of Innovation Policy: Sweden 2012, http://dx.doi.org/10.1787/9789264184893-en.
Note: SBIR = small business innovation research.

While all these recommendations are relevant to the current review, the most closely related to the issues dealt with in this report are presented in italics: *fostering critical mass*, *excellence and relevance in public-sector research* and *improving public governance of the innovation system.*

The recommendations on improving public governance in the 2012 Review are primarily concerned with improving co-ordination and reducing fragmentation in the Swedish STI funding system, which comprised many medium-sized agencies, research councils and private foundations. The multiplicity of medium-sized agencies operating a host of sometimes overlapping, also medium-sized programmes was often found to reduce their overall effectiveness. Accordingly, the 2012 *Review* recommended scaling up the size of (some) agencies, initiatives and specific project funding.

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ANNEX A2.1

Table 1.A2. Main strengths, weaknesses, opportunities and threats identified in the 2012 Review

Strengths	Opportunities
• Successful socioeconomic development combining economic success with a high degree of equality and outstanding quality of life. • Specialisation at the high end of global value chains and fast-developing innovative services. • Good framework conditions for innovation including solid macroeconomic fundamentals and institutions, a robust financial system and a supportive business environment. • A strong human resource base. • High investment in R&D and other knowledge-based capital and a strong ICT infrastructure. • A strong science base with high inputs, strong actors (notably research universities) and very good output in terms of the number and quality of scientific publications. • Excellence in industrial research and world-class innovation. Strong MNEs operating globally, including in R&D and innovation. • Participation in international academic and industrial networks, including in key areas such as pharmaceuticals, ICT and engineering. • Successful participation in European Framework Programmes and other international co-operative efforts. • High quality of institutions, which fosters transparency and high levels of trust, reduces transaction costs and facilitates adaptation to changing environments. • Wide public acceptance of innovation and recognition of the importance of science, technology and innovation (STI) for sustainable future growth.	• Good conditions to benefit further from globalisation. • Increased contribution of the strong core of academic research institutions to social and economic development. • Development of larger and more prominent centres of excellence at the top universities. • Development of regional knowledge hubs involving the new smaller universities (possibly with public research institutes). • Further internationalisation of research, including through attraction of foreign researchers and students and the attraction of FDI in R&D. • Development of a comprehensive innovation strategy to strengthen core actors and long-term commitments across sectors and levels of government. • Strengthening of smaller firms in various ways. • Further development of innovation in services. • Larger-scale policy initiatives to address Grand Challenges, including demand-side instruments. • New approaches and practices in innovation procurement adapted to the new environment.
Weaknesses	**Threats**
• Some aspects of the framework conditions for innovation, e.g. the area of financing. • Declining educational performance (PISA results). • A suboptimal system of academic IP. • University centres of competence/excellence are relatively small which can reduce their impact.	• Failure to maintain high productivity growth. • Loss of competitiveness, as new global actors enter the high end of value chains and markets. • Failure to maintain existing advantages (e.g. in clinical research). • Failure to make full use of the country's rich knowledge base and loss of innovative edge in the face of global competition.

• Insufficient links between traditional universities and SMEs. • Innovation policy is weak relative to other policy areas, e.g. higher education. • Lack of a holistic, “all-of-government” approach to innovation policy. • Large number of medium-sized funding agencies engaged in similar funding activities. • Unclear governance in regional innovation policies. • Uneven record on evaluation.	• Insufficiently structured technology transfer and links between industry and research. • Failure to nurture the emergence of new industrial activities, including in the services sector. • Increasingly fierce competition for top international talent in Swedish universities. • Offshoring of MNE production activities and leading corporate research centres (e.g. pharmaceuticals). • Overemphasis on consensus building when decisions need to be taken rapidly.

Source: OECD (2013), OECD Reviews of Innovation Policy: Sweden 2012, OECD Publishers, Paris.

CHAPTER 3. STRENGTHENING SWEDISH UNIVERSITY RESEARCH

While research excellence has always been an objective of Swedish research funding policy, it has become the object of particular attention in the last decade, as signs have emerged of stagnation in quality – at least as measured in bibliometric terms. Many argue this is one symptom that the balance between institutional ("core") and third-party competitive funding has been upset. The last two Innovation and Research Bills have sought to restore this balance by increasing the amount of institutional funding provided to universities for research purposes. This chapter explores these policies, their background and their apparent effects.

It starts by reviewing the systemic foundations of different types of research funding, as well as some specificities of the Swedish university system. It situates Swedish funding policy and performance in an international context, then summarises recent Swedish policy and the roles of different funding sources for university research. Finally, it discusses the apparent effects of these policies and the degree of complementary actions that will be needed for them to attain their objectives.

3.1 Institutional research funding in the Swedish context

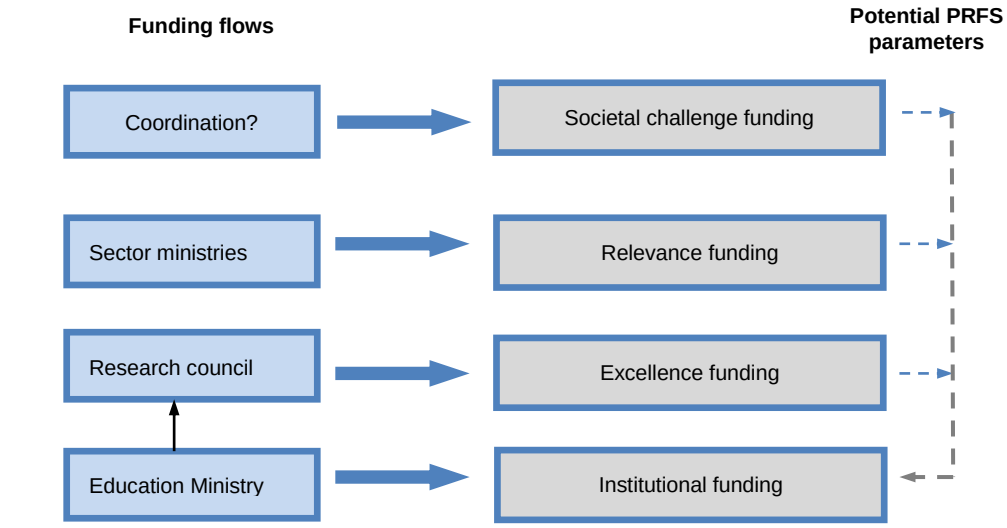
3.1.1 University institutional research funding in a systemic context

Western university research funding systems comprise a mixture of institutional (or "block" or "core") funding and TPF.

Historically, European universities were funded through a single grant, normally provided by an education ministry, intended to cover both teaching and research. The OECD has historically referred to this as the GUF. The principle of university autonomy meant that the internal allocation of this money was decided by the individual university rather than the state – though the state's often important role in deciding the number and type of academic jobs meant that universities were not entirely free from state influence. Over time, university reforms have reduced or eliminated the role of the central state in university appointments. At the same time, education ministries have increasingly specified the allocation of institutional money towards teaching or research, more recently connecting them to various indicator systems related to inputs, outputs or performance.

In recent decades, the growth of research councils, innovation agencies, and other government and non-government bodies offering university research grants has meant that the old institutional funding system is now but one element in university research funding, although it is almost universally the largest individual income stream for any university. Figure 3.1 summarises the main public research funding sources for universities.

Figure 3.1. Systemic roles of university research funding sources



Source: Arnold, E. et al. (2015), Impacts on the Framework Programme in Sweden.

Education ministries tend to provide institutional funding for three reasons:

- to provide continuity and a stable basis for planning
- to provide strategic resources enabling universities to invest in new fields, themes and research methods ahead of the point where they can credibly persuade third-party funders to support their work
- to enable all academics to pursue a minimum level of research without dependence on the vagaries of TPF.

University autonomy means that it is difficult for the state to ensure the money is used in these ways. University governance will determine how the money is spent.

Recent performance-based research funding systems aim to make part of institutional funding contestable, giving an additional incentive for quality.

Education ministries often provide a second funding stream through research councils or national science foundations. This funding is allocated at the project level, by assessing competing proposals based on quality or "excellence" criteria. The academic community generally plays a strong role in this decision, which provides incentives for producing excellent research. Project-level funding is also believed to provide implicit quality assurance of the institutionally funded research effort in order to produce sufficiently high-quality applications to external funders.

A third funding stream comes from other ministries, which provide incentives to do mission research. This category includes both innovation-related research (often funded by an industry ministry through an innovation agency) and work related to other ministry missions, such as transport, health, energy and the environment.

So far, the EU is the only entity to have established a fourth funding stream to tackle "societal challenges". These are currently addressed at the national level through existing channels, which poses the problem of determining how to programme and co-ordinate activities at this level. Over time, societal-challenge funding appears likely to generate another funding stream, which will provide incentives to the universities.

Each of the external funding streams may be – and actually is in Sweden – supplemented by private research-and-innovation funding foundations.

The overall effect, therefore, is to offer universities an incentive system. Universities have the option to use TPF strategically, or at minimum as a way to observe which researchers are highly valued externally. Over time, the external incentives will likely encourage the successful fields in the university to grow faster than the rest, helping shape the university structure to aim for excellence, relevance or some combination of both. Some performance-based research funding systems deliberately exaggerate this effect by coupling core funding with particular sources of external funding, so that some core funding can be redirected to support the work funded through TPF.

The extent to which universities can, and do, respond to this system of research funding is key to its effectiveness. University autonomy means that universities are not obligated to allocate increased performance-based core funding to the higher-performing departments or groups that attract it. While its differential effects will tend to shape the national system of university research in the directions encouraged by the external funders, it offers those universities that develop strategies the option to pursue specific kinds of funding that support those strategies.

The degree to which external funders make and implement strategy – whether to support excellence in general, promote specific types of mission research or act as change agents, deliberately aiming to alter the direction of the research-performing system – is also key.

3.1.2 Historically driven characteristics of the Swedish university system

The "Swedish model", which calls for universities to perform research relevant to the needs of industry sectors, is much broader than that seen in many other countries. Key decisions about the structure and respective roles of Swedish universities and research institutes were laid out during the Second World War. These continue to have a decisive effect on the government's ability to implement research and innovation policy. These decisions, and the subsequent development of the Swedish model, have important consequences, which impede the operation of the incentive model illustrated in Figure 3.1.

- While the universities were given wide responsibilities for sector research, the extent to which this was reflected in the conditions under which institutional funding was provided was minimal.

- Subsequent transfers of sectoral resources into university hands meant that these were absorbed by organisations that continued to organise on a Humboldtian model and felt no particular obligation to maintain staff or infrastructure specifically to address sector needs.

- Academic governance in both research councils and universities impeded the formation and implementation of strategies, encouraging lock-ins and hindering change.

The Swedish university system (Table 3.1) is not homogenous. It has deep roots in European history. Sweden can boast two of the oldest and most prestigious universities in Europe – Uppsala (1447) and Lund (1666) – both of which began life as theological seminaries. The Karolinska Institute (KI) medical school was granted parity with the universities in 1861. The Stockholm college (*högskola*) was given parity with

the universities in 1904 and only became a university in its own right in 1960, while the Gothenburg college received parity in 1907 and became a university 1954. What is now the Royal Institute of Technology (KTH) in Stockholm was set up by royal command to provide technical education in 1827, becoming KTH in 1877. Chalmers Slöjdskola was set up also by industry in Gothenburg in 1829. It expanded through state funding from the 1870s onward and after some name changes, became Chalmers Tekniska Högskola in 1937.

Like other European countries, Sweden embarked on a programme of university expansion in the 1960s.

Table 3.1. Swedish universities, 2005

Universities	Date of establishment
Uppsala universitet	1477
Lunds universitet	1666
Goteborgs universitet	1954
Stockholms universitet	I960
Umea universitet	1965
Unkopings universitet	1975
Karolinska institute	1810
Kungl. Teknlska hogskolan	1826
Chalmers teknlska hogskola	1829
LuleA teknlska universitet	1997
Handelshogskolan I Stockholm	1909
Sverlges lantbruksunlversitet	1977
Karlstads universitet	1999
Mittuniversitetet	2005
Vaxjo universitet	1999
Orebro universitet	1999

Source: Tegner, O. (2006), Högre utbildning och forskning 1945-2005 en översikt.

All the universities listed in Table 3.1 are state agencies, with the exception of Chalmers and Jönköping, which are private foundations funded by the state through performance contracts.

The Humboldtian university model, which originated in Germany in the early 1800s, heavily influenced Uppsala University and the development of other Swedish universities. The Humboldtian idea of academic freedom as the right for academics to choose what they want to teach, and for students to choose what they want to learn, has become deeply embedded in the Swedish system and is still frequently invoked in debates about research and innovation policy.

Until 1992, university professors were appointed by the government. Today, the government appoints rectors nominated by university boards, but the universities retain significant influence over appointments. Thus, the 1993 university regulation (*högskoleförordning*) says that before the board proposes a rectorial candidate to the government, it shall "hear" the faculty members and the students (Högskoleverket, 2006).

The Chancellor of the Swedish Universities has been a paid civil servant since 1964 and was elected up to 2013, at which point the position became a government appointment (and the first woman in Swedish history was appointed to the job).

University boards were previously chosen internally, but the government imposed external representatives to the boards beginning in 1976; a further reform in 1988 required a majority of external members, in line with international good practice.[1]

The autonomy principle meant that (except in relation to salaries) universities' use of core funding was their own business. The 1992 Research Bill (FP1992/92:170) pointed out that most universities tended to use core funding to match the inflow of external funds, while others used it to match the flow of PhD students.

Swedish universities' difficulty in developing strategy is a longstanding problem. The 1996 Research Bill (FP1996/97:5) established a requirement for universities to write strategies. The following bill (FP2000/01:3) noted they were poor quality and thematically unspecific, and that their main message was that the universities wanted to receive funding for a greater number of centres. The 2000 Research Bill pointed out the practical difficulty of persuading the universities to arrange a thematic division of labour in their graduate schools, let alone in their wider research and education activities. By the time the 2004 Research Bill (FP2004/05:80) was passed, university strategies had begun to address thematic specialisation, but were still struggling to set priorities or reallocate resources. As a result, external funding remained the main driver of changes in university specialisation.

Since the mid-1990s, the universities have increasingly exploited centre programmes to build larger research groups, gradually undermining the traditional division of labour, where a single professor took responsibility for each particular sub-field. Government and foundation funding of graduate schools both within and across universities from the early 1990s onward has reinforced this shift. However, few of the research centres or graduate schools that have been funded have turned into permanent structures, and these areas evolve continuously.

3.1.3 Sectoral research funding and the role of the universities

Sweden's technological and industrial competitiveness was a source of growing concern in the years leading to World War II, owing to the large and strengthening capabilities of Germany, the United Kingdom and the United States (Weinberger, 1997). In 1940, the Swedish government convened a commission (Statens offentliga utredningar [SOU], 1942), led by Gösta Malm, about how to strengthen Swedish engineering research. It set up a separate commission, also chaired by Malm (SOU, 1943:34), to analyse the future organisation of higher education in technology. This commission specified in some detail how the two technical universities then in existence (KTH and Chalmers University of Technology) should develop. It rejected a proposal to set up a national institute of technology, instead proposing the creation of a technology research council (TFR). The TFR comprised three members representing industry (including Ingenjörsvetenskapsakademien, the Royal Swedish Academy of Engineering Sciences [IVA]) and four from higher education, in the belief that the academic influence would make the board "neutral" (Weinberger, 1997). In practice, the TFR funded basic technological research at universities and – right up to the end of the 1950s – very little research by industry (Weinberger, 1997).

Key consequences of the two Malm commissions were:

- integration of teaching and research in technological subjects
- a decision not to fragment national research resources for fundamental research between universities and a new scientific institute sector (with the condition that, where institutes were necessary, they should focus on applied research and industrial development)
- a delegation of power over technical research funding to the academic community
- a view of higher education research as playing a strong role in human capital production, rather than as an isolated, knowledge-producing activity (Sörlin, 2006).

Gösta Malm effectively set down the Swedish model of higher education organisations as performing not only education and (basic) research, but also playing a significant role in sector research – which in other systems would be done in a separate institutional sector. Malm's conclusion that technological research policy should focus on university research was reinforced by a 1979 parliamentary decision that "the universities shall undertake a significant proportion of sector-related research, *viz* research that aims to support or develop state agencies' activities" (SOU, 1980). The universities were to function as "research institutes for the whole of society". The expanding knowledge infrastructure was to focus on the universities, particularly the production of qualified manpower at first-degree (masters) level.

The education minister pointed out in the subsequent research bill that he had authorised 23 permanent professorial chairs in the seven major research universities in order to strengthen their sectoral capacity.

During the 1960s and 1970s, the amount of state-funded "mission" or "sector" research increased significantly. This was the result both of increases in state agencies' R&D budgets and the creation of free-standing research-funding agencies, thereby separating R&D contracting from performance. Boards with a majority of members elected by the academic community led the education ministry's research councils. Sectoral funders, on the other hand, were not academically led; while many relied on scientific panels and committees to advise them on priority-setting, civil servants rather than academics made the final funding decisions. Many other sector funders acted in similar fashion, but without distinguishing between the parent organisation and the funding organisation.

The sectoral funding governance model has been politically contentious from the start, with parts of the research community trying to bring sectoral funding under researcher control. The rapid expansion of sector research meant that it took time to build up new, high-quality research milieu; as a result, sector research was often deemed inherently of poor quality, especially in the energy area where the national policy response to the oil-price crisis of 1973 was a massive expansion of research into alternative energy sources (Wennerberg, 1996).

In 1998, the Research 2000 Commission proposed that all sector-research funding should be stopped, and the money transferred to the university system through researcher-governed councils (SOU, 1998). While the proposal was widely derided (especially by IVA), it prompted the government to restructure the research-funding agencies. The education ministry's councils were merged into a new Swedish Research Council (Vetenskapsrådet [VR]). Two additional research councils (the Swedish Council for Working Life and Social Research [then known as FAS, now FORTE), and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS) were set up for sector research but – like VR – were steered by researchers, subjecting parts of sectoral funding to governance by the research community.

An evaluation of the reform (SOU, 2008) showed at best mixed results. The evaluator found that researcher governance on VR effectively prevented it from fulfilling its aim of reducing fragmentation, creating critical mass, increasing interdisciplinary research, helping to define research policy and acting as a change agent in the funding system. In both FAS and FORMAS, researcher governance tended to drive out sector research. Some FAS principals set up separate funding lines to make up for this deficit, though FAS had succeeded in proposing a number of interesting research themes within its operations. The strategy of FORMAS had moved closer to the VR strategy; funding was still fragmented and the focus on achieving sector research goals had lessened. For all intents and purposes, FORMAS might as well have been merged into VR. By contrast, the VINNOVA continued its predecessors' tradition by acting as a change agent by extending its activities beyond technology programmes with a view to modernising the actors and organisations in the innovation system. The main criticisms levied against VINNOVA were that is was untidy and worked with an overly lengthy list of priorities.

3.2 Recent policies for strengthening institutional funding

The Innovation and Research Bills of 2008 and 2012 responded to the widespread perception that the universities were under-provided with institutional funding for research. Both bills featured measures to increase universities' institutional-research funding as a proportion of their total research income, as well as offer incentives to support the excellence and strategic relevance of work funded by this source. One measure was to increase directly the amount of institutional research money provided by the state to the universities. The other measure, the SFOs, involved a competition whereby universities received additional institutional funding provided it be tied to specific (and strategic) areas of research during the first five years. Thereafter, they could use the incremental institutional funding as they wished.

3.2.1 Boosting GUF for research

The 2008 Bill earmarked SEK billion 1.5 (kronor) – out of a total SEK 5 billion increase in the research and innovation budget – to increase the GUF research budget, noting this measure should be the first in a number of growth steps. The 2012 Bill provided a further SEK 1.2 billion increase in the GUF research budget (out of a total increase of SEK 4 billion) over its validity period. Research and innovation Budgets grew by SEK 600 million in 2014 and are scheduled to grow by another SEK 300 million in 2016 (Swedish Government, 2012).

Along with the increase in GUF earmarked for research, the 2008 Bill also introduced a research performance-based allocation system. The aim was to maintain high and competitive scientific quality, as well as improve Swedish universities' competitive position internationally through greater specialisation, prioritisation and developing individual research profiles (Swedish Government, 2008). The 2008 bill listed increased international competition, growing student numbers, stagnating university budgets and the growing share of TFP in HERD as constraints on Swedish universities' autonomy and factors contributing to their weakened international position, thus creating the need for more institutional funding (Swedish Government, 2008).

The performance-based research funding (PRFS) system introduced in the 2008 Bill tied 10% of GUF earmarked for research to two equally weighted quantitative indicators (Swedish Government, 2008).

- The first indicator measures scientific production and impact and is based on publication numbers and citation analysis using four-year averages. The citations are field-normalised and extracted from the *Web of Science* database.

- The second indicator measures the amount of external funding. It features almost all sources of TPF.[2] It reflects the broad mission of Swedish HEIs and a desire to assess not only "academic quality", but also "innovation performance". The indicator uses a three-year income average.

The introduction of an indicator-based system rather than a peer review system allowed rapid deployment of the new allocation system. Limiting the system's scope to 10% of GUF meant that the PRFS only applied to the increased GUF for research, so the change could not initially produce losers. The 2008 Bill also stipulated that GUF allocations should be rebalanced simultaneously to allow HEIs a minimum of SEK 8 000 per full-time equivalent (FTE) student; this change masked the true impact of the new indicator-based system.[3]

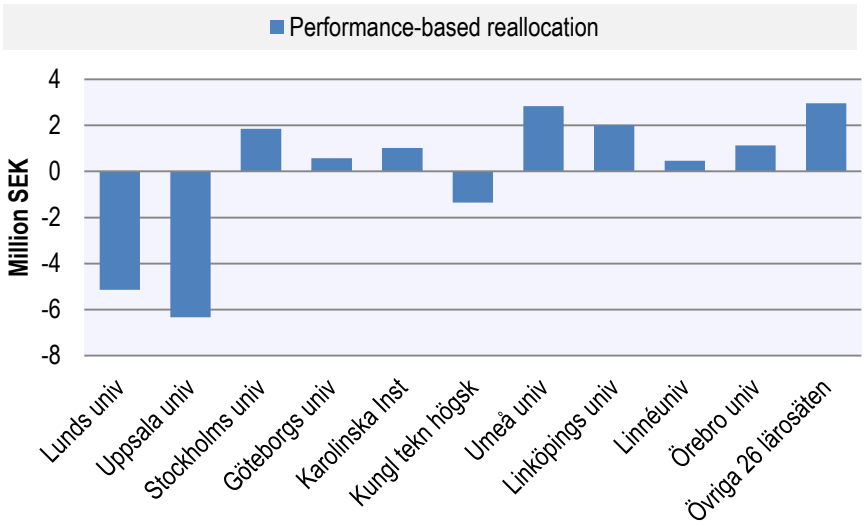
The 2012 Bill again highlighted Sweden's declining competitiveness compared to neighbouring countries in terms of both scientific outputs and the impact of scientific research; it highlighted the difficulty of competing at the leading edge of research (Swedish Government, 2012). The 2012 Bill also argued, however, that while HEIs needed enough GUF to continue to perform their basic research mission,

they also needed to be in a position to perform research driven by societal needs. It therefore proposed to continue the measures introduced four years earlier, with increased emphasis on instruments (e.g. the strategic innovation areas) designed to improve competitiveness and help universities make long-term decisions on priorities and critical mass in certain fields (Swedish Government, 2012).

The 2012 Bill increased the share of research-related GUF governed by the indicator-based system to 20% and retained the concept of a basic minimum for HEIs, based on student numbers. The same equally weighted indicators continued to be used, with some small changes to the TPF calculation base.

As expected, the PRFS had minimal economic effects (Figure 3.2).

Figure 3.2. Performance-based reallocation of GUF for research, 2012



Source: Fridholm and Melin (2012). *Med glädje, men inte med lätthet" –om högskolans fördelning av de direkta statsanslagen för forskning* (Distribution of governmental direct appropriations to research at Swedish universities).

The redistributions for 2014 projected in the 2012 Bill indicated that two universities would each lose around SEK 10 million and that KI would gain an additional SEK 40 million (Swedish Government, 2012). These amounts are not negligible, but in the wider scheme of things they constitute little more than minor perturbations. For KI, the gain amounted to approximately 2% of its overall GUF allocation and 1% of its overall research income, including TPF. For most HEIs, the funding impact of the introduction of the PRFS on their overall share of GUF for research has also been marginal.

3.2.2 The strategic research areas (SFOs)

The government introduced the idea of SFO funding in the 2008 Research Bill (FP 2008/09:50). It argued that the proportion of university research funding available for long-term investigator-initiated research was too low, that short-termism in funding effectively prevented universities from setting long-term research strategies, and that they should be freed to do so. In addition to the direct increase in GUF for research, the government argued for the need to allot a proportion of research funding to generating societal benefits or solving societal problems. Past funding schemes had not succeeded in building strengths in such areas within the research system. One weakness was that projects tended to be small and did not cover full costs.

SFO grants were allocated on a competitive basis for five years, after which an evaluation would take place. The government intended the research to be "strategic", in the sense that it could be relatively fundamental, but was clearly directed at a particular problem or set of problems. The research theme was to be socially determined by the government, but the specific use of the research funding was to be decided by the universities. By using the established external research funders to allocate the SFO grants, the government could guarantee a transparent and rigorous assessment process through which to select the best proposals. Thereafter, the universities could treat the grants as additions to their institutional funding and make their own determinations on how to use the money. This form of funding was intended to allow the universities to take bigger risks and use bolder ideas in research than is possible under traditional funding mechanisms.

The 2008 Research Bill held that while the SFOs should strengthen universities' strategic specialisation, they should also involve co-operation – especially as they were thematically related to many of subjects of the European Framework Programme – and should increase the supply of appropriately qualified manpower in their areas. These areas should involve:

- research with the capacity and potential to reach the highest international quality levels
- research that can address societal needs and solve important problems in society
- research in areas related to Swedish industry.

Based on consultations with state agencies, business associations and companies, as well as a VR analysis of Swedish research strengths, the government decided on the following subject areas:

- medicine and life sciences
- technology
- climate change.

The government also determined that some funding should be made available to the humanities and social sciences. It listed 20 priorities, with detailed justifications for each one. To maintain the diversity of the research-performing organisations, two such organisations should normally receive SFO funding for each of the 20 priorities.

The weight and diversity of expectations were high. The government noted the importance for the universities to use some of the SFO money to fund curiosity-driven research. It also stressed that societal stakeholders should be involved in formulating the problems tackled by the SFOs, and that companies should be involved in carrying out SFO projects. Research institutes could participate as partners in SFOs, as they are active in research in relevant fields. As the SFOs address internationally important themes, universities should also co-operate internationally in the research areas defined by their SFOs. Finally, society's need for educated manpower implied a necessary a link between SFO activities and education at the universities.

3.3 Swedish university growth, funding and performance

In a context of extensive growth of the university system, Swedish university research funding has long been generous. The country spending a high proportion of GDP on HERD, with very significant additional funding coming from a rather long list of (both public and private) TPF providers. Efforts to

increase the quality of research through performance-based funding were introduced in 2008, about the same time as a notable stagnation in output quality became evident.

3.3.1 University growth

As is the case in many industrialised countries, the Swedish university system has seen massive growth over the last 50 years in terms of student numbers, university staff and the number of new universities and colleges founded or upgraded between the 1960s and the 1990s (see OECD, 2013). In 1964, the OECD listed four universities, three technology institutes, two commercial colleges and two medical colleges (OECD, 1964). Today, Sweden has around 40 publicly financed universities and colleges, including around 10 major universities (half of which are specialised).

The smaller universities and colleges mostly focus on teaching and have substantial student numbers, with less favourable teacher-student ratios than the larger universities. Institutions with university status can grant PhDs in any field. Many of the smaller HEIs had been granted the power to award PhDs in at least one discipline.[4] Concerning research, a number of the smaller universities have built up some capacity, often specialising in applied research relevant to regional industries – although overall capacity is still relatively limited.

Around 90 000 students enter Swedish universities and colleges each year. The overall number of students was nearly 35 0000 in 2014, compared to 150 000 in 1978 and around 30 000 in 1960 (Swedish Higher Education Authority [UKÄ], 2015a; OECD, 1964). Out of the total number of students in 2014, 42% studied law and social sciences, around 25% studied natural sciences and engineering, and a further 8% studied medicine. Currently, around 65 000 students graduate each year. Approximately 15 000 PhD students also study at Swedish universities, with nearly 3 000 graduating each year. PhD students are treated as university employees and financed mainly out of the research GUF stream. Due to their status and the high Swedish labour costs, they are more expensive than in most other countries. Natural sciences, medicine and engineering together account for approximately 75% of all PhD graduates (UKÄ, 2015a). For an extensive description of student numbers and structure, see also OECD (2013).

Swedish universities employ more than 50 000 FTEs, including administrative staff but excluding PhD students. Around 30 000 FTEs are research and teaching staff, compared to approximately 20 000 in 2000 and 25 000 over 2005-08 (UKÄ, 2015a).

Some 18% of the research and teaching FTEs are professors, 29% are senior lecturers, 18% are lecturers, 10% belong to the recently created category of "career and development positions", and 25% belong to "other categories" like researchers and research assistants (UKÄ, 2015a). The absolute and relative numbers (research/teaching compared to administration) have increased considerably in recent decades.

Three categories have seen particularly strong growth. Senior lecturers (more than 2 000 new positions – a 33% increase over the last 10 years), "other" positions (with PhDs) as well as the new career-development positions (over 2 000 new positions with fixed-term contracts). On the contrary, the number of less senior positions has decreased. Also in the last 10 years, more than 1 000 new professor positions have been created (UKÄ, 2015a). In general, the pipeline has become bigger and features more career-development and other post-doc positions, more senior lecturers and more professor positions. A recent VR report has nonetheless shown that in recent decades, PhD holders remaining at universities face less secure career paths, are more often employed in successive fixed-term contracts, and are promoted (including elevated to full professor status) later in their academic career (Vetenskapsrådet, 2015a).

3.3.2 Sources of funding for research

Across Europe, universities are mainly financed by the state, primarily through GUF (Lepori et al., 2007). In the last two or three decades, however, the share of TPF in university funding has increased in most countries.

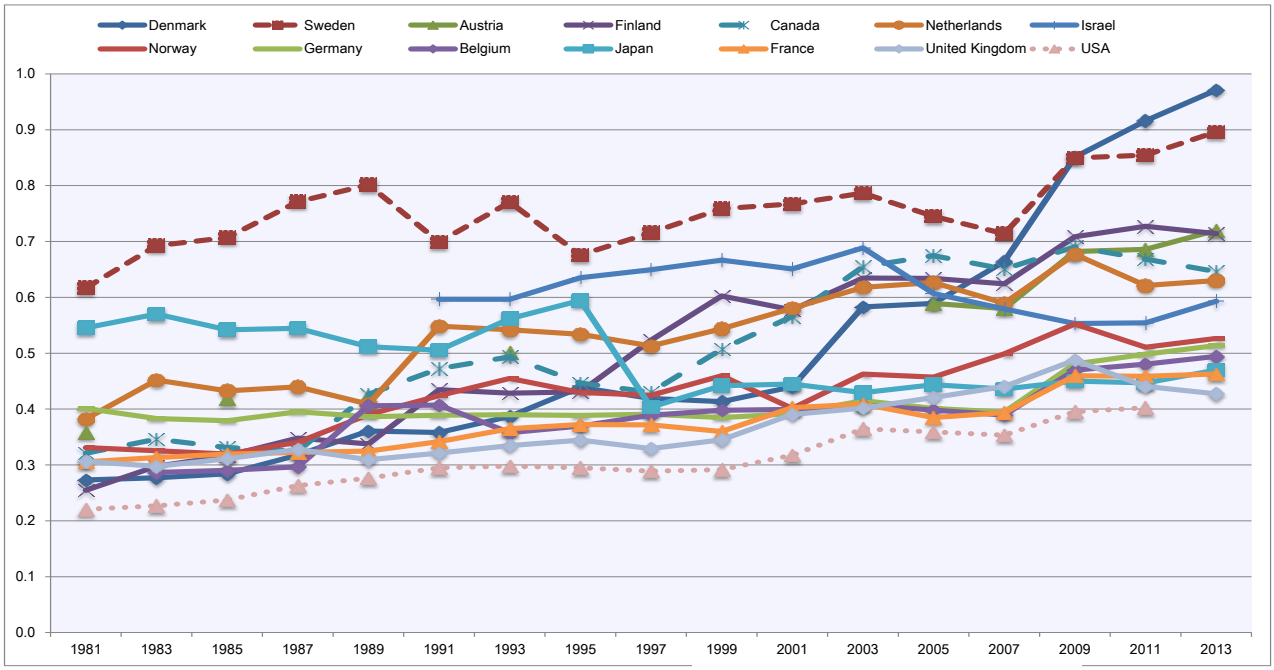
Total income from the HEI sector in Sweden grew until 2003, stagnated until 2008, then grew again to around SEK 65.5 billion in 2014 (UKÄ, 2015a). Until 2008, income streams for education and research either grew at the same rate or remained static. From 2008 to 2015, research income grew by 32%, from approximately SEK 30 billion to SEK 38 billion, while the education stream grew by only 4%, standing at SEK 25 billion in 2015 (UKÄ 2015a).[5]

The cautious implementation of performance-related funding follows a global trend, though countries employ a range of different instruments (Jongbloed, 2009; Auranen and Nieminen, 2010; Hicks, 2010; Hicks, 2012). Some apply indicator-based allocation models to varying proportions of GUF, while others use peer review at the core of their assessment exercise; both indicator- and peer review-based instruments involve retrospective analysis. A third group of countries uses forward-looking performance contracts, often in conjunction with indicator-based financing.

Even though the indicator-based system was introduced fairly recently in Sweden, an ongoing discussion is taking place about switching from indicator-based financing to a system based on peer review, similar in nature to the Research Assessment Exercise/Research Excellence Framework model in the United Kingdom. VR recently developed a model called Fokus (Research Quality Evaluation in Sweden) using expert panels to evaluate aspects such as scientific quality and impact outside academia (Vetenskapsrådet, 2014).

Figure 3.3 shows the growth of HERD as a percentage of GDP over time in a range of countries. Swedish spending on HERD has traditionally been high, ranking first in OECD comparisons until relatively recently. Only Denmark currently spends more as a proportion of GDP. The HERD/GDP ratio was relatively stable before 2008, but grew from 0.75% in 2008 to 0.9% in 2013 as a result of growing budgets – though it did not grow quickly enough to stop Denmark from overtaking Sweden in 2010 (OECD, 2015).

Figure 3.3. HERD as a percentage of GDP, 1981-2013



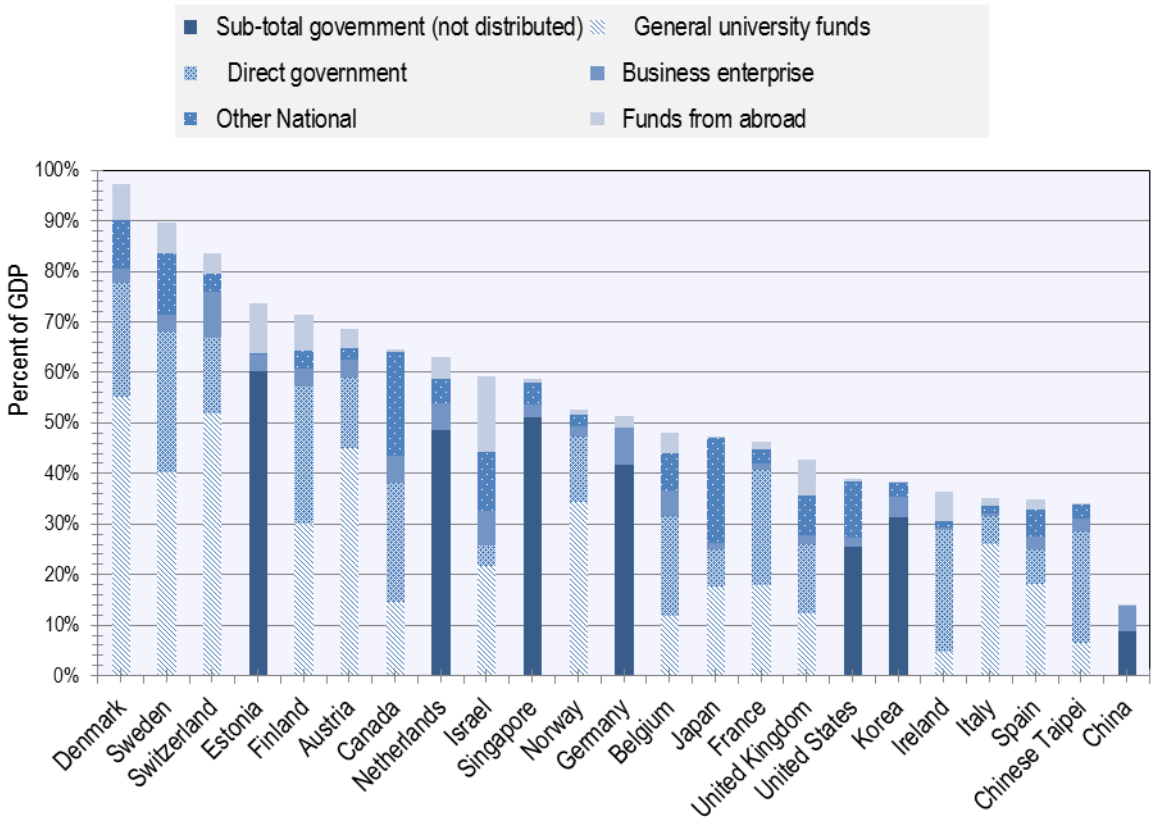
Source: OECD (2015), *Main Science and Technology Indicators 2014/2,* http://dx.doi.org/10.1787/msti-v2014-2-en.

As overall HERD has increased, the research component of both GUF and TPF have also increased. In 2014, GUF for research amounted to approximately SEK 17 billion, while VR and agency budgets accounted for a further SEK 10 billion out of the total HERD budget of SEK 38 billion. Taken together, they account for 71% of the total. Another SEK 2.6 billion comes from semi-public sources, such as the Swedish Foundation for Strategic Research (SSF) or the Knowledge Foundation (KKS), and the remainder from private sources, such as foundations, the EU and industry.

Figure 3.4 provides an international comparison of HERD funding sources. The share of TPF in HERD in Sweden has traditionally been high. In 2011, it amounted to 43% of all research and PhD income across the HEI sector (Swedish Government, 2012).[6] It can be much higher in some universities (e.g. 65% at KI). In comparison, Switzerland, Austria, Norway and Denmark for example have lower shares, while Finland and the United Kingdom have higher shares. The presence among the top handful of research-performing countries (in bibliometric terms) of countries with both high and low shares of TPF in the university funding mix makes it risky to attribute scientific success or failure to this ratio, especially as no wider body of statistical evidence exists to back up such a claim.

The wider literature is not especially conclusive with regard to the importance of structural factors in research performance. Aghion et al. (2010) provide evidence from the United States and Europe that strong, competitive settings (institutional- and project-based funding), combined with a high degree of autonomy, lead to higher research outputs. Auranen and Nieminen (2010) developed a model to test whether higher competitiveness in GUF and TPF allocation mechanisms leads to higher publication outputs and more efficient university system, but the results of the eight-country comparison do not unequivocally demonstrate this. Whatever the effects of structure, Sweden's scientific production efficiency (at least as seen through the narrow lens of the ratio of HERD to scientific articles) is lower than in other leading countries.

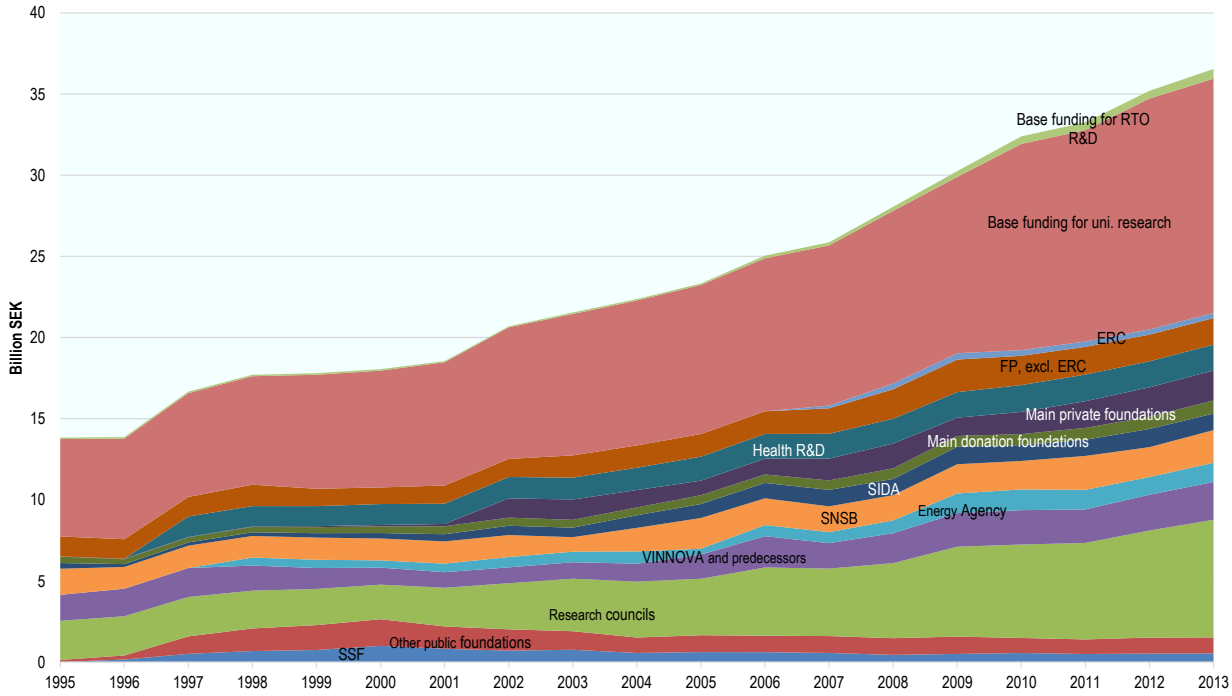
Figure 3.4. HERD funded by source in selected countries (2013)



Source: Joint OECD-Eurostat international data collection on resources devoted to Research and Development, http://dotstat.oecd.org/Index.aspx?DataSetCode=ONRD_FUNDS.

Figure 3.5 shows (in current prices) the increasing amounts of funding for R&D, innovation and demonstration available in the Swedish system since 1995. Overall funding, notably universities' institutional-research funding and funding made available by research councils, has increased rapidly in real terms.

Figure 3.5. Main sources of funding for R&D, innovation and demonstration available to Swedish actors

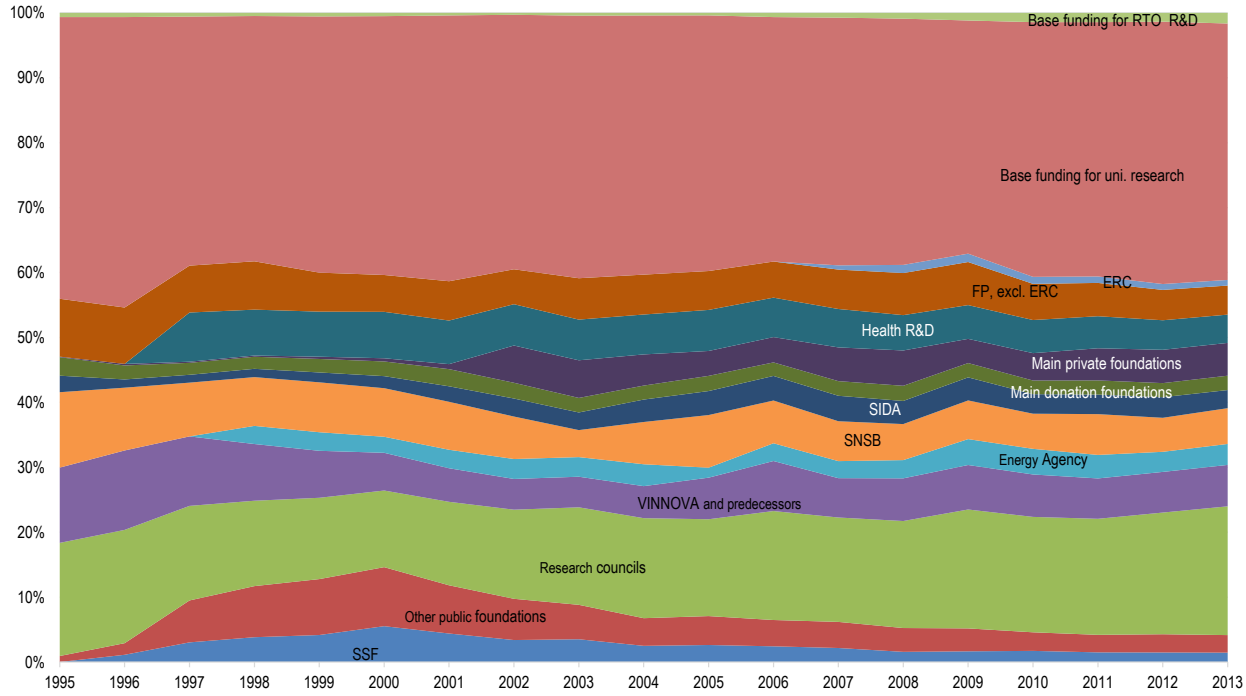


Sources: Annual reports, SCB national statistics, VINNOVA FP statistics and personal contacts. Cited from Åström et al (2014), *The Swedish Foundation for Strategic Research: An analysis of its impact and systemic role*.

Notes: Data are missing for the fund-based foundations before 2001; coverage of private foundations is incomplete. SNSB and SIDA funding include some amounts spent abroad.

Figure 3.6 shows the shares of competitive funding available, excluding institutional research funding to universities and RTOs. It shows that the contribution of the EU Framework Programme to total competitive funding is very substantial, standing at about 10% of the total. Private research-funding foundations are equally substantial contributors. The Swedish Space Agency (SNSB) has been a fairly significant funder throughout the period. Over time, the importance of the research councils has increased, while that of VINNOVA and its predecessors has fallen. Public foundations (i.e. the wage-earner funds) were very significant in their earlier years, but their share of total funding is falling as their funds are consumed.[7]

Figure 3.6. Shares of external, competitive funding for R&D, innovation and demonstration



Sources: Annual reports, SCB national statistics, VINNOVA FP statistics and personal contacts. Cited from Åström et al. (2014), *The Swedish Foundation for Strategic Research: An analysis of its impact and systemic role*.

Note: Data are missing for the fund-based foundations before 2001 and that the coverage of the private foundations is incomplete.

The Swedish wage-earner funds present a particular problem for policy, in that government cannot instruct them. Reductions in the "VINNOVA" line in Figure 3.6 were partly compensated by a transfer of responsibility for a number of strategic technologies (and, indeed, personnel) from NUTEK Teknik to SSF in the mid-1990s. This was a political compromise, in which the government effectively persuaded the Foundation to take on these technologies by cutting related funding at NUTEK. While SSF was able to provide considerable amounts of money for these technologies in its first decade, its spending power is declining as its fund is consumed. As the state, through VINNOVA, has not taken back responsibility for these technologies, it is argued that a funding gap is opening up in relation to certain enabling technologies in Sweden, which the state needs to address (Åström et al., 2014). At the same time, VINNOVA has reduced its focus on technology programmes, putting the emphasis instead on developing the innovation system and its actors, as well as developing and exploiting technology, arguably further widening the technology funding gap.

University researchers in Sweden can apply for funds from many sources of TPF. The 2012 OECD review of Swedish innovation policy describes nearly 20 large and mid-sized funding organisations (OECD, 2013). Supporting research is the main mission of some of these organisations. For others, research is funded in support of their main mission. As noted earlier, TPF sources have grown significantly in recent years. Table 3.2 tracks the development of some of the major sources by comparing the funds available in 2007 and 2014. Over this period, TPF growth was even stronger than GUF growth for research.

Table 3.2. GUF and TPF sources for research, 2007 and 2014, million SEK

Source	2007	2014	Comments
Total university research income[8]	25 410	38 041	
GUF	11 826	16 932	Funding for universities only
Grants	10 250	17 291	
Contract research	1 773	1 600	Stagnating, low in international comparison
of which SWE industry	*411*	*686*	Low in international comparison
VR	2 238	4 460	
FORTE	268	438	
FORMAS	485	933	
VINNOVA (funds to universities only)	498	902	About 40% of overall VINNOVA budget
STEM (energy)	293[9]	651	
Space Board	47	81	
SIDA	316	160	
KKS, SSF, MISTRA	870	1,039	All semi-public foundations; stock market important
Swedish Cancer Society	272	354	
Riksbanken (RJ)	129	241	
Wallenberg (KAW)	317	961	
Other private foundations	1 181	1 780	All other private foundations

Source: VINNOVA compilation of UVÄ data (2015).

There are at least three historical drivers of this funding heterogeneity:

- The Swedish model addressing "sector" research needs means that Sweden maintains very few government laboratories compared with other countries. Instead, a number of ministries maintain funding organisations that commission sector-related research on a competitive basis, largely from the universities.[10]

- The wage-earner funds provide funding that in other countries would come from the state. Their particular history means that they have (deliberately) been set up in a way that prevents the state from absorbing them.

- For cultural and historical reasons, Sweden has a very large private foundation sector. Its roots stem from the same tradition as late-19th century industrial philanthropy, which shaped the US funding landscape. This culture seems to be very much alive, prompting the founders of some growing Swedish companies to also establish foundations.

The proportion of the overall effort dedicated to innovation is small compared with some other countries. VINNOVA, for example, has less than half of the budget of equivalent agencies, such as the Austria's Research Promotion Agency (Österreichische Forschungsförderungsgesellschaft, FFG) and Finland's TEKES.

The major third-party funder is VR, which focuses on investigator-initiated or "bottom-up" research, which is generally regarded as "basic". The proportion of the total funding available for basic research, however, is somewhat larger. While they were given a sector-funding mission, Formas and FAS/FORTE have seen the importance of funding for academic basic research grows over time (SOU, 2008). An earlier evaluation of the Energy Agency's research goals over from the mid-1970s to the early 2000s found a marked drift from applied research and demonstration towards basic research (Arnold et al., 2003), showing that sector funders also tend to fund some basic research. Many private research foundations also focus on basic research.

The 2012 *Review* (OECD, 2013) raised the question of whether 20 or so research funders were too many. This multiplicity has its roots in some Swedish specificities that make the Swedish TPF system only partly comparable to TPF systems abroad. The Review posed the legitimate question of whether the fragmentation encourages the Swedish tendency to use small funding instruments, which may hinder building up critical mass compared to some systems abroad. It is also noticeable that funders jointly run some research programmes in response to challenges that cut across their areas of responsibility. When taking into account the growing importance of societal challenges in research and innovation policy, it is legitimate to ask whether some of these multiple funders could and should be merged. Particular potential to do so may exist among the sector funders, so as to provide a more co-ordinated approach to societal challenges.

The systemic view of Figure 3.1 shows that research funding from the GUF and TPF interact implicitly. Two main types of interaction play a role in forming university strategy. First, the VINNOVA "triple helix" funding model requires co-funding from its beneficiaries. With centre funding, it typically expects its contribution to be matched by both universities and industry, so that each "pays" one third of the costs. In other programmes, industry normally provides the matching contribution. To a large extent, the academic and industrial contributions are in kind rather than in cash, however. From the university perspective, this is a particularly explicit case where TPF effectively binds up part of institutional research funding.

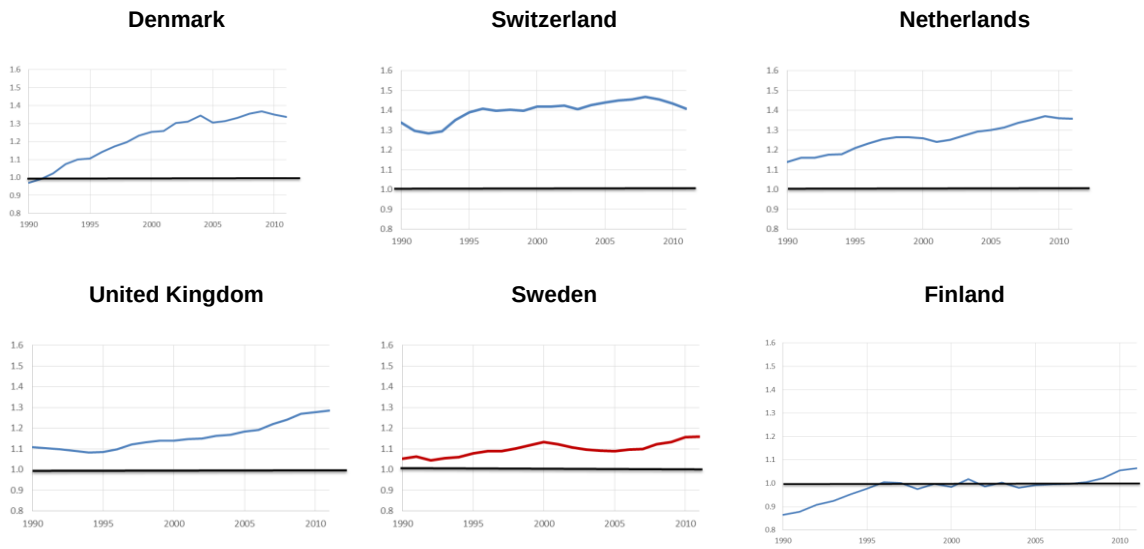
The second interaction between the GUF and TPF comes through employment. Like a number of other countries, Sweden uses a mixture of GUF and TPF to fund permanent university faculty. This imposes a constant burden on academics to obtain TPF, eliciting many complaints – particularly relative to the fact that increased GUF is needed in order to reduce reliance on TPF. However, the reality of universities' expansion of recent decades is that they have hired additional faculty on the same basis. Hence, each increase in GUF triggers increased demand for TPF, and GUF increases perpetuate – rather than mitigate – the perceived problem of over-dependence on TPF. The analysis of the SFOs in this chapter provides a further example of this mechanism in operation.

3.3.3 Performance from an international perspective

Sweden has a longstanding scientific tradition and has contributed disproportionally much to progress in a number of scientific fields, including biomedical research. It has long been seen as a leading science nation. From the perspective of both local and international observers, high Swedish spending on science and research has generated high levels of output and quality.

This perception has changed in the last decade, when Swedish research output and impact has tended to stagnate,[11] while that of other small countries has improved. In Europe, Switzerland, Denmark and the Netherlands now perform better in terms of indicators such as publication outputs and average, as well as top-level citation impacts (Karlsson and Persson, 2012). The average annual growth rates in Swedish-authored scientific articles among the 1% and the 10% most cited articles (see Figure 3.7) is much lower than in all comparator countries. Further, Swedish universities have a relatively low proportion of highly successful subject fields, which also appear to yield comparatively few top publications (OECD, 2013). Overall, in terms of these bibliometric indicators (which of course are not the only possible ones and which contain well-known imperfections), the system produces a lot of good research, but not enough excellent research at the highest levels. More research is needed, going well beyond bibliometrics, in order to explain the causes and dynamics of Sweden's relative performance.

Figure 3.7. Top 10% citation rate performance of Sweden and comparator countries

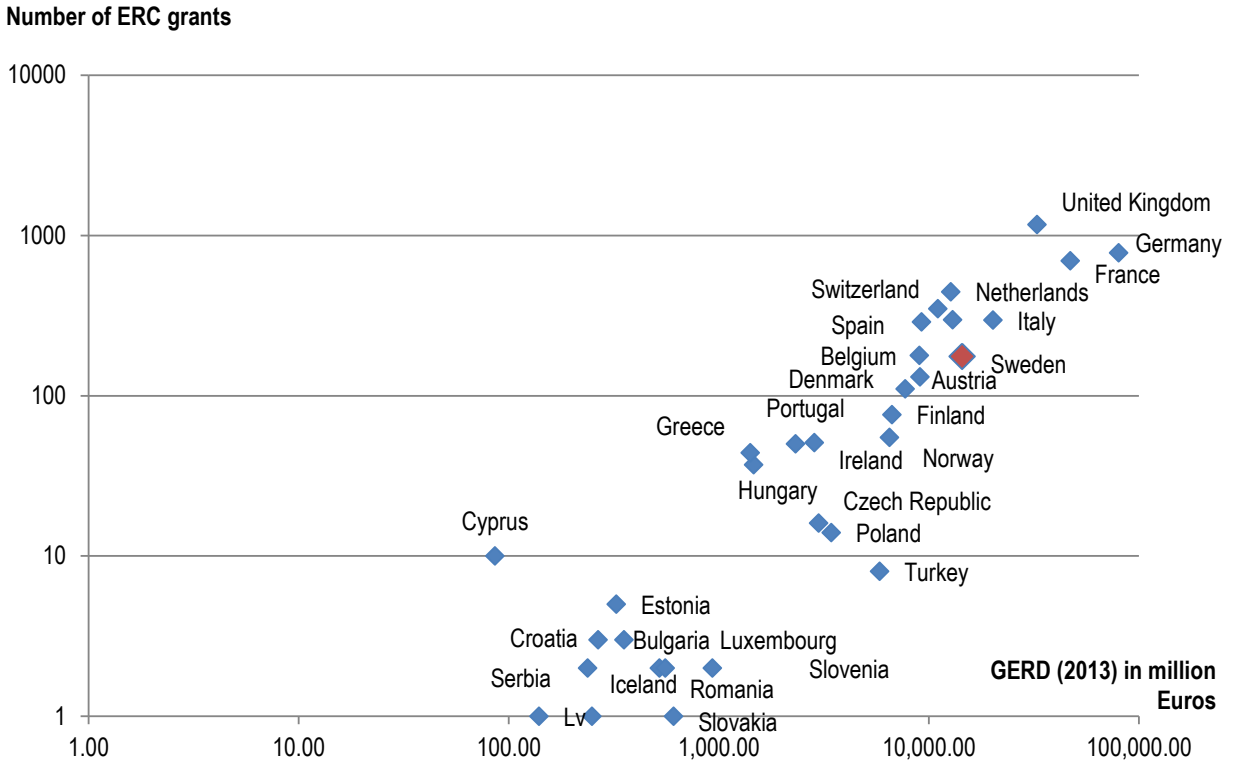


Source: Öquist and Benner (2012), Fostering breakthrough Research: A comparative study.

Note: Production of highly cited papers; development of the top 10 %-index between 1990 and 2011 for Sweden and the 5 reference countries. The curves are based on three-year moving averages.

Another widely used indicator of top-level researcher performance is success in obtaining European Research Council (ERC) grants. Relative to the national researcher population or the number of applicants, Sweden's performance is solid, but not outstanding. Figure 3.8 indicates that Sweden's returns from the ERC relative to the national R&D effort input are about what could be expected, but no better.

Figure 3.8. GERD and ERC grants by current host country, 2007-13



Source: ERC database of ERC funding activities, available at https://erc.europa.eu/projects-and-results/statistics; OECD (2015), *Main Science and Technology Indicators 2014/2,* http://dx.doi.org/10.1787/msti-v2014-2-en.

Öquist and Benner (2012) have argued that the performance gap is due to variations in forms of university governance and behaviour in different countries. They claim that three reasons explain the "relatively slack" performance in breakthrough or top-class science: (i) priority setting at national level; (ii) direction and funding of research; (iii) defective university governance. They argue that unlike Denmark, the Netherlands and above all Switzerland– which contribute more strongly to the most-cited small percentage of scientific articles – Sweden fails to focus on top-class science or nurture top talent. In other words, funding is insufficiently skewed to allow excellent research groups to emerge and accumulate enough resources to build strong positions in international research competition. This argument was taken up in the 2012 Research Bill (Swedish Government, 2012).[12]

Methodologically, the 2012 analysis has been criticised as lacking input-output comparisons across the comparator countries and failing to consider the relative importance of variables such as career or funding systems (Sandström and Heyman, 2015). However, the alternative explanatory approach suggested by these authors does not put Sweden in a leading position either. More recent analysis (Vetenskapsradet, 2015b) shows that Swedish scientific outputs have grown over the last few years, but that the gap between Sweden and the comparator countries is still considerable.

3.4 SFOs in focus

The intention behind the SFO programme was simultaneously to increase the proportion of institutional research funding in universities' funding mix and strengthen university research in areas of strategic relevance to Sweden.

3.4.1 Implementation

At the qualitative level, the experience of the SFO programme supports the idea that the connection between GUF and research performance (and hence the use of resources, prioritisation, etc.) is strongly mediated by governance.

The government gave VR the lead role in implementing the SFO programme,[13] supported by the Swedish Energy Agency, Formas and VINNOVA, based on these agencies' fields of thematic expertise.[14] The programme would in principle grant two awards per theme. Universities could apply (alone or in partnership with others) to as many themes as they desired. While they could not lead more than one application per theme, they were free to be partners in any and every application, forcing them in their applications strategies[15] to trade off their potential share of income to eliminate potentially dangerous competitors by partnering with them. Research institutes could apply as partners; companies and state agencies could also be partners, but could not receive any funding. Universities would receive the money awarded as increments to their institutional funding. The three formal assessment criteria set out in the 2012 Bill were potential for high quality, relevance to societal problems and relevance to industry.

The number and focus of university SFO applications varied. Unsurprisingly, the larger research universities receiving large amounts of institutional research funding submitted the greatest numbers of applications. Nevertheless, the number of applications per unit of institutional funding varies widely among universities suggesting that strategy was a key determinant in their use of the SFO scheme (Table 3.3). Success rates were also very different, at least partly reflecting differences in the way individual universities approached the SFO application process, with some submitting large numbers of applications and others taking a more focused approach.

Table 3.3. SFO applications and success rates

Consortium leader	Acronym	No. of applic-ations	No. of successful applic-ations	Success rate	Share of leader-ships	Applications per MSEK institutional funds
Lund University	LU	16	9	56%	21%	0.0083
Uppsala University	UU	12	7	58%	16%	0.0062
Karolinska Institute	KI	7	6	86%	14%	0.0048
Chalmers University of Technology	CTH	8	5	63%	12%	0.0098
Royal Institute of Technology	KTH	8	5	63%	12%	0.0058
Linköping University	LiU	11	3	27%	7%	0.0137
Stockholm University	SU	5	3	60%	7%	0.0033
Umeå University	UmU	6	2	33%	5%	0.0058
Gothenburg University	GU	12	1	8%	2%	0.0083
Lund University of Technology	LTH	6	1	17%	2%	0.0170
Swedish University of Agriculture	SLU	4	1	25%	2%	0.0048
Defence College	FHS	1	0	0%	0%	0.1083
Skövde College	HS	1	0	0%	0%	n.d.
Borås College	HB	1	0	0%	0%	n.d.
Jönköping College	HJ	4	0	0%	0%	n.d.
Kristianstad College	HK	3	0	0%	0%	n.d.
Mid-Sweden University	MIU	2	0	0%	0%	n.d.
Södertörn College	SH	1	0	0%	0%	n.d.

Source: VR.

Overall, the lead partners received 76% of the resources. Analysis of the individual grants shows that most partner universities were consigned to minor roles (Swedish Research Council, 2015), with the exceptions of four SFOs that engaged in significant facilities-sharing.

While individual SFO grants are not large by international standards, total SFO funding is sharply skewed towards large, traditional universities. With 16% of total SFO funds, LU was the largest beneficiary. The top three together – LU, CTH and KI – took 45%; the top six took 77%.

Table 3.4 shows how universities' SFO grants compare with their institutional funding for higher education and research. The proportion of institutional research funding to total institutional funding is just under one-half,; the new regional universities and colleges are much less research-intensive than traditional universities. KI is an outlier in the other direction: its main business is research, which represents 70% of total institutional funding. Overall, SFO money increased universities' total institutional funding for research by 8%. Those with greater increases were generally the established research universities, though CTH earned a disproportionally high increase – as did FHS – from a very small base.

Table 3.4. Universities' institutional and SFO grants, 2013

	Basic grant for education (MSEK)	Basic grant for research (MSEK)	Research/total basic grant)	SFO grant (MSEK)	SFO/Basic research grant
BTH	267	86	24%	2	2%
CTH	807	817	50%	177	22%
Fhs	24	9	28%	2	23%
GU	1,872	1,453	44%	44	3%
Hh	362	56	13%	2	3%
KaU	581	201	26%	2	1%
KI	616	1,460	70%	164	11%
KTH	1,033	1,371	57%	151	11%
LiU	1,354	800	37%	65	8%
LnU	976	284	23%	3	1%
LTU	625	353	36%	44	12%
LU	1,840	1,926	51%	184	10%
Mdh	569	84	13%	5	6%
SLU*	861	833	49%	36	4%
SU	1,563	1,520	49%	87	6%
UmU	1,236	1,035	46%	58	6%
UU	1,523	1,943	56%	131	7%
Overall	**16,107**	**14,232**	**47%**	**1,156**	**8%**

Source: VR.

3.4.2 University strategies and success in the SFO scheme

In principle, the SFOs provide an unusual opportunity for universities to implement thematic strategies, since it is almost always easier to induce change when adding resources than when terminating old activities to fund new ones. The SFO evaluation (Swedish Research Council, 2015) suggests variations both in university management's ability to address the SFO opportunity through an overall institutional strategy and whether it was effectively obliged to let the faculties and departments select the SFO topics they would pursue. Table 3.5 summarises the evaluation's findings about the extent to which university management was able to steer the pattern of SFO applications to ensure consistency with a broader university strategy, based on interviews with university management.

Since universities – not individual researchers – who submitted SFO applications, they all had to be signed off by top university management. Table 3.5 summarises the real power of top management, as suggested in the interviews, as opposed to its formal power. Naturally, the universities generally tended to apply for SFOs in their areas of strength, irrespective of whether they had a wider thematic strategy; to do otherwise would more or less guarantee failure. But the extent to which they made strategic use of the competition differed considerably. The most successful universities – CTH, KI and KTH, all strong specialised universities, dealing with technology or medicine – closely linked SFO applications and strategy. At the other extreme, top management at the least successful applicant – GU, a full-range university (though without an engineering school) – was liberal in allowing research groups to apply. The other strong traditional universities – LU, SU and UU – were able to achieve success rates around 50%,

based on their established academic strengths. Overall, among the major beneficiaries, the SFOs seem to have fed into existing strengths, but only triggered changes in direction in the few cases where top management had an established change strategy.

Table 3.5. Success rates in applications for SFO leaderships and role of university management and strategy in determining SFO applications

University	Applications (Successes)	Success rate	Remarks
CTH	8(5)	63%	Used SFOs to strengthen "areas of advance" identified in new university strategy.
GU	12(1)	8%	Had no thematic prioritisation or restriction on researchers' freedom to apply.
KI	7(6)	86%	Applied for SFOs within the defined pillars of strength at KI
LiU	11(3)	27%	Used SFOs to support two strong areas and build a new interdisciplinary area.
LTH	6(1)	17%	SFOs reflect strength of applying groups/departments.
LU	16(9)	56%	SFOs are consistent with University's 29 thematic priorities; focused on collaborations with other universities.
KTH	8(5)	63%	SFOs treated as additional project funding for existing thematic pillars at KTH. Funds will be reallocated after five years.
SU	5(3)	60%	Used SFOs to strengthen existing groups, especially cross-faculty groups.
SLU	4(1)	25%	SFO proposals were selected by top management, consistent with SLU thematic strategy.
UmU	6(2)	33%	Only applied for SFOs in areas of existing strength selected by top management.
UU	12(7)	56%	University strategy had no thematic priorities. Top management selected SFO applications in areas identified as strong by a recent evaluation of UU.

Note: Italicised universities are those where the evaluation shows top management to have played a decisive role in choosing which SFO leaderships to apply for.

3.4.3 Results of the SFO evaluation

The 2008 Research Bill stated that the SFOs should be evaluated after five years, and that resources could be transferred as a result from some research performers to others (FP 2008/09:50), though this did not occur in practice.

The Swedish Research Council organised the evaluation in 2014, supported by the other funding agencies involved. The terms of reference required answering five questions:

- How has the research been planned and steered ("strategic management")?
- What are the quality, results and effects of the research?
- What has been the strategic significance of the initiative for society and for the business sector?
- What is the state of collaboration between the universities and with other stakeholders?

- What is the state of the link between strategic research and education?

A full 28 national and international peer reviewers assessed the quality and other technical aspects of the performance of individual SFOs, based on their self-evaluations and bibliometric data. An international expert panel then addressed the universities' performance based on the peer reviews, self-assessments, and interviews with university and SFO management.

The panel concluded that the scheme was "an excellent and original initiative from the Swedish government", but that in line with the terms of reference, it focused on the performance of the funded universities and SFOs, rather than on evaluating the relevance and effects of the SFO initiative itself. The panel held that about one-third of the SFOs were reaching their quality objectives, one-fifth were operating below par (in terms both of quality and strategy), and the balance appeared to be growing and improving. In principle, SFO funding allowed the universities to take greater risks in research than would have been the case with normal project funding, but the evaluation did not find practical examples of this. While the 2008 Research Bill clearly explained that SFO funding would become incremental to universities' institutional research funding after five years, university and SFO managements appeared uncertain that these resources would remain in place.

As the panel noted, the large number of SFOs meant that the funding received was modest compared with centre initiatives in many other countries. The universities used much of the money to recruit (largely junior staff, but in some cases also selectively acquiring more senior personnel); other major uses of funding were doctoral programmes and research equipment. Universities often contributed additional internal resources, but the greatest effects were where SFO applications had been guided by university strategy. Researchers and managers generally confirmed that the SFO resources would likely have been more widely dissipated across the university had they not been tied to specific themes, but instead given as un-earmarked increases in institutional funding. Universities generally expected that they would largely use the increased funding in the same thematic areas, provided the increase in institutional funding was maintained after the first five years. Some responses indicated, however, that the focus would likely dissipate over time.

In practice, the tendency to use most of the funding to recruit permanent staff would of course make it difficult for universities to redirect the resources away from SFO priorities in the short term. As with earlier increases in institutional funding, the institutional response was therefore to "lock in" the new resources by hiring people, with the consequence that – like other Swedish university researchers – these new hires would have to seek external funding very actively. Only KI and UmU intended to use the resources to reduce the pressure on researchers to obtain external research funds.

The SFOs were not wholly in existing strong fields, although most were. While the bulk of the SFOs funded "more of the same", the care sciences, mining and security were areas where the SFOs acted as change agents, potentially altering the shape of Swedish university specialisation.

The SFOs clearly encouraged collaboration, both within and among the Swedish universities. However, the evaluation panel was disappointed at how little effect they had had on international collaboration – presumably because the scheme did not provide any specific incentives promoting international co-operation, either for Swedish researchers or foreign partners. A further weakness was that while the SFOs tended to increase doctoral recruitment, they had little or no effect on undergraduate education.

The SFO evaluation panel found "surprisingly little evidence of the creation of systematic processes to promote innovation in the SFOs". The universities that already worked closely with industry had good practice, and a few SFOs had set up joint academic-industry boards to promote links. By their nature, the

care sciences need close contact with patients and health authorities, so the three SFOs in that field were well connected to users. Overall, however, the panel found the link to innovation disappointing. This is not altogether surprising, given the lack of any requirement for user involvement in governance, funding or active research in the SFOs.

3.5 Assessment

The type of funding system illustrated in Figure 3.1 is more or less a requirement in a research and innovation system where research performers (e.g. the universities) are autonomous. That autonomy has historical roots in the need for universities to be able to disagree safely with the state and the Crown, but is also anchored in some of the thinking behind the new public management movement. Autonomous and intelligent agents are better placed than central authority to find their way and execute their mission in complex circumstances where the state of knowledge is uncertain or changing. The agent's closeness to relevant facts and possession of expertise are key enabling factors; a considerable degree of autonomy is necessary to exploit these strengths.

The corollary is that the agents – in this case, the universities – require high levels of strategic competence and flexibility to perform their tasks. Without this, they under-serve their internal objectives of teaching, research and sharing knowledge with the rest of society; they also become unresponsive to the behaviour and need signals the funding system provides on behalf of wider society. This section identifies a number of weaknesses in university organisation and governance, as well as in the wider incentive system and overall funding policy. Rectifying these weaknesses would likely improve the performance of a good – but not good enough – research system.

3.5.1 The universities

The internal structures and culture of the major Swedish universities are strongly bottom-up: university leadership appears to have relatively low control over (top) recruitments, career structures, allocation streams and thematic portfolio development. Recruitment practices and career structures also offer opportunities for improvement.

The SFO experience supports the conclusions in OECD (2013) that "… Swedish universities are rather decentralised organisations and their leadership is not comparable to that of some Swiss or American counterparts … university leadership seems to have limited control over research allocations … The governance of universities seems to come from … departments, from many strong individuals and from a chorus of outside (funding and social) institutions …". An analysis of the long-term performance of Sweden (and Swedish universities) in the EU Framework Programmes reaches similar conclusions (Arnold et al., 2008). Öquist and Benner (2012) state that in-house quality control is underdeveloped and that "… faculty resources are distributed in relation to the universities' capacity to attract external funding[16] … [and] their leaders' work has changed towards administering assorted functions (management) rather than exercising genuine academic renewal (leadership)." This contrasts unfavourably with Dutch, Swiss and Danish university governance.

The capacity of university leadership to make strategic thematic or funding decisions has nonetheless grown over the last few years. While the manner in which universities actually use the GUF and performance-related funding is under-documented, the key study (Fridholm and Melin, 2012) indicates that:

- The education ministry's overall allocation to universities of GUF for research is historically driven. One consequence is that the oldest universities receive disproportionately more funds relative to their size than newer universities, particularly young regional universities and colleges.

- Increased GUF allocations are sometimes used for implementing strategic projects – typically infrastructure – and (to some extent) setting new thematic directions.

- Both the overall GUF for research and the performance-based element are allocated at the overall university level and then more finely allocated within faculties.

- Universities are increasingly performing their own internal research-assessment exercises, which tend to have a greater effect on their behaviour than the national performance-based system for reallocating GUF.

The above suggests that universities' ability to deal strategically with GUF-related resources is improving, albeit variably. The SFO experience was that the universities with a clear established strategy were the more successful with their proposals.

Many observers see the lack of clear and comprehensive career models as one of the greatest shortcomings of the Swedish university system. The lack of a comprehensive tenure-track model and the strong role of TPF success means that there are many short-term positions, as well as a need for even researchers holding permanent positions to fund part of the own salaries through TPF. Both a tenure model and a clearly designed post-doc phase are needed. In addition, Swedish universities employ a much higher percentage of faculty members with a PhD from their own university than their homologues in a number of comparator countries (Aghion et al., 2008; Franzoni, Scellato and Stephan, 2012).

Öquist and Benner (2012) argue that this weak career path leads to weaknesses in nurturing top talent at the universities. Although the opportunities for younger researchers have improved through a number of recent TPF young researcher programmes (by the ERC, SSF and VR), these still leave both junior and senior people overly dependent on external funding for their salaries. In addition to an improved career path, the authors claim that there is a need for selected top recruitments from abroad – a policy that was introduced in the 2012 Research Bill and is being implemented with funding from VR. Little evidence exists so far that universities are seeking to do this from their existing resources.

A key problem remains the interdependence of GUF and TPF, which generates an inflationary spiral of expansion rather than concentration.

3.5.2 GUF for research

The literature contains a great deal of discussion on the preconditions for successful scientific research. Case-study work by Heinze et al. (2009) and Laudel (2006) suggests that adequate levels of institutional funding should be made available to individual researchers on a flexible basis to facilitate creative research. These funds are partly needed to compensate for the risk-averseness of peer-reviewed funding, which tends to use conservative judgements in assessing proposals, thereby discouraging exploratory work (Heinze, 2008).

The GUF increases in the 2008 and 2012 bills offered the prospect of improved research performance and a rebalancing of a system strongly reliant on medium-sized TPF projects.[17] The increases were also accompanied by new incentives for recruiting high-quality international researchers, as well as new forms of TPF initiative. The SSF, VR and – at the European level, ERC – programmes offering funding to top-class (younger) individuals were specially important(Hallonsten and Hugander, 2014).

The additional indicator-based GUF allocation was expected to stimulate the search for competitive advantage (Swedish Government, 2008), leading to a more explicit differentiation of roles and thematic specialisation among HEIs. There is little evidence this goal was achieved. The largest part of the

additional GUF appears to have fed into existing activities and fields; it was also used for additional recruitments within existing groups fields, and often followed or matched TPF inflow in universities. Few signs point to meaningful reallocations among universities yet; if any strategic clustering or specialisation has occurred in the past few years, it was more likely in response to SFO funding or large TPF grants than to changes in the GUF.

The 2012 Bill proposed a further addition to the additional GUF funding for research introduced in the 2008 Bill, but advocated some patience before the desired potential impacts could show up in statistics and evaluations. In this context, the 2015 VR report on Swedish research outputs claims that "Swedish higher education institutions are exhibiting strong growth in production [of scientific publications]. …. The findings show that the implementation of the 2009 resource allocation model has made an impact" (Vetenskapsradet, 2015b7). It adds that "In spite of large increases with respect to both the number of articles and the number of citations between 2000 and 2011, the productivity of the system as a whole has fallen slightly over the period, when using cost per article and costs per normalized citation as measurements."

To date,limited evidence therefore exists of the desired structural changes in the university sector. The effects on performance of increased GUF for research are at best uncertain. They appear to be significantly impeded by the limited (if improving) ability of university leadership to design and implement strong strategies, as well as by its failure to disconnect the use of GUF for research from TPF. Until these strategic capabilities are improved and the cycle of interdependence between GUF and TPF is broken, increasing GUF for research is unlikely to have a commensurate impact on overall research performance.

The international evidence on the effects of performance-related funding schemes is limited, but experience of the longest-standing system (in the United Kingdom) suggests that it is not so much the amount of GUF steered by the PRFS as its effects on individual researchers' careers that determines the effects of the system. The UK system also comes with a number of health warnings about unexpected or undesirable effects, such as reduced scientific innovation, co-operation, interdisciplinarity and diversity (in the sense of the presence of heterodox approaches) (Martin, 2011).

3.5.3 Third-party funding (TPF)

TPF is most powerful as a policy instrument in the presence of strong, autonomous institutions able to make choices about which external incentives to accept and how to balance these external impulses against the institutional strategy. If the institutions are too strong, TPF does not steer the system enough to address societal needs. If they are too weak, the risk is that TPF will over-steer the system.

The TPF landscape supporting the Swedish model of universities' role in society in Sweden is heavily populated (see Section 3.3.2). An apparent consequence is that grants are (by international standards) at best "medium-sized", potentially limiting their effects on structure and specialisation, and perhaps even on international competitiveness. This issue could be tackled through re-organisation, adjusting funders' internal prioritisations or further co-operation. For the time being, however, it does seem to limit the ability of TPF to balance some of the strategic inertia in the university system.

VR is the largest of the TPF organisations. The (now rather old) evaluation evidence suggests that its academic governance makes it hard for the organisation to act as a change agent (e.g. in the same manner as the National Science Foundation in the United States). As there has been no change in governance and little change in policy, VR will likely continue to reinforce rather than help change the structure of the science structure. International experience implies that decoupling its governance from the academic community, even to a modest extent, would free it to be a counterweight to the universities, and therefore

more actively promote the desired excellence in the research system. Until this happens, it will likely remain captive to the conservatism typical of funders that are governed by their beneficiaries.

TPF providers appear to offer greater opportunities for co-ordination. One clear problem identified in the recent impact study of the SSF (Åström et al., 2014) is the partial decoupling from the state funding system of research policy relating to strategic and enabling technologies. As the Foundation's capital dwindles, so the resulting funding gap grows. The study argues that the state will soon need to assume responsibility once again for this component of the research-funding portfolio. More generally, inadequate co-ordination across the funding system leaves it liable to undesirable gaps.

A second, wider co-ordination problem is that the diverse nature of sector funders may impede the development of programmes and policies addressing the societal challenges. The example of the Research Council of Norway shows that it is possible to programme basic, applied and innovation research together – something that has long been important to industrial innovation, but becomes even more important in relation to societal challenges. While the Council's very unusual form of organisation would not an obvious match for the much larger Swedish system, the need to co-ordinate and co-programme should be tackled – both because such horizontal co-ordination is necessary to address the societal challenges, and to provide definite signals and incentives the university system can address.

3.5.4 SFOs

The SFO instrument addresses both the government's desire to increase the quality and capacity of the Swedish research system in strategically important areas and the perceived need to increase universities' institutional funding. While most thematic or programmed funding provides signals and incentives for orienting the universities' work in specific directions, this funding is external and by nature, temporary. The SFOs give the universities the means and the option to continue to institutionalise the SFO priorities through permanent appointments and establishing or strengthening individual research groups. Not only does this generate an unusual opportunity (always assuming that the SFO priorities remain relevant over the long run), it also allows universities in the longer term to embed the new institutional resources within their "business as usual" internal allocation schemes. Whether the way these resources are then used continues to have social relevance depends on the individual university's wider strategic capabilities.

At first impression, the scheme appears to suffer from goal overload, related to its long list of goals (e.g. specialisation, building capacity, excellence, collaboration, increased risk-taking, affecting education and generating social impacts) across 20 areas and 43 consortia. The large number of areas also means that like many other Swedish schemes, the SFO scheme allocates rather small amounts of resources at the project level. The average SFO consortium receives SEK 105 million from the scheme over a five-year period. While this not a trivial sum, neither is it large, and the scheme asks a great deal in return.

The 2008 Research Bill argued that the short-termism of much of the existing research funding system impeded universities from developing long-term strategies. The SFO experience suggests the opposite, namely that universities with longer-term strategies are better equipped to exploit funding opportunities than others. Clearly, the balance of funding opportunities available to research-performing organisations will affect what they can do, but an ability to make and implement strategies, and to change course, is a necessary (but not sufficient) condition for robust universities to evolve alongside shifting needs and opportunities.

A related idea is that the long-term nature of SFO funding would enable universities to do riskier research. The evidence does not clearly confirm or refute this hypothesis, nor does it show whether longer-term funding from a five-year SFO linked to institutional funding, or a ten-year competence or excellence centre that provides external funding, enables greater risk-taking. However, a strong consensus exists that

peer review-based project funding tends to be conservative, leading to both debate and experimentation among funders about how to fund high-risk, interdisciplinary or "transformative" research. Under the circumstances, funding systems would do well to offer both short- and long-term funding opportunities. The growing body of evidence suggesting that performance-based institutional research funding can discourage risk-taking and diversity in research should also be taken into account – otherwise both project and institutional funding may accidentally conspire to encourage unadventurous and uninteresting research.

The universities' tendency to use SFO money for recruitment purposes is understandable in the short term. It increases research capacity in the relevant strategic research area and obligates the university to maintain that capacity, because it is difficult to fire people. Yet increasing the number of researchers who need funding does not help resolve the research community's belief that it is over-dependent on external funding. Both the earlier expansions of the higher education system and the reform that increased the number of professors contributed to this problem. Clearly, additional institutional funding will not solve it if the money simply goes to increasing the number of researchers. A more fundamental change is required in career paths and universities' basis for internal allocation of institutional funding.

Another key objective of the SFO scheme was to build areas of research strength and specialisation in Sweden. Inherently, such a scheme can add, but not subtract, resources. In the final analysis (and given their autonomy) only the universities themselves can decide which activity they should discontinue in order to strategically refocus resources. This underscores their need not only for strategy, but also governance forms that allow them to implement some aspects of strategy that may not be popular with all the university members. The SFO scheme can contribute to increased specialisation, but will not achieve it alone. The scheme encourages co-operation among universities – thereby creating some opportunities for co-ordination – but there is no evidence these are sufficient to generate significant change. Arguably, funding co-operation may have been a way to undermine the scheme's specialisation aims, as it reduces the resource pressure on the weaker research environments that were unable to lead consortia and had to settle for minor roles.

Sweden lacks a mechanism for explicit co-ordination and (re)division of labour among universities. International experience does not offer a clear way forward. Norway, for example, has tried to encourage negotiated specialisation through the so-called SAK[18] process for a number of years, to no evident effect. Whether negotiated solutions (which encourage cartel-like structures and inhibit exit) would be superior to competitive solutions – except perhaps in the case of new fields, which are inherently weak in their early years – is equally not obvious.

The SFO scheme appears to have had no effect on international collaboration. This is perhaps not surprising, given that it offered no incentives for such collaboration, over and above the normal ex ante appreciation of international collaboration in the peer-review process. Overall co-publication data suggest that Swedish researchers are already highly embedded in international research communities; thus, other incentives (such as the pursuit of excellence, complementary assets or EU Framework Programme funding) may well be adequate. More specific measures may be appropriate in newer areas (such as healthcare research) that are not yet well linked internationally.

Whether the SFO scheme has had much effect on undergraduate education is hard to determine – and would be surprising, as most of the funding enhances existing strengths. The opportunities to drive educational change can be found in the new thematic areas, which make up a small part of the overall activity.

The government's ambitions to involve the research institutes and industry have barely been realised. There was no requirement or reward for universities to seek out institute participation, nor were there

rewards or incentives for active industry involvement. In a number of cases, industry provided letters of support to SFO applications. In a research and innovation system like Sweden's – where reasonably good links exist between at least some of the universities and industry, and where industry has other incentives to engage in such links –companies are generally happy to sign letters of support. They involve no commitment, cost nothing, and reinforce social capital that can be exploited when genuine co-operation is needed. In SFO projects, industry is rarely involved in advice, governance or the research activities themselves. Any industry influence on SFO activities is therefore a second-order effect, arising not from the scheme itself but from the wider network of relationships in which everyone knows how to "play the game".

A further lesson can be drawn from the fact that universities have been invited to co-operate with industry but do not do so much in practice: in such a situation, the beneficiaries will not share the resources they obtain unless they have incentives or requirements to do so. This is not misbehaviour, it is simply normal behaviour.

Some of the limitations of the SFO scheme seem to derive from the governance processes that affect it. The choice of areas was heavily influenced by the desires and needs of the research community, which naturally proposes that funders offer them more money to do what they are already doing. The scheme's "more-of-the-same" character no doubt has its origins in this consultation process. Implementation of the scheme at the project level is necessarily in the hands of the universities and is therefore strongly affected by their ability to set strategy and change direction. This brings additional conservative tendencies into play.

The focus of the SFO evaluation – which largely follows the SFO tradition of trying to evaluate beneficiaries' performance, rather than testing the appropriateness and impacts of the programme itself – also seems to have been unfortunate from a policy perspective. Both purposes are important – and their evaluation was implicit in the 2008 Research Bill. The originally stated intention that an evaluation after a period of five years should also lead to a reallocation of resources does not appear to have been realised – and indeed, the evaluation was not designed to produce a rationale for such reallocation.

Finally, the SFO scheme is an object lesson in the importance of the interaction between an intervention and its context. Some of the issues it targeted cannot be changed without changing the context itself. A key lesson is the need for a more systemic approach to designing such interventions.

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1 The interim report from the committee currently investigating university governance proposes arrangements that would make it possible to restore an academic majority, if the university so desires (Ledningsutredningen, 2014). Compared with reforms elsewhere, this could be seen as a step backwards.

2 Funds stemming from university endowments are excluded.

3 The foreseen allocations and reallocations can be found in Swedish Government (2008).

4 The challenges these organisations face were discussed in OECD (2013).

5 In the late 1990s, education income totalled approximately SEK 20 billion, while research income stood at approximately SEK 25 billion.

6 For the distribution of GUF and TPF in each university in 2012, see Swedish Government (2012).

7 Some of the foundations were required to consume their capital over time; others were required to preserve it. The Strategic Foundation is among those required to consume its capital

8 A few smaller sources are not included in this list. Only Swedish funders are included in the list of organisations.

9 This is the figure for 2008.

10 Logically, this means that Swedish HERD should be a little inflated compared with HERD in other countries that do the equivalent research within the government-institute sector.

11 Some analyses show nevertheless that some growth did take place in the 2000s in universities and some medical universities/faculties in terms of citations and highly cited papers (see Vetenskapsradet, 2015b).

12 Similar arguments were already used in the 2008 Bill (see Swedish Government, 2008).

13 Regeringsbeslut II:14, U2008/7680/F, 2008-11-27.

14 VR, Utlysning; Strategiska forskningsområden, 2009-01-15.

15 Where they had strategies – not all the universities did.

16 While the role of university boards in such larger allocation decisions remains unclear, it is stated that their contribution to strategic orientation may be rather weak.

[17] Average VR grants are reported as worth SEK 3.6 million (approximately EUR 0.4 million), including overheads and high costs per PhD student (Hallonsten and Hugander, 2014).

[18] Samarbeid, arbeidsdeling og konsentrasjon (Cooperation, division of labour and concentration).

CHAPTER 4. LINKING SWEDISH RESEARCH AND INNOVATION

Current thinking on the functioning of innovation systems emphasises the importance of interactions and knowledge flows among institutional actors. In turn, many policies geared towards improving the performance of innovation systems aim to stimulate these interactions and knowledge flows. Some of these policies are specifically designed to improve the productivity of research in terms of realising innovation-related outputs.

Such policies can take many forms. Historically, the government has had a long-standing interest in promoting collaborative R&D and innovation activities among actors – such as universities, government laboratories, private research institutes, and both small and large firms – operating at different points along the research-innovation spectrum. While these activities have often taken the form of national R&D or innovation programmes, many variants exist at both the regional and international levels. Regional "cluster" policies aiming to exploit the benefits of agglomeration are particularly common across the EU. They typically go far beyond supplying funding for joint projects, by providing support for infrastructural developments (such as incubator facilities and science parks) that encourage synergy between local research and innovation actors. Some policies (e.g. touching on the missions of universities, or the scale and scope of the public and private research institute sectors, or more generally on risk-investment opportunities) also aim to effect infrastructural change at the national level, through legislative and regulatory changes that affect the scope or power of different sets of actors to interact with each other.

Sweden's relatively high expenditure on R&D, and the lack of a clear relationship between these inputs and innovation outputs, has stimulated a number of policy debates over the years.[1] After very briefly reviewing certain characteristics and actors of relevant research and innovation developments in Sweden, the spotlight in this section falls on two areas covered by the 2008 and 2012 Research and Innovation Bills: the role of the research-institute sector in bridging the gap between research and innovation, and the launch – as a consequence of the 2012 Bill – of the SIOs initiative (*Strategiska Innovationsområden*), which supports joint R&D and innovation-related activities among different sets of actors. While neither of these developments can be expected in isolation to have a radical impact on the relationship between research inputs and innovation outputs in Sweden, both can be expected to contribute to improving the links between them.

4.1 Linking research and innovation in Sweden

4.1.1 Higher education institutions and the third mission

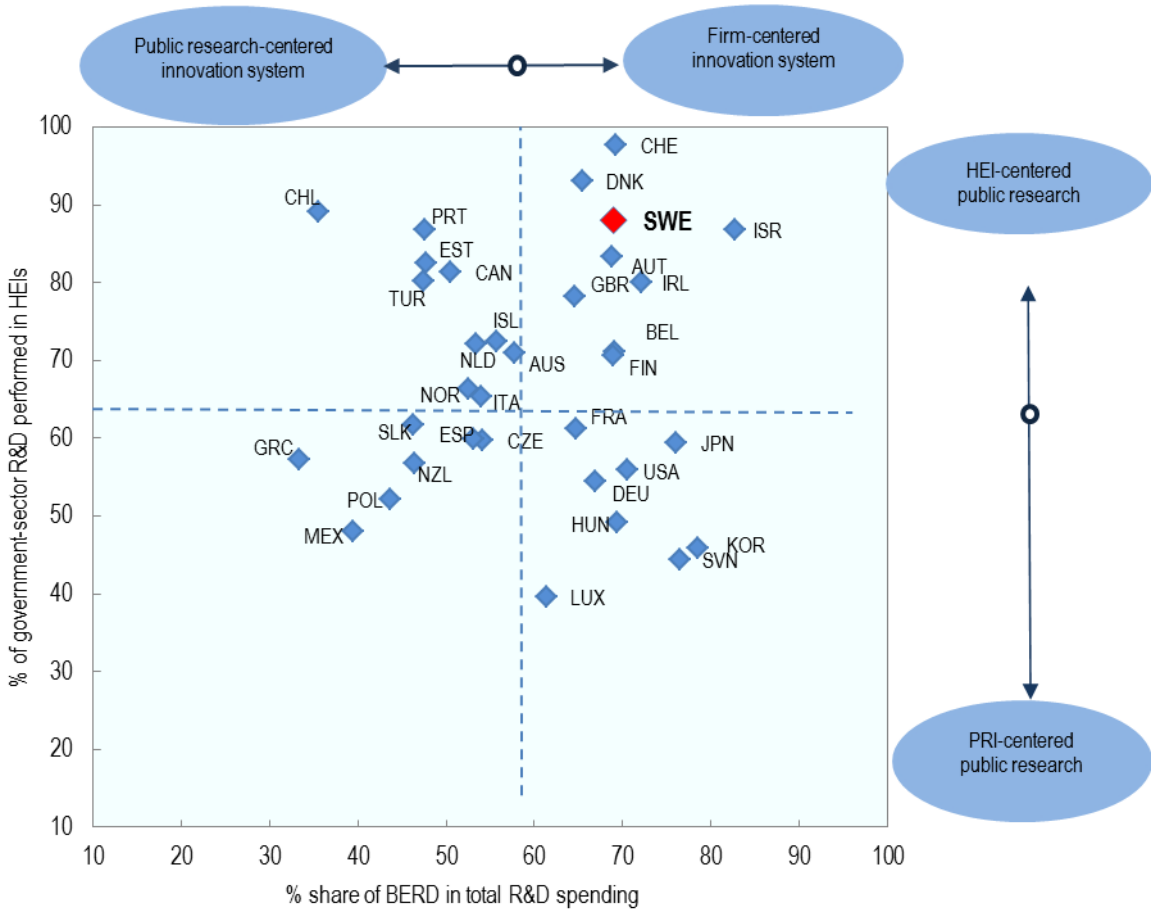
Universities and other HEIs play important roles in modern-day innovation systems through teaching and R&D, and increasingly through their "third mission" – facilitating innovation and engaging with local economies. The demands on many HEIs have therefore multiplied and now encompass attracting, retaining and educating students; competing for and producing high-quality research and researchers; and helping to develop innovation, regional growth, public goods and societal collaboration.

Universities operate in what has been termed the "knowledge triangle" (KT), defined by the three elements of education, research and innovation. KT policies have evolved to stimulate and enhance the interactions between these domains and their overlapping sets of actors, with HEIs occupying a central position.

This is particularly the case in Sweden, since Swedish HEIs have been long been tasked with a "third mission" – namely, to act as the main public-sector organisations expected to build a bridge between research and the broader needs of society. This includes the responsibility to link research and innovation, articulated by the Malm Commission in 1942, and reiterated and extended in the 1992 University Law.

The possible interrelationships between research, education and innovation are closely tied to an innovation system's structure. Even among OECD countries, however, these structures differ. Figure 4.1 characterises innovation in OECD member countries and non-member economies along two dimensions: the share of business R&D in total R&D spending and the share of public R&D accounted for by higher education, as opposed to the government sector (e.g. government laboratories and research institutes). It reveals the substantial variation that exists across industrialised economies. The share of business in total R&D varies from around 30% to around 80%; along the other dimension, some countries are almost exclusively reliant on HEIs to conduct public research, while others conduct research mostly within the government sector.

Figure 4.1. Characterisation of national innovation systems, 2010



Source: OECD (2013), *OECD Reviews of Innovation Policy: Sweden 2012*, OECD Publishing, Paris.

Note: BERD= business expenditure on research and development.

Sweden stands at the top right-hand quadrant of Figure 4.1, indicating that its innovation system is more firm-centred and its public research system more HEI-centred than most of the other countries depicted. In this categorisation scheme, it is in a similar position to Austria and Ireland.

Indeed, Sweden is notable for the relatively small amount of R&D funding that is channelled through public research institutes.[2] The majority of public R&D is undertaken by HEIs. In an innovation system that is primarily firm-centred rather than public-research centred, the onus is therefore very much on universities rather than on other public-sector actors to fulfil their third mission and ensure strong links with industrial innovation actors.

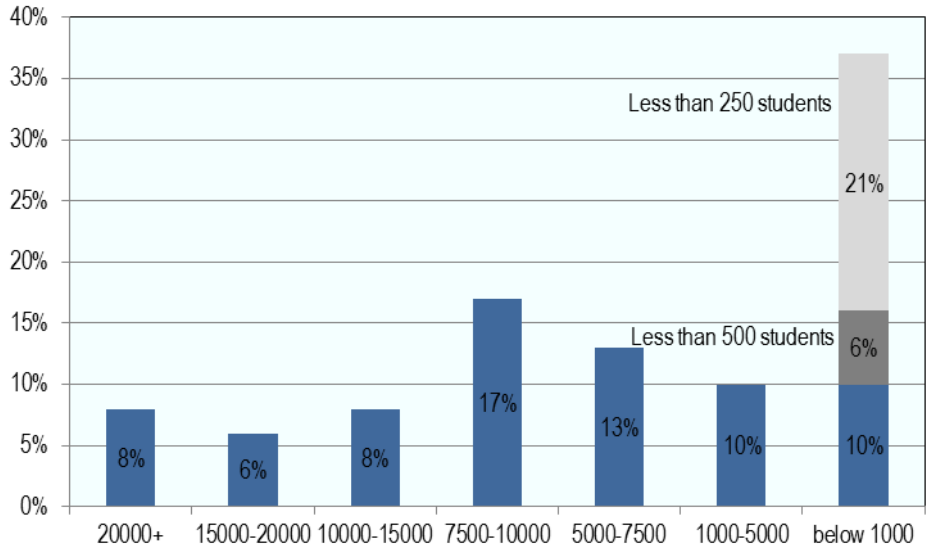
4.1.2 Variations between HEIs

Different universities play different roles, with some fulfilling all three missions described above and others specialising. In some countries, there exists a distinction between universities that combine teaching and research, and others that specialise only in teaching; focusing on third-mission activities may be the responsibility of only a few, all or none of the universities in a particular country.

The Swedish Higher Education Authority recognises 48 HEIs, comprising universities, university colleges (*högskolor*) and "other" types. Sweden has a unified HEI system: the same law governs and regulates all state HEIs. The majority of universities and university colleges are public-owned, though a small number are self-governing and independent. Most notably, Sweden numbers three private universities: Chalmers University of Technology, Stockholm School of Economics and Jönköping University Foundation.

Figure 4.2 shows the wide variations in the size distribution of HEIs in Sweden. Four public research universities (Stockholm University, Lund University, the University of Gothenburg and Uppsala University) stand out, with between 27 000 and 38 000 students at the undergraduate and graduate levels. Institutions with fewer than 1 000 students account for around 38% of institutions, though some (such as the University College of Opera) have recently merged into larger institutions; most are highly specialised, especially in the arts and design, music or theology. HEI size can affect the quality and efficiency of higher education, and an institution's ability to form wider linkages.

Figure 4.2. Size profile of HEIs in Sweden, 2013



Source: Swedish Higher Education Authority database on HEIs (*Statistikdatabas om högskolan)*.

Note: Does not account for institutional mergers since the date of reference.

Though Sweden formally has a unified system of HEIs comprising universities and university colleges, it can be argued that universities have greater prestige than university colleges. Geshwind and Broström (2015) distinguish between three types of HEIs: 12 research-intensive "established" universities; 11 teaching-oriented university colleges; and 9 institutions (4 of which have recently been granted university status and 5 university colleges) conducting research of sufficiently high quality to award PhDs. The authors show that 89% of research funding is allocated to the "established" universities, while they account for 57% of higher education students in Sweden. By contrast; the teaching-oriented university colleges account for 29% of higher education students, but only 4% of total research funds.

Some Swedish universities perform better than others in terms of fulfilling third-mission objectives. Some of the less research-intensive, but technologically capable engineering schools, for example, have developed very strong links with industry; links between industry and some of the more research-intensive natural science schools in major universities are much weaker.

Elsewhere, the potential for some of the more recent regional universities to establish strong research-innovation links is somewhat limited by their relatively weaker research capabilities, although many of them have established strong links with local communities and industries because of their teaching orientation and sensitivity to local industry needs.

4.1.3 The role of research institutes in the knowledge triangle

In Sweden, the third-mission task of linking research and innovation has been an integral responsibility of HEIs since the 1940s. By contrast, many other countries in Europe and elsewhere opted to create or develop strong sectors of this nature. Both VTT in Finland and TNO in the Netherlands have played – and continue to play – strong roles in their respective national innovation systems, as research actors, innovation sources, and intermediates between the science base and the industrial-innovation community (Arnold, Barker and Slipersæter, 2010).

This situation in Sweden is, however, evolving, with the relatively recent emergence of a stronger, less fragmented research-institute sector. While this phenomenon has to potential to have a significant effect on research-innovation links at an aggregate level, much will depend on the ability of the overall innovation ecosystem to accommodate it.

4.1.4 Swedish industry

Sweden has long had a strong, high-performing business sector, renowned for both its R&D and innovation capabilities, and its export-oriented internationalised firms (OECD, 2013). The industrial ecosystem continues to be dominated by the existence of large multinationals in key sectors of national strength, e.g. AB Volvo (trucks, buses and construction), Volvo Cars (automotive), and Ericsson (telecommunications).

Many of the industrial giants have Swedish roots, but advancing globalisation has come with ownership changes that have diminished Swedish ownership and control (e.g. in the case of ABB, Scania, Volvo Cars and AstraZenaca). Also as a consequence of mergers and acquisitions, some production and R&D facilities have been distributed globally, though much capacity still remains in Sweden.

Although Sweden still ranks highly in international comparisons of BERD, signs have pointed to a relative decline in recent years. While this owes in part to globalisation and the relocation of the R&D capacity of large firms (such as AstraZeneca), this is not the whole story. Although large companies dominate BERD expenditure, small and medium-sized enterprises (SMEs) have historically performed a significant proportion of indigenous R&D and in fact – particularly in the case of SMEs with fewer than 50 employees – have shown a pronounced relative decline in BERD (see OECD, 2013).

Sweden has a rich and varied industrial landscape, with traditional strengths in high- and medium-technology sectors. Key manufacturing sectors are automotive and components; aerospace; machinery and electro/electronics; pulp and paper; chemicals and pharmaceuticals; and medical technologies. The country also has a strong and growing service-industry sector. This diversity is a key feature and strength of the Swedish economy, yet only two regional agglomerations or "clusters" – – the information technologies cluster in Stockholm[3] and the automotive cluster in Västra Götaland – can be termed large, "three-star" clusters by international standards (Ketels, 2009). Other clusters tend to be in medium-technology areas, and a few new high-technology clusters are emerging.

In summary, although Swedish industry remains healthy and robust in international comparison, concerns have grown that actions are needed to ensure it retains its position as one of the leading R&D and innovation-based economies in the world.

4.2 The role of research institutes

Since the war, the Swedish research policy doctrine has been 'institutes bad, universities and colleges good'; no discussion necessary…. Undeniably, in the context of Swedish research policy there is a 'truth' that institutes represent poor research policy and that builds on three fundamental ideas:

- Free-standing institutes involve a fragmentation of resources, while resources should be concentrated;
- That the connection between education and research should be defended
- The risks of sclerosis are high in institutes and that that risk is much higher than in the universities." (Sandén and Sandström, 1992)

"One can quite simply wonder whether the industrial research institutes are research policy's unwanted children" (Eriksson, 2010).

The comparative neglect of research institutes in Swedish research policy has been much discussed and analysed. It is the consequence of the government's 1942 decision, based on the reports of the Malm Commission, to focus most state-funded research on the universities. Analysis of the history of Swedish research policy also suggests that the dominance of the academic community in Swedish culture, as well as the governance of research policy, have furthered this neglect. The last decade, however, has seen a gradual increase in state funding for the industrial research institutes in an effort to make them – if not central – then at least less peripheral players in the national innovation system. This section discusses the history of the research institutes, their resurgence and options for enhancing their contribution to the innovation system.

4.2.1 What are research institutes?

Three broad categories of institutes exist (Arnold, Barker and Slipersæter, 2010):

- scientific research institutes
- government laboratories
- research and technology organisations (RTOs).

Scientific research institutes do fundamental or applied science and tend to have a very high proportion of core funding in their income. In some places, they are associated with science academies or research councils. They often do the same kind of research as universities, though some are entirely separate because they depend on large facilities that are difficult to manage in a university. Sweden has almost no institutes of this type: science is almost wholly done in the universities.

A second category of research institutes – often referred to as "**government laboratories**" – focuses on producing public goods to meet the knowledge needs of the state or wider society. Also known as "sector" institutes, they are generally owned by the state, and their main function is to deliver services and policy-relevant information to the government. Examples of such institutes include nuclear research, metrology and marine institutes (which mix counting fish stocks with more fundamental work in marine biology). Most of their income generally comes from the ministry whose policy mission they support. The few large Swedish institutes outside the Research Institutes of Sweden (RISE) group, such as the Swedish Defence Research Agency (Totalförsvarets forskningsinstitut [FOI]) and Swedish Environmental Research Institute (Svenska Miljöinstitutet [IVL]), tend to belong to this category.

A third category of **research and technology organisations** (RTOs) or "industrial research institutes" is funded by the state and tackle industry's knowledge needs and a range of knowledge-related services, with the aim of fostering industrial and economic development. The RISE institutes belong to this category. International examples include VTT Finland, the Fraunhofer Society in Germany and TNO Netherlands, but smaller and more specialised such institutes also exist. While they often originate as testing laboratories, product and process developers for industry, or branch-based research associations, they focus on user- or problem-oriented research for society's benefit and normally win the bulk of their funds competitively. Typically, their role is to assume some of the risks of industrial innovation, helping companies exceed their own technological capabilities. The state normally provides core funding of 10-30%. In some cases, research associations exist without state subsidy (e.g. in both Austria and Germany), but they as a result tend to do close-to-market research and fall outside of the RTO category.

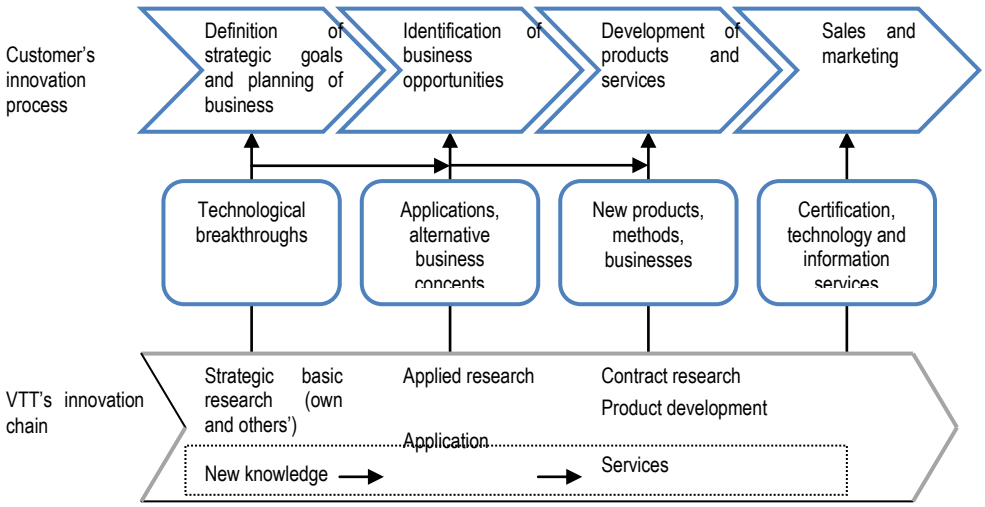
Government labs have increasingly been encouraged to also sell RTO services, and some of the very big RTOs abroad also have departments that effectively work as government labs. As a result, these often become hybrid institutions.

RTOs tend to operate with an explicit or implicit business model involving:

- exploratory research and development to develop an area of capability or technology platform
- further work to refine and exploit the knowledge in relatively un-standardised ways, often in collaborative projects with industry
- more routine exploitation of the knowledge, including through contract research, consulting and services.

Figure 4.3 shows the VTT version of this model. In principle, RTO core funding is primarily intended to pay for the first, exploratory stage, where the RTO develops the knowledge and capabilities needed to support their industrial customers. This is the key distinction between an RTO and a technical consultancy. The public money is used to create the capabilities the institute needs to take companies "one step beyond" what they could otherwise do, thereby providing social returns by de-risking innovation (Sörlin et al., 2009).

Figure 4.3. The VTT innovation model



Source: VTT.

4.3.2 The Malm Commission and its consequences

While the Malm Commission prompted the "Swedish model" of universities that expects them to handle many of industry's sector-specific needs,[4] the Commission also emphasised the need to establish research designed to meet the needs of specific branches of industry, especially those that were fragmented and dominated by small companies with limited research resources. As a result, the Institute of Metallography and three new institutes – Träforskningsinstitutet, now part of Innventia in the RISE group; a food and canning institute that is now the Swedish Institute for Food and Biotechnology (Institutet för livsmedel och bioteknik); and the Textiles Institute – were set up during the Second World War, co-located with the two technical universities. Tight links with the universities were ensured by the fact that the institute directors were generally also university professors (as with the Fraunhofer Institutes in Germany today) , though this practice proved to be unsustainable in the Swedish university system.

These early institutes appear to have been inspired by the UK research associations. They existed to serve the collective research needs of branches of industry, were run by foundations owned by companies in the relevant branch, and were funded through framework agreements between these foundations and the state. From the 1960s on, they were described in Sweden as *kollektivforskningsinstitut*. The state tended to take care of their capital costs, while industry paid for their operation. Consistent with the pattern in other countries, the share of total costs borne by the state was large at the outset, but fell over time as industries learnt the value of working with the institutes, and as their internal R&D capabilities increased.

Sörlin (2006) points out that the institutes were only one part of Swedish industrial development policy during the post-Second World War period – a fact that the Malm Commission took explicitly into

account in recommending institutes for fragmented industrial branches. The other was a series of ”development pairs” in sectors where the state was a powerful actor, and where a dominant Swedish supplier existed. Development pairs where technologies were co-developed and transferred to the industrial partner included Televerket (the state-owned telephone company) and Ericsson in telecommunications, SJ (the national railways) and ASEA in railway technology, Vattenfall (the state-owned electricity generating company) and ASEA in power generation and transmission –. In addition, Sweden had a powerful military-industrial complex, with similar co-development relations, supporting the national policy of armed neutrality. The scale and influence of the development pairs also meant that universities of technology were greatly influenced by their needs, , so that their presence affected human-capital formation as well as the direction of research. The institutes operated in more fragmented branches of industry, where no such development pairs existed and they correspondingly wielded less influence over university research. However, the development pairs began to break up in the 1970s and state procurement markets became more open to competition. The defence relationships were further weakened by the desire for a large peace dividend at the end of the Cold War. These relationships have not been replaced; despite the growth of the institutes in the post-War period, their absence from the industries formerly dominated by “development pairs” meant that the institute system was largely limited to the more fragmented parts of industry.

4.2.3 Development of institute policy

In 1959/60, the institutes collectively received 54% of their income from the state through framework agreements, 27% from the companies that made up the industry research associations involved, 6% from research councils, only 5% from industrial contracts and 8% from other sources. By the mid-1970s, the framework agreements were providing some two-thirds of the institutes’ total revenues. In 1991, they provided about 40% (SOU, 1991). However by the middle of the first decade of the Twenty-first Century the share of state core funding was down to about 10% of their turnover.

The Swedish National Board for Technological Development (Styrelsen för teknisk utveckling [STU]) was set up in July 1968, replacing the researcher-governed Technology Research Council (Teknikforskningsrådet) with an agency intended to pursue a more active style of research and innovation policy. STU was given responsibility for running the framework contracts with the institutes. It oversaw the creation of many new institutes, so that the institute sector grew from 6 to 32 institutes and research associations between 1960 and 1982; the state’s investment continued to grow over this period. Increasingly, some of the new institutes were technology- rather than branch-focused.

A study undertaken in 1991 (SOU 1991) found that Sweden had 35 research associations: 26 with their own institutes (*kollektivforskningsinstitut*) and 9 operating through a committee that bought research and services from third parties on behalf of their members (*programstyrelser*). It found that many of the institutes (and especially the *programstyrelser*) were too small to be effective and do high-quality work. The study argued that a new strategy was needed to consolidate institutes in related areas and focus on a handful of broad technologies strategically relevant to the Swedish economy. It identified the lock-in risks associated with research associations, arguing that the institute system “can in certain respects be characterised as conservative rather than dynamic”. The study also pointed out that (as in the United Kingdom) Swedish research policy focused on basic research, and questioned whether this balance was appropriate in the context of Swedish industry’s knowledge needs. It argued that a strength of the Swedish system was that Swedish institutes were often better coupled with universities than universities in other countries.

With the establishment of the Wage-Earner Foundations in 1994, the Knowledge Foundation was given a role in developing the research-institute sector, although core funding for the institutes continued to pass through the successors of STU until RISE was created in 2009.

The Kofi Committee (SOU 1997:16) triggered some changes in the system:

- A new core funding model was established to help research institutes develop new capacities and support joint projects between the institutes and member groups.
- The institutes were encouraged to become limited companies.
- The 1996 Research Bill provided some institutes with a special subsidy from NUTEK to help them serve SMEs. This revived earlier programmes funded by NUTEK.
- Additional funding enabled institute staff to take PhDs.

Another consequence of the Kofi Committee report was to set up IRECO Holding AB in 1997 (jointly owned by the Ministry of Enterprise, Energy and Communications and the Knowledge Foundation [KK-stiftelsen]) as the state's holding company for its interests in RTOs. The Kofi report also triggered efforts to engage in structural renewal among the institutes. Long-running framework agreements with established branch research associations were terminated. KK-stiftelsen encouraged mergers and reorganisations that would help the institute sector shift from responding individually to the needs of individual industry branches towards proposing more polytechnic offerings, encouraging scale and enabling the institutes to tackle their customers' problems (which increasingly spanned several different technologies).

In the 2000 Research Bill, the government encouraged further mergers among the institutes. After a period, IRECO sketched a "four-leaf clover" model of four more-or-less technology-focused meta-institutes and suggested which of the old institutes should become part of which "leaf" (Arnold, E. et al. (2007). In the ensuing negotiations, the institutes effectively decided for themselves where they would best fit, and by 2006 the structure was fully in place.

The 2004 Research Bill stressed the increased importance of the state in relation to industrial research. It argued both that the institutes' core funding should be increased, and that the institutes should have closer relations with the universities.

The Sörlin report (Sörlin, 2006) commissioned by the industry ministry analysed the history and current position of the institutes in Sweden. It proposed that not only the IRECO institutes and SP, but also key government labs, be considered for integration into a single holding company. Such an integration would produce an organisation spanning the roles of RTOs and government labs, and give Sweden a single strong institute actor able to tackle the full width of problems and challenges posed both by companies and wider society. A strong player could also evolve, building new institutes or capabilities as necessary and better co-operating with the university sector. While recognising the risk that the research associations would act as brakes on development, Sörlin (2006) proposed that they retain their partial ownership of the institute sector. In the previous period, the institutes had been starved of funding, and that situation needed to be rectified. The new institute system should have core funding in the 15-20% range. Properly funded, it would be a significant force for development in the national innovation system.

The government set up a working group of civil servants from the ministries to develop an implementation plan (Näringsdepartementet, 2007). The essence of the plan was to complete the four-leaf clover by integrating SP Technical Research Institute of Sweden (SP) and increase core funding, but not to bring in the government labs. The working group said that its proposals were consistent with past policy: "The working group does not want to propose a change to the long-standing Swedish tradition of having a strong university sector that does the bulk of state-funded research."

The 2008 Research Bill reacted to the Sörlin report (Sörlin, 2006) by increasing the IRECO institutes' core funding from about 10% to 15% of turnover and calling for continued consolidation, extension and development of the "four-leaf clover" institutes. A new state-owned holding company (RISE) was expected to take over the institutes and to co-ordinate and steer them more actively than IRECO. The aim was not to create a single organisation on the model of VTT, SINTEF, Fraunhofer, TNO or other large, polytechnic RTOs abroad. The roles of the holding company included developing common strategies for expanding the institutes; allocating and using resources made available for restructuring; developing criteria for and allocating core funding; providing common infrastructure; and, where appropriate, co-ordinating research among the daughter institutes. A key task was to make sure that the institutes used their increased core funding to develop capabilities that would allow them to support industrial innovation in and by companies.

The 2012 Research Bill lauds both the growing size and increasing core funding allocated to the institutes, providing further resources intended to bring their core funding towards Sörlin's 20% goal. Core funding had peaked at 18% in 2011, subsequently falling because RISE's industrial income was rising faster than the core funding. The 2012 Bill noted that the RISE institutes had a total of 15 000 SME customers, but argued that they could support innovation in SMEs even further; it further noted that ties to the universities had become closer and should further be strengthened. The Bill noted that RISE participated in 13 of the 43 SFOs, as well as in various centres of competence and excellence. It required RISE management to refine and improve its processes for monitoring the socio-economic impacts of its work and its principles for allocating core funding among RISE institutes, as well as to reinforce headquarter functions.

4.2.4 The RISE Institutes

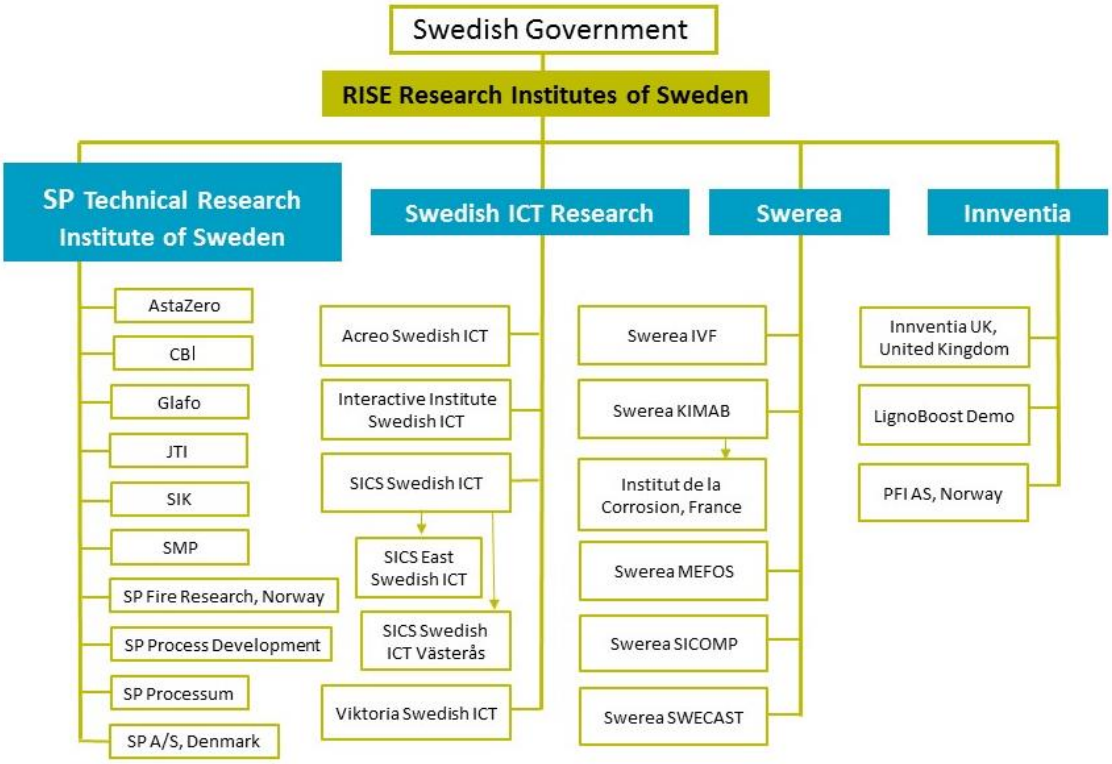
The Knowledge Foundation transferred its shares to the state and IRECO was re-branded RISE (ri.se – Research Institutes Sweden) in early 2009. It remains a private, non-profit company in legal form, as are all its subsidiaries. Consistent with its role of "steering" rather than managing the institutes, RISE has a small staff of only five to six FTEs. Its goal, set out in its instructions from the state is as follows (our translation):

- The overall objective of the RISE institutes is to be internationally competitive and to support sustainable development in Sweden by strengthening industrial competitiveness and renewal. The task of RISE AB is to represent the state as owner of the RISE institutes and enable their development, consistent with the overall objective.

- The company's tasks are to maintain a dialogue with business and the co-owners, steer the RISE institutes, allocate strategic development (SK or core) funding, represent the institute sector in various contexts, lead the branding effort in Sweden and internationally and to evaluate the benefits and impacts of the state's investment in the RISE group (RISE, 2014).

Figures 4.4 and 4.5 show that RISE is effectively organised as a development of the four-leaf clover. SP was incorporated into RISE in November 2009. The individual "leaves" (SP, Swerea, SWICT and Innventia) are 100% owned by the state. The state owns 100% of all the SP subsidiaries through SP, but many of the other institutes are partly owned by research associations or – in a limited number of cases – regional interests. Overall, the state is the sole shareholder in SP (100%), the majority shareholder in SWICT (60%) and a minority owner of Swerea (43%) and Innventia (29%). The book value of the state's shares in RISE is a little under SEK 500 million (kronor). In principle, this leaves substantial share value in the hands of the other shareholders, though it is not clear whether this value could be realised in the absence of a market and given the non-profit status of the companies involved.

Figure 4.4. The RISE Group Institutes



Source: RISE, accessible at http://www.ri.se/sites/default/files/files/docs/rise_legal_sept2014_eng.jpg .

RISE does not brand its subsidiaries. Rather, each of the four leaves has its own brand, which it attaches to the names of the individual institutes. For example, the production engineering institute IVF trades as Swerea-IVF. This implies that neither the shareholding structure nor customer needs would permit a single overall brand, or support RISE operating as a single entity.

Figure 4.5. Technical specialisation of RISE subsidiaries

Source: RISE, accessible at http://www.ri.se/en/research-institutes .

RISE has overlaid 14 technological "platforms" across the institutes aiming to provide a broader interface for customers and encouraging the institutes to work together where appropriate.

When RISE was established, core funding stopped flowing through the Swedish Governmental Agency for Innovation Systems (VINNOVA) and went instead directly to RISE, severing a historic link with innovation funding. The funding system's explicit objective was to restructure the system into fewer, bigger institutes, but devoted rather limited sums of money to this effort (RISE, 2010). Total funding provided directly to RISE by the state was SEK 355 million in 2009, of which SEK 310 million went to core "competence" funding, SEK 31 million to structural change and SEK 14 million to running the RISE holding company.

In 2011, RISE decided that it would devote core funding to four objectives and raise significantly the proportion allocated to the first objective to reduce the pressures from the research associations on RISE (RISE, 2011). The four objectives are:

- co-operation among the institutes
- internationalisation
- structural development
- demonstration.

From about 2011, the proportion of research income granted by VINNOVA to RISE rose, with the institutes playing a substantial role in the strategic innovation agenda (SIA) initiative that year – a

precursor to the SIO initiative from which the institutes also benefited substantially, as they did from the Challenge-driven Innovation (UDI) programme. Already since 2008, they had been involved in 13 of the SRA grants allocated by the government, though their overall financial share was small.

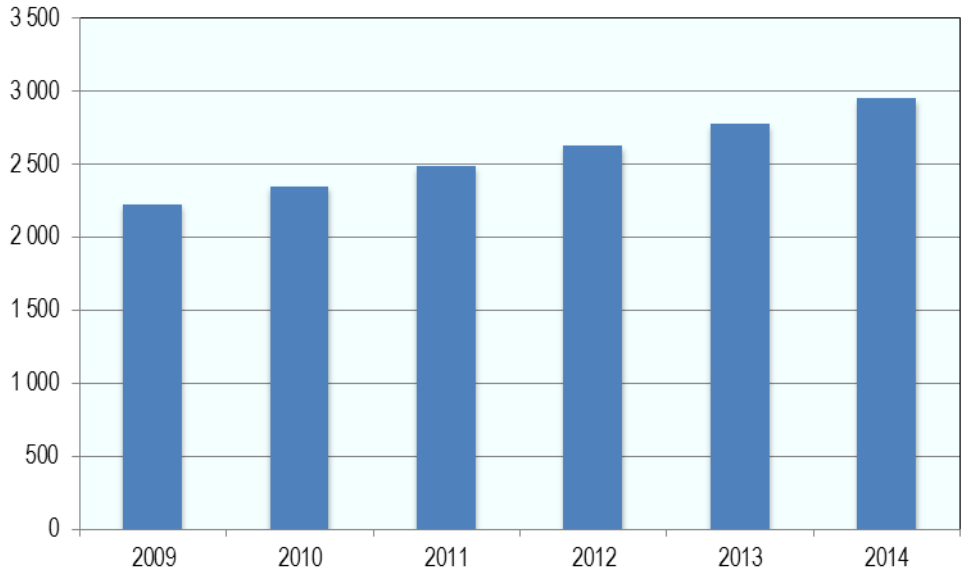
In 2013, RISE and VINNOVA established a programme to develop and make available more test beds and demonstrators at the RISE institutes. That same year, RISE also received a SEK 100 million grant to set up a new institute, SP Process Development.

The government has at various intervals asked RISE to support SMEs, recognising that in fact most of its income comes from large companies. Few data are available, but in 2010, 13% of RISE's total income came from SMEs. The OECD estimates the corresponding figure in 2011 at about 19%, or one-third of total industrial income. RISE has recently created a central support function for SMEs wanting to participate in the European Framework Programme Horizon 2020.

In the last two years, RISE has initiated studies to underpin the development of a clearer common strategy. Following an impact analysis by Tillväxtanalys, it has also launched a project to demonstrate the institutes' value by estimating economic impacts of parts of their activity.

RISE's overall turnover has grown by about 6% a year since it was set up (Figure 4.6). (Inflation in Sweden has mostly ranged between 0-2% during this period.)

Figure 4.6. RISE group turnover, 2009-14



Source: RISE (2015), Annual Report 2014.

The SP and Swerea "leaves" have grown substantially, while SWICT and Innventia have not (Table 4.1). Core or "competence" (SK) funding has been spread widely across the group.

Table 4.1. RISE institute turnover and proportion of their turnover coming from SK funding, 2007-14

	SP		SWICT		Swerea		Innventia	
Year	Turnover	% SK	Turnover	% SK	Turnover	% SK	Turnover	% SK

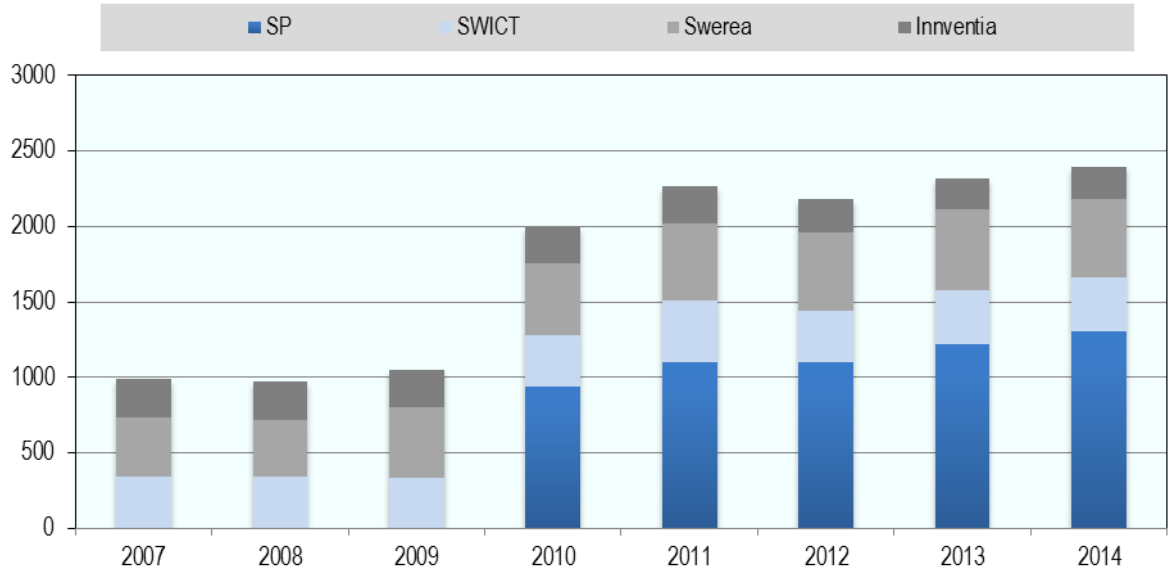
	SP		SWICT		Swerea		Innventia	
	MSEK	funds	MSEK	funds	MSEK	funds	MSEK	funds
2007	nd	nd	336	nd	480	nd	298	nd
2008	nd	nd	340	nd	399	nd	341	nd
2009	947	13%	415	13%	545	15%	309	16%
2010	1,024	19%	425	19%	573	19%	335	20%
2011	1,109	18%	429	19%	605	18%	333	71%
2012	1,230	16%	429	19%	648	17%	306	21%
2013	1,356	16%	432	19%	667	nd	305	nd
2014	1,488	15%	449	25%	677	18%	298	21%
Growth 2009-14	24%		8%		24%		-4%	

Source: IRECO and RISE annual reports.

Notes: nd= no data; MSEK: million Swedish kronor.

Figure 4.7 shows the development of manpower within the main institutes. (The discontinuity between 2009 and 2010 is caused by the entry of SP.) Current RISE employment of about 2 400 is comparable with VTT (about 2 600) or SINTEF (about 2 100), but somewhat less than employment at the GTS network in Denmark (just over 4 000).

Figure 4.7. IRECO and RISE institutes – employees 2007-14



Source: IRECO and RISE annual reports.

Note: SP joined the group at the end of 2009 and is included in the chart from 2010 onward.

Table 4.2 shows a breakdown of the RISE institutes' income sources in recent years. The division is relatively stable, with core (core and structural adjustment) funding at about 18% of the total – close to the 20% recommended by Sörlin. The biggest source of income is contracts with Swedish industry. Less than half the international income is from the EU Framework Programme, with the balance largely coming from foreign industry.

Table 4.2. Sources of RISE income, 2010-14

Year	Business	SK, structural funding	State funders	International
2014	55%	18%	20%	7%
2013	57%	18%	18%	7%
2012	59%	18%	17%	6%
2011	59%	18%	16%	7%
2010	56%	19%	25%	

Source: IRECO and RISE annual reports.

4.2.5 International trends and drivers in the RTO sector

The last major international study of the development of the research institute sector was done in 2010 (Arnold, Barker and Slipersæter, 2010). The study was based on case studies of institutes across the European Union and European Economic Area, as well as a foresight exercise involving members of the European institute sector. It identified five important drivers of sector change and another five trends.

The driving forces identified were as follows:

Increasingly sophisticated demand. With industrial development, production becomes more technology-intensive, and industrially oriented institutes increasingly move towards more demanding research as some of their knowledge and services becomes more commonplace. Eventually, market-facing institutes move towards research-intensive co-operation with sophisticated users, typically helping to break knowledge or capability bottlenecks in users' innovation processes.

- **Convergence**. Both science and technology are exhibiting increasing convergence of technologies and disciplines (Massachusetts Institute of Technology, 2011). Some research has an increasingly systemic character (European Science Foundation, 2009). At the same time, users are producing increasingly complex products requiring access to multiple technologies.

- **Globalisation** is widely discussed as a change driver. Scientific research institutes share scientists' propensity for international co-operation. This happens more in "basic" than applied disciplines and in small rather than large countries, as well as for extra-scientific reasons such as former imperial links (Frame and Carpenter, 1979). Motivations for international research co-operation that apply to institutes include: accessing leading edge and complementary knowledge and partners; tackling large or complex problems; sharing infrastructure; accessing funds or customers abroad; accessing geographically specific research subjects or data; accessing markets or regulatory/standardisation domains; and improving institutes' reputations (Edler et al., 2007).

- **Core funding**. Institutes are being pressured to increase their proportion of competitive funding and reduce their dependence on "core" funding. They are expected to produce quantifiable outputs, such as scientific publications and patents, more efficiently.

- **EU policy**. The effort to generate a European Research Area (ERA) (Busquin, 2000) provides particular change drivers in Europe. An ERA would require greater concentration of research resources. To date, EU policy influence over national institutes has largely been limited to supporting the creation of EU-wide associations and enticing them to participate the Framework Programme. EU-level incentives for cross-border restructuring may well appear in the future. Institutes could be made central to the ERA, but are largely locked into the national level by national funding (ERA Expert Group, 2008; Arnold, Barker and Slipersaeter, 2010). Government labs face task duplication, a need for specialisation, re-division of labour and in some cases closure of duplicative facilities, for example in metrology (Barker, Cox and Sveinsdottir, 2012). These drivers underlie the following trends in the institute sector.

- **More fundamental research, university links and up-skilling of institute staff**. The increasingly scientific basis of technology and the growing capabilities of institute customers require closer symbiosis between institutes and universities, and hence cross and joint appointments, exchange of PhD students and joint research projects, helping the institutes develop capabilities while signalling new research opportunities to the universities. This is a long established trend (van der Meulen and Rip, 1994). Institutes employ more PhDs and publish more in peer-reviewed journals than in the past. They increasingly co-publish with other institutes (Arnold, Barker and Slipersaeter, 2010).

- **Polytechnicity**. Convergence means that institutes' thematic specialisation must shift constantly, driving them towards a wider range of disciplines. Similarly, users' growing capabilities pose increasingly cross-disciplinary problems. Larger, more polytechnic RTOs have long been the trend. This process began 20 years ago in Norway (Skoie and Ødegård, 1990) and has resulted in a consolidation of much of the RTO effort into SINTEF (Gulowsen, 2000).

- **Organisation and scale**. Some of the smaller and more fragmented systems have been consolidated, as in Norway, Sweden, Austria and (since 2014) in Finland. The Austrian Institute of Technology is as a conglomerate based on the Seibersdorf Institute. In Denmark, the GTS - Advanced Technology Group RTOs have successively merged, halving their number over the past decade. At the large end of the spectrum, however, organisations have not grown recently, except for the Fraunhofer Society, which expanded into the former East Germany and is now growing internationally.

- **Internationalisation**. Some RTOs diversify geographically to keep in touch with their customers, while others may do better by building scale at one location. So far, globalisation by traditional public RTOs has been limited (Berger and Hofer, 2011). Nonetheless, successful RTOs, notably VTT, SINTEF, TNO, GTS and Fraunhofer, now obtain significant industrial income from cross-border trading. At least in Europe, the policy drivers for internationalisation are likely to become stronger.

- **Widening missions and the growing importance of competition**. The need to diversify income sources drives institutes to address new customers and widen their skills (PREST, 2002; Lähteenmäki-Smith et al., 2006; Arnold, Barker and Slipersaeter, 2010). Over a very long period, they have tended to derive a growing proportion of their income from competitive funding for public as well as private work.

Thus, institutes need to continually widen and deepen their capabilities to keep up with developing customer needs and the growing scientific component of their work.

4.2.6 Assessment

While the "Swedish model" gives a smaller role to the institutes than in many countries, they have nonetheless been an explicit part of research and innovation policy since the Malm Commission. The contested nature of universities' role in handling sector research needs, and the universities' tendency to revert to Humboldtian principles, has made it difficult to encourage the needed overlaps between the two sectors. Above all, the fact that research and innovation policy has primarily been conducted on the universities' terms means that institute policy risks at best being ancillary.

A fortunate by-product of Swedish research policy's focus on universities has been that many Swedish RTOs have longstanding close links with them. This has effectively given them a head start on RTOs in some other countries, whose relationships with their respective university sectors are not so close. The growing science and technology intensity of R&D and innovation everywhere cannot be tackled adequately by the kind of clear territorial demarcation between different kinds of organisations that has sometimes been demanded in Swedish research policy debates. Overlap and co-operation – as well as a bit of competition – are necessary for the RTOs to maintain and develop their research base, and for universities to receive clear signals about industrial problems and development potentials.

The RTOs have important roles to play in the type of comprehensive and capable innovation system needed to support national competitiveness. Sweden is having to get used to the fact that many of its strongest firms have moved from being nationally oriented multinationals to global transnationals whose links to the Swedish innovation system can no longer be taken for granted. All of industry needs to be offered a place in a system that delivers high-quality basic and applied research, manpower, co-operation and services, as well as physical and service infrastructures, at various stages of technological development. Institutes' functions (and especially the functions of RTOs) have been sufficiently studied to show that they are significantly different (Arnold et al., 2007), and that neither the RTOs nor the universities alone can meet all the requirements for building an attractive innovation system in which both local and international firms can flourish. Hence, there exists strong justification for making the Swedish RTO system more effective.

Like other European countries, Sweden has seen a significant growth in the number and size of various university-based centres of excellence in the past 20 years. It is sometimes argued that these centres (particularly competence centres) offer a more modern alternative to RTOs. They involve long-term research relationships between companies and universities, where VINNOVA practice has shown that institutes can productively be involved. Nonetheless, they always focus on small sets of firms and deal primarily with the "early" stages of the innovation process, where the universities are well equipped to partner with industry. The RTO scope of activities is much wider and benefits a much wider set of industrial companies than those that are able to participate in competence centres.

The legacy of branch-focused research associations also leads to RTOs being criticised for not being "modern". Moving from branch- and membership-based governance and structure to a more polytechnic organisation addressing wider industrial and social needs is an important challenge in Sweden as elsewhere.

The change drivers identified internationally also apply to RISE. The growing sophistication of demand means that RTO offerings cannot be static. Their scientific content tends to increase over time, which in turn provides a reason for close co-operation with the university sector. RISE has a strong tradition of using adjunct professorships and hosting PhD students to create bonds with the universities; these partnerships should be enhanced rather than diminished. Convergence is yet another reason for RISE to operate as a polytechnic organisation. Globalisation affects both the need to address a wider customer base at home and the requirement to operate internationally with existing and new technologies. The

institutes need to access both global and national knowledge, and to excel in certain areas of specialisation – in turn providing opportunities to export their services. Greater embedding in international knowledge generation and knowledge markets can only strengthen the institutes and the Swedish economy.

No clear answers can be found in the literature or in practice relative to the "optimum" level of core funding. Simply put, the smaller the proportion of core funding, the more RTOs are driven to work with short-term, close-to-market problems; a higher proportion gives them the freedom to take a longer-term view. Anecdotally, several of the most successful Swedish institutes have successfully mixed challenging research and academic linkage with strong industrial performance, despite their modest level of funding in recent years. Sörlin's 20% represents a good guess, situated in the middle range between the low funding (10% or sometimes less) of the highly applied Norwegian institutes and the longer-term perspectives enabled by the higher percentages at Fraunhofer, VTT and TNO. But there may be scope to consider whether the average should apply to everyone, and RISE already does provide differentiated levels of core funding to different areas, as well as to explore more closely the opportunities to attach core-funding levels to the nature of the intended research and the linkages needed with other partners within the knowledge triangle.

RTO involvement in research and innovation policy instruments has varied somewhat over time. It is encouraging to note a resurgence of institute involvement in VINNOVA programmes. One area of constant ambiguity in policy has been how – and to what degree –the capabilities of the RTOs to support SMEs can be exploited, as related programmes have started and stopped. The need for SME support is structural rather than occasional; and requires developing a longer-term policy and establishing a long-lasting set of instruments.

RISE management faces a number of challenges in developing the organisation. It is important to note that other RTOs (such as TNO and VTT) that appear to be "unitary" do in fact operate in a fairly decentralised way. The RISE approach of acting as a holding company rather than an active manager has some virtue – but some opportunities to reap economies of scale and scope are not being taken. The struggles that the Fraunhofer society has dealt with in trying to build platforms across individual institutes' specialisation testify to the difficulty of refocusing a fragmented structure towards more polytechnic ends. RISE has a similar struggle on its hands. The progress it has made towards creating a unitary and polytechnic RTO system has been hard-won and slower than is desirable. RISE is now rightly organising to transfer its remaining shares from membership organisations to the state. Correspondingly, it needs a stronger mandate from the government to be a more active manager, while avoiding the over-centralisation to which some foreign RTOs have fallen prey, with deleterious effects on their performance.

That Swedish policy for the societal challenges is largely undefined is both a gap and an opportunity for RISE. Like their equivalents at the European level, RISE institutes are well positioned to make major contributions to this policy agenda. Their success in VINNOVA's UDI gives a foretaste of their potential to contribute to wider societal and industrial agendas.

4.3 Strategic innovation area (SIO) initiative

This section focuses on the Swedish SIO initiative, which was announced in the 2012 Research and Innovation Bill. Its aim is to improve international competitiveness and find sustainable solutions to global challenges by enhancing interactions between the many varied actors who play a part in healthy innovation systems. This involves supporting the formulation of SIAs and launching a number of strategic innovation programmes (SIPs).

The following section describes the origins, objectives, and implementation of the SIO before focusing on its position within the policy portfolios of VINNOVA and, more broadly, Swedish research

and innovation policy. Attention then shifts to a series of issues and suggested actions for the future that deserve further policy attention.

4.3.1 Origins and objectives of the SIO

Origins

The 2012 Research and Innovation Bill bases the rationale for an initiative such as the SIO in terms of the generally accepted view that innovation can both underpin the search for solutions to global challenges and create future growth markets in these areas. More specifically, it recognises that interaction and collaboration between diverse sets of innovation actors is key to developing a healthy innovation ecosystem.

The rationale is also based, however, on a recognition or perception that interaction of this nature needed to be enhanced within a Swedish context. This was largely due to the reaction of certain sections of the innovation community – particularly industry – to a perceived imbalance resulting from the 2008 Research and Innovation Bill. The Bill allowed for substantial increases to universities' research funding, including the introduction of an additional funding scheme for strategic research areas (SFOs). Many in the industry and research institute communities believed this would lead to greater interaction with universities and pledged their support for particular institutions when universities applied for these additional funds. Complaints arose in many quarters, however, when this interaction failed to materialise, leading to a statement in the 2012 Research and Innovation Bill about the need for greater collaboration with industry and the overall community.

Objectives and tasks

To fulfil this need, the 2012 Research and Innovation Bill gave VINNOVA the task of designing strategic, challenge-oriented innovation areas that had strong links with the research base and would lay the foundation for new, long-term and deeper collaborations among universities, research institutes, industry, the public sector, civil society and other stakeholders. The Swedish Energy Agency and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas) were also expected to contribute funding to areas within their remit, and VINNOVA was expected to co-ordinate and collaborate with other relevant ministries and agencies involved in innovation activities in fields such as mining, mineral and steel research; forest raw materials and the bio-based economy; and sustainable building.[5]

Critically, however, the Bill also stated that it was not up to government to decide which areas were deemed strategic. Rather, this should be decided through establishing bottom-up processes allowing the innovation actors themselves to define priority areas, with government facilitating the process and establishing a framework of selection criteria reflecting societal challenges, high scientific quality, collaboration, cross-disciplinarity and co-financing. These criteria were also expected to govern the choice of activities conducted within these areas, with the community itself responsible for proposing and, importantly, managing the activities.

The overall objective of the SIO, therefore, was to stimulate innovation by enhancing collaboration between a broad range of innovation stakeholders in areas deemed to be strategically important from both a community and government perspective. Correspondingly, the main tasks of the government agencies, VINNOVA in particular, involved:

- encouraging and supporting potential stakeholders to formulate SIAs

- establishing a process that allowed a broad range of innovation stakeholders to propose SIPs, based on these SIAs, within areas they deemed strategic
- defining a set of criteria to assess the rival merits of the SIP proposals
- facilitating and overseeing a selection procedure involving external experts
- allowing stakeholders to set up their own management and administration structures for SIPs within each strategic area
- establishing a process allowing the actors within each area to propose a range of potential activities, especially issuing calls for project proposals within each SIP
- helping to define a set of criteria to assess the merits of rival project proposals, though the SIP management teams were primarily responsible for the orientation of calls and election call criteria
- facilitating and overseeing a project-selection process for the calls involving external experts.

One key point that should be stressed at this stage is the revolutionary nature of this whole process compared to historical practice within VINNOVA. Conventional practice had been for government/VINNOVA to designate priority areas on a much more top-down basis, albeit one involving more restricted and informal consultation with key stakeholders. The most radical change involved the transfer of managerial responsibility for the SIPs to the programme participants themselves, albeit with VINNOVA (and the other agencies involved) retaining the final say over which activities received funding. In essence, this constitutes a significant step towards outsourcing or devolving administrative responsibilities and forming what many – including senior personnel within VINNOVA – have termed "mini-VINNOVAs".

4.3.2 Implementation of the SIO

Strategic research agendas (SIAs) and strategic innovation programmes (SIPs)

To establish which areas could be classified as strategic, VINNOVA[6] provided seed funding (if necessary) to innovation community actors to work together to formulate SIAs through widespread consultative processes involving large numbers of relevant actors. Once completed, it invited proposals for SIPs within the areas defined by these SIAs, conditional on the existence of an agenda supported by relevant actors. This model of developing research agendas prior to formulating a work programme closely resembles that developed and used in the EU-ERANET scheme over the last decade, with which many participants in the SIO were familiar. The same model can also be found in a number of other European countries.

The bottom-up ambition for stakeholders to define strategic areas through this process was largely realised. Different configurations of research and innovation actors generated SIAs in areas of their own choosing and then submitted proposals for SIPs within them, subsequently generating further proposals for activities to be conducted within these programmes. In each case, these proposals were evaluated by independent experts in processes facilitated by the agencies, which were ultimately responsible for the formal funding decisions. The final decision on the total number of strategic areas also lay with the agencies, though this was largely determined by the available budget.

Funding for each SIP is provided initially on a three-year basis, with the possibility of renewal for a maximum of nine further years based on review processes every three years.

To date, there have been three waves of calls asking for SIAs to be formulated and submitted as part of the process of designating SIPs; a total of 16 SIPs had been selected by October 2015. Beneficiaries in the first wave of five SIPs tended to be communities in areas of traditional Swedish strengths (mining and metal mining, metallic materials, lightweight materials, process industries and automation, and production technology) that had prior experience in formulating roadmaps and innovation agendas of this nature. For example, innovation actors in the process-automation area had formulated a research agenda prior to formulating the SIO. Involvement in VINNOVA's VINNVÄXT programme (which aimed to create functional regions united by a common topic beyond county borders) had identified the need to collaborate on a Scandinavian level if Swedish actors were to influence the formulation of relevant policy initiatives at the EU level. This led to the formulation of a research agenda for the industry, which was in place when the SIO was announced and submitted during the first wave of proposals for SIPs. The outcome was the Process Industrial IT and Automation (PiiA) SIP.

Similarly, industrial and academic participants in the Innovair, an initiative focusing on innovation in the aeronautical sector (which formally became a SIP in the second wave), emulated practices within the European Union and formulated a strategic innovation agenda two years prior to the launch of the SIO. The Swedish Steel Association also benefited from many years of experience in working with the industrial steel community to define topics of mutual interest to its members, and from participation in the European Technology Platform for Steel.

In most instances, however, even when communities had prior experience of formulating strategic research and innovation agendas, they were encouraged to broaden the consultative base prior to submitting proposals for SIPs.

Whereas the first wave of SIPs focused on areas of traditional strength and areas (i.e. the mining and steel sectors) specifically highlighted in the 2012 Research Bill as deserving special treatment , the second and third waves of SIPs had a greater focus on some areas more obviously related to societal challenges, in line with the call for SIAs to focus on challenge-oriented areas. The second wave of six SIPs (including Innovair, which was only formally incorporated as a SIP in the second wave, even though it was based on two earlier initiatives that pre-dated the SIO) focused on aerospace, bio-based innovation, life sciences, the Internet of Things, smart electronics and graphene; the third wave of five SIPs covered resource and waste management, automated transport systems, medical and health-related technologies, smart built environments, and transport infrastructure.

In a small number of instances where the panels of independent experts had rejected proposals, the communities were asked to consider resubmitting them after taking into account the existence of overlapping proposals. Thus, communities submitting ten separate agendas related to the forestry sector eventually submitted a combined proposal.

This process of "consolidation" occurred at several stages, including the SIA development stage. In the case of the forest-related agendas, each of the ten agenda-projects developed their own agendas ,but also developed in parallel a joint agenda, which subsequently became the basis for the proposal to establish a BioInnovation SIP. This was not funded in the first round, but was accepted in the second round after it was revised and resubmitted. A similar process took place in the smart electronics field. In an another case, two separate agendas were developed and two corresponding SIP proposals submitted. After rejection, the two agendas were integrated and a considerably revised SIP proposal submitted and accepted. All in all, the integration and redesign of agendas and SIP proposals in several steps performed an important function of bottom-up integration and "gathering of strength" (*kraftsamling*); this process that was only very

"softly" influenced by VINNOVA, as the community of actors came to realise they had to combine their efforts to produce competitive proposals that were worthy of funding.

The nature of SIPs in the SIO

All the SIPs involve a broad range of actors, including universities, research institutes, large companies and SMEs. This considerable breadth distinguishes SIOs from earlier VINNOVA sectoral support programmes or parallel initiatives such as the Strategic Vehicle Research and Innovation programme, all of which tended to involve a more limited set of industry players (e.g. Volvo and Saab in the vehicles programme). Other distinguishing features include the actor-led procedures determining the nature and strategic direction of the SIPs, and the strong role played by these actors in SIP governance.

As of August 2015, 16 SIPs had either been launched or were about to be launched based on the formulation of SIAs. Each SIP is managed by an external project co-ordinator and overseen by a board of directors, which is responsible for designing the SIP activities (often assisted by an appointed "agenda council" comprising select members of the community) and implementing them after they have been sanctioned by VINNOVA.

Table 4.3 shows the range of SIPs involved in the three waves of SIOs[7] and illustrates the diversity of organisations involved in terms of project Co-ordinators, and board chairs and members.

Table 4.3. SIPs in the SIO: Governance aspects of the first wave of SIPs

SIP	Programme office	Organisational affiliation of Board members		
		Global companies	SMEs and other companies	Universities; institutes; public sector; industry assoc.; other orgs.; individuals
First round projects				
Mining & metal production	Luleå University of Technology	**LKAB (2);** Atlas Copco; Boliden; Sandvik	Zinkgruvan	Swerea MEFOS; SGU; Uppsala University; Luleå University of Technology
Metallic materials	Swedish Steel Producers' Association	Sandvik/Seco Tools		**Swedish Steel Producers' Association**; Swedish Foundry Association; Swedish Aluminium Association; Swerea KIMAB; Peter Samuelsson
Lightweight	Swerea	**GKN Aerospace;** AB Volvo; Saab; Scania; Volvo Cars	Biteam; Lamera; Semcon	Swerea SWECAST; Swerea SICOMP; Swerea IVF; KTH Royal Institute of Technology (KTH)
Process Industrial IT and Automation (PiiA)	SICS Swedish ICT Västerås AB	**ABB;** Boliden; Borealis; Midroc; Siemens	Swedish Orphan Biovitrum SOBI	The Swedish Forest Industries Federation ; Swerea; SICS; Måns Collin
Production 2030	Association of Swedish Engineering Industries	AB Volvo; Assa Abloy; Saab; Scania; SKF		The Association of Swedish Engineering Industries (2); IF Metall; Swerea IVF; KTH; Chalmers University of Technology

Source: VINNOVA.

Table 4.4. SIPs in the SIO: Governance aspects of the second wave of SIPs

SIP	Programme office	Organisational affiliation of Board members		
		Global companies	SMEs and other companies	Universities; institutes; public sector; industry assoc.; other orgs.; individuals
Second round projects				
BioInnovation	Swedish Forest Industries Federation	Albany International; Perstorp; SCA	SEKAB; Sveaskog	**Bo Källstrand**; SmartTextiles; Region Västra Götaland; Chalmers University of Technology
SWELife	Lund University	Astra Zeneca; GE Healthcare; Novo Nordisk	APL Apotek Produktion & Laboratorier AB	**Karolinska Institutet**; Göteborg University; Umeå University/RCC North; Lund University (2); Lund Life Science Incubator; Region Skåne; Uppsala Bio; Gothia Forum
Internet of Things	Uppsala University	Ericsson; *ABB; LKAB*	HIQ; Sigma Connectivity; *Teyi Services*	**Teknikföretagen**; SP; KTH; Uppsala University; Malmö University; *Swedish Centre for Innovation and Quality in the Built Environment; ACREO; The Swedish Electronics Trade Association; Swedish M2M Service Enablers*
Electronic Components and Systems	Acreo Swedish ICT	ABB; Saab	Ascilion; Cobolt; Eskilstuna Elektronik-partner; Prevas/Svensk Elektronik; Silex; BW Management Consulting	**Mats Odell**; Acreo; Luleå Tekn University; KTH
Graphene	Chalmers University of Technology	**Saab**	Graphensic; Lindmark Innovation	FOI; SP; Chalmers University of Tech; Uppsala University; *Linköping University*
Innovair	Swedish Air Transport Society	**GKN; Saab**	Brogren Industries; Nordic Aircraft	Swedish Air Transport Society; Swerea; Chalmers; Swerea; FMV; Swedish Armed Forces

Source: VINNOVA.

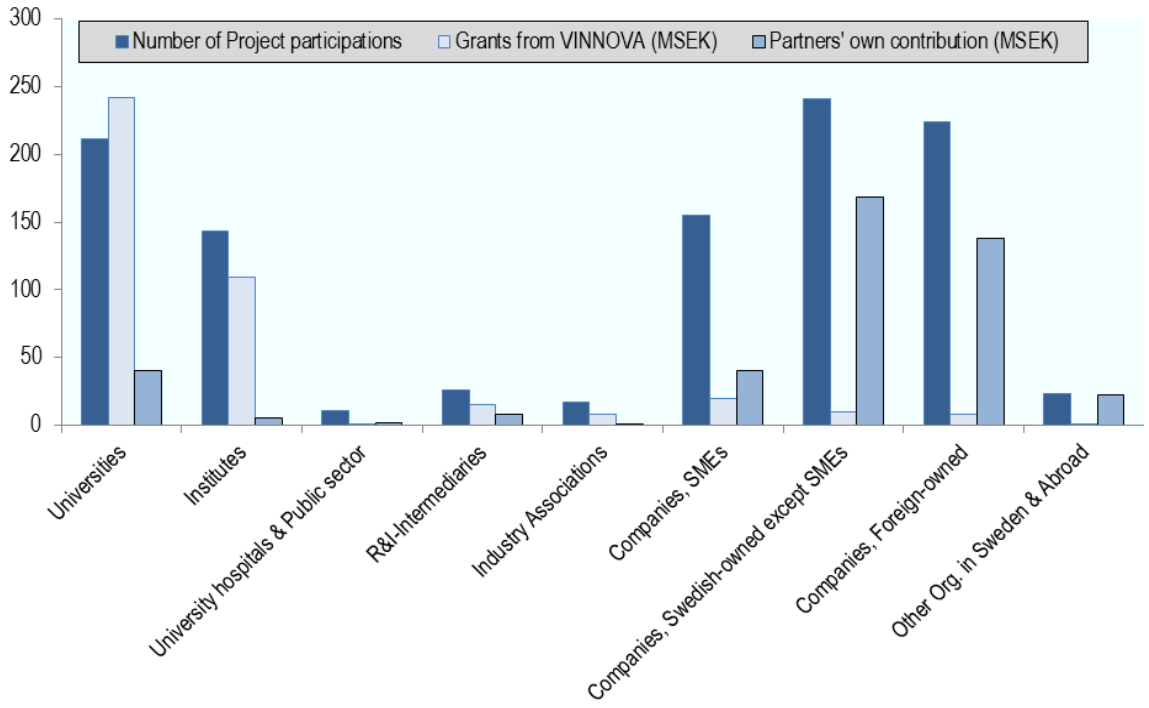
Table 4.5. SIPs in the SIO: Governance aspects of the third wave of SIPs

Strategic innovation programme	Programme office	Board chairperson (according to application)	Organisational affiliation of board members according to application
Third-round projects			
RE:Source	SP Technical Research Institute of Sweden	Christer Forsgren, technical director of Stena Metall	7-12 members with equal representatives from enterprises; society; authorities and research organisations
Drive Sweden	Lindholmen Science Park	Catharina Elmsäter-Svärd (former minister of infrastructure)	Trafikverket; Transportstyrelsen; Stockholm Stad; Forum för innovation inom transportsektorn; Ericsson; AB Volvo; Volvo Cars; Saab; KTH; Lindholmen Science Park
SIO Medtech 4 Health	KTH Centre for technology in medicine and health	Anna Lefevre Skjöldebrand, VD Swedish Medtech	No information
Smart Built Environment	Swedish Centre for Innovation and Quality in the Built Environment (IQS)	No information	The Programme board consists of about 8-10 representatives from companies; public authorities and academia
INFRASweden2030	KTH Road2Science	Tore Nilsson, PEAB	PEAB; Sweco; Skanska; NCC Roads; Atlas Copco/Dynapac; KTH; SIS; Swedac

Source: VINNOVA.

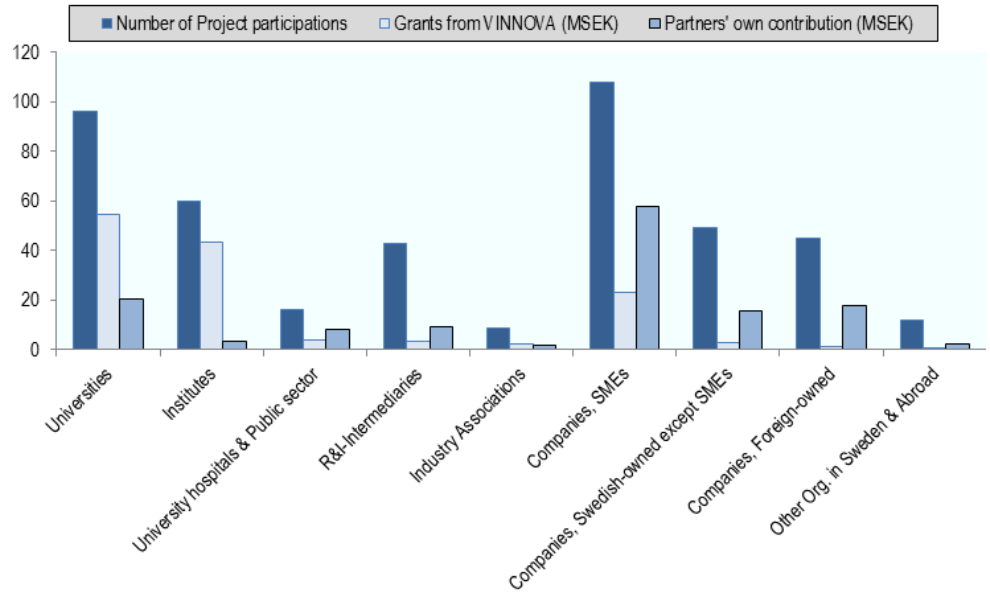
During the OECD mission to Sweden, SIP participants noted that involvement in SIO had considerably expanded their existing networks; and the range of actors now involved in the SIO as a whole is vividly demonstrated in Figure 4.8 and 4.9, which provide relevant data for the first two waves of SIPs. In the first and second waves, universities and other HEIs receive the bulk of public funds, followed by research institutes. It should also be noted that in terms of overall funding levels, the funds available to universities are approximately matched in both waves by the total collective funds associated with industrial participation (including SMEs, larger Swedish-owned companies, foreign-owned companies and companies owned by municipal/county councils), with the bulk provided by industry itself rather than by the public purse.

Figure 4.8. Participants in the first wave of SIPs[8]



Source: VINNOVA.

Figure 4.9. Participants in the second wave of SIPs[9]



Source: VINNOVA.

Further analysis of the data made available to the review team indicated that 30 organisations dominated the funding profile of the SIO in January 2015, with 22 in receipt of public funds. The most prominent, ranked in terms of total funding, were Lulea Technical University, SWEREA AB, Lund University, Swedish ICT Research AB. Chalmers, Luossavaara-Kiirunavaara Aktibolag and KTH.

The range of research areas covered by the SIO is also appreciable. In an analysis conducted by VINNOVA using data available in January 2015, covering the first two waves of SIPs, funding spread across some 20 separate research areas, with approximately 75% of the funds concentrated in just four research areas: mechanical engineering (27%); materials technology (19%); electrical engineering, electronics and information technology (19%); and other engineering (10%). Because of the difficulties associated with classifying multi-faceted projects into categories of research that are difficult to define precisely, these figures should be treated with caution, but they do indicate that projects in the initial waves were strongly related to traditional areas of strength in Sweden.

Analyses of fund distribution by application area, product area and industry sector demonstrate similar patterns. In terms of application areas, work was primarily related to production processes. Similarly, in terms of product areas, projects largely focused on manufactured products. Finally, in terms of industry sectors, approximately two-thirds of the projects were relevant to the motor vehicles, metals, other fabricated metals and other machines sectors. This was most marked in the first wave of SIPs, as demonstrated by the focus of the SIPs listed in Table 4.3, though work spanning other research areas, product areas and industry sectors grew in prominence in subsequent waves (see Tables 4.4 and 4.5).

The nature of projects funded by the SIPs varies enormously. Collecting comprehensive information on the nature of all the individual projects launched to date, or categorising projects – e.g. in terms of Frascati definitions or technology-readiness levels – was not feasible during this review. However, the interviews conducted during the OECD mission to Sweden indicated that the project portfolio contains much that is of interest to academics and industry alike, including examples of work in "breakthrough" technology areas, the production of demonstrators as outputs and plans to include product vendors.

SIP activities

Once initiated, the SIPs are responsible for devising and implementing activities in line with the overall aims of the SIO. These primarily involve launching calls for project proposals (perhaps one or two calls every year for each SIP) and overseeing the implementation of the resulting projects. These calls (which can be for pre-studies or full projects) are designed by the SIPs themselves, with various inputs from programme co-ordinators, board members and consultation exercises, sometimes involving the appointment of agenda councils. Once launched, responsibility for the selection of projects to be funded once again lies with the panels of independent experts constituted by VINNOVA.

This requirement has not been welcomed unequivocally by all the SIPs. Some have argued that they are in a better position to judge whether or not individual projects match the project portfolios they deem necessary to achieve their overall goals. One project co-ordinator argued cogently that informed decisions needed to be taken on the basis of a roadmap of all potential funding flows into an industrial ecosystem (to be developed by the SIP) to avoid allocating funds in areas where gluts might be expected in the near future or to participants likely to be diverted from project goals by their involvement in other initiatives.

That said, VINNOVA has shown some flexibility as the initiative has evolved. In the first instance, VINNOVA took complete control of the selection process once SIPs came to them with a call proposal, with applicants sending their proposals to VINNOVA for review by independent expert panels responsible for assessing their excellence, potential, structure and management. In one SIP, for example, project proposals now go both to VINNOVA and the SIP management, with the VINNOVA review panel classifying projects through a "traffic-light" system (yes/maybe/no), and the SIP commenting on the relevance of all projects to the overall SIP portfolio and advising on the fate of marginal projects. Moreover, it is also now possible to launch individual "strategic projects" without issuing a call if the SIP and VINNOVA both agree with this course of action.

The orientation and selection criteria of the calls and distribution of funding among different calls are mostly decided by the programme leadership. The programmes also carry out a small number of "strategic projects" that are usually larger and organised in a more direct (and usually quite complex) process without open calls. In this case, the funding agencies are responsible for decisions on whether to fund proposals for strategic projects, based on their evaluation of whether the process of developing the proposals has been sufficiently open to potentially interested parties.

Although calls for proposals dominate the activity profiles of the SIPs, they are also responsible for carrying out a range of other activities. These include:

- holding regular (e.g. monthly) meetings of core participants to review progress and take management decisions
- organising regular (e.g. annual) consultations with the SIP communities to continuously assess needs and priorities
- producing roadmaps and commissioning analytical studies (e.g. screening similar initiatives in other parts of the world)
- appointing agenda councils comprising not only board members, but also other members of the community, to update roadmaps and refresh strategies
- organising industry fairs and workshops on specific topics of interest to the community
- organising visits of core members to relevant centres of expertise and policy initiatives in other countries
- using SIPs as a platform to examine relevant EU activities and initiatives, with a view to both shaping these developments and taking advantage of funding opportunities
- attending "sharing" meetings set up by VINNOVA for SIPs to share lessons among themselves.

Some SIPs have also thought about offering direct services to SIP participants, but have felt constrained by concerns about violating state aid rules.

4.3.3 The SIOs in context

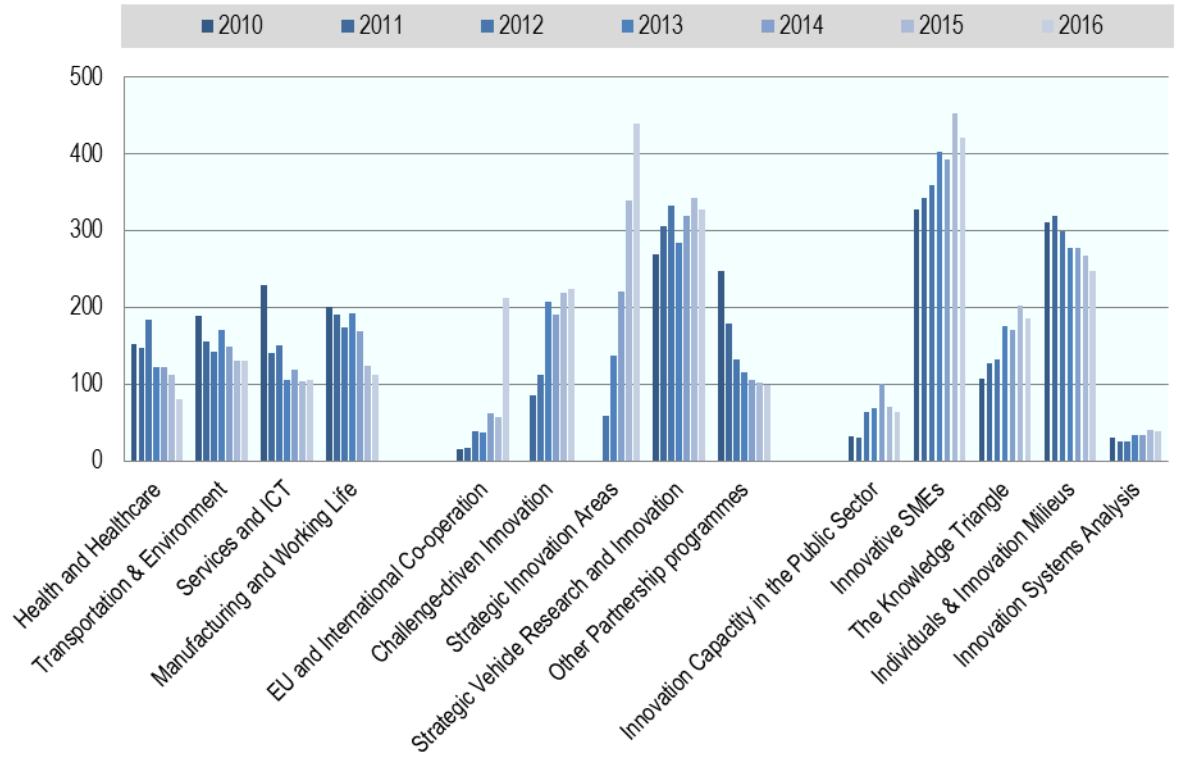
SIOs within VINNOVA

VINNOVA is responsible for managing and co-ordinating a large number of programmes, all of them designed to support aspects of the Swedish innovation system. These can be divided into three main clusters:[10]

- **Thematic programmes,** supporting the development of new knowledge and expertise within thematic areas deemed by the state to be strategically important: these focus on health and healthcare; transportation and the environment; services and ICT; and manufacturing and working life. Many of the programmes started at the end of the last decade and the funding allocated to them has declined annually since 2010, but is now expected to stabilise.
- **Capacity development programmes,** aimed at strengthening the innovative capacity of specific sets of innovation actors: these focus on innovation capacity in the public sector; innovative SMEs (the largest in terms of annual funding in this block of programmes); enhanced interactions between research, innovation and education in the so-called knowledge triangle; and individuals and innovation milieus. This involves creating strong research and innovation networks, infrastructures and milieus, including establishing the Berzelii Centres (based on excellence in basic research, but aimed at developing co-operation with industry); the VINN Excellence Centres (focusing on more downstream development); and VINNVÄXT (competitive research and innovation funding for regional clusters). While most of the programmes covering innovative SMEs and innovative milieus have their roots in initiatives that began in the early part of the 21st century (or earlier in the case of the VINN Excellence Centres), new programmes have been initiated and funding expanded in the public sector and the knowledge triangle.

- **Co-operation programmes,** aimed at pooling resources and creating and strengthening links across borders between different knowledge areas, industries and countries, especially in areas relevant to societal challenges: these focus on EU and International Co-operation and the Swedish Challenge-driven Innovation (UDI) programmes[11] – both of which have seen annual budgets rise substantially over 2010-16 – and partnership programmes. The partnership programmes focus on the needs of specific sectors (e.g. forestry and timber, transport, information technology and telecommunications, mining, steel, bioscience and financial market research) and have existed in various forms since 1994. Existing Swedish sectoral programmes include Strategic Vehicle Research and Innovation – which has benefited from high and generally increasing annual budgets since 2010 – and five other partnership programmes supporting financial market research, the National Aviation Engineering Research Programme and the Green Aviation Demonstration Programme, as well as two smaller programmes supporting rock and mineral products and the construction industry. The decline in "other partnership programme" funding is due to the planned phasing out of industrial-sector programmes initiated in 2006 and 2007. Since 2012, however, funding for the SIO (designed to help broad sets of innovation actors across academia, the public sector and industry prioritise and collaborate in research and innovation areas they deem strategically important) has risen annually and now has a larger annual budget than any other initiative supported by VINNOVA. This is illustrated in Figure 4.10.

Figure 4.10. Funding for VINNOVA initiatives, 2010-16



Source: VINNOVA.

Figure 4.10 and discussions with VINNOVA representatives demonstrate the increasing importance of **co-operation programmes** such as SIOs, EU and International Co-operation, UDI and Strategic Vehicle Research and Innovation, but declining support for other programmes of a sectoral nature. This

also points to the stabilisation of funding for **thematic programmes** and the continued importance of support for **capacity-development programmes,** such as Innovation Capacity in the Public Sector, Innovative SMEs and the Knowledge Triangle, and Individuals and Innovation Milieus.

The most marked feature, however, is growing support for the SIO programme, with its emphasis on devolving responsibility for many aspects of programme management and creating a series of "mini-VINNOVAs" to handle the SIPs, and the parallel decline in support for many older-style sectoral programmes, which are effectively being replaced by the SIO model.

It is also worth comparing the SIO programme with the UDI programme, since the rhetoric surrounding both focuses on innovation that can help resolve societal challenges. The main difference between the two programmes is that UDI more closely resembles a conventional programme involving multiple calls for projects than a series of mini-VINNOVAs. UDI also differs in that it lies closer to the "systems integration" end of the spectrum and to end-users than the SIO; this is apparent from its much greater involvement in projects by the public authorities, although the public sector is likely to be more involved in the last round of SIPs.

The UDI programme also differs from the SIO in another important respect. The projects selected for inclusion in the UDI are dictated by their fit with four overarching societal challenges (related to health care; the development of sustainable cities; the development of competitive and sustainable production regimes; and the evolution of Information Society 3.0). Some might argue that these stretch conventional definitions of societal challenges, but the important point is that projects have been selected on the basis of their potential contributions to these challenges, however they have been defined.[12] By contrast, although the 2012 Research Bill couched the rationale for the SIO in terms of its potential contribution to resolving societal challenges, the first wave of SIPs was not overtly geared to this aim.[13] Indeed, none of the SIO participants interviewed during the course of this review that were involved in these first wave SIPs discussed the relevance of projects to societal challenges, focusing instead on their relevance to industrial needs. Admittedly, the second and third waves of SIPs are more oriented towards societal challenges, but compared to programmes like UDI, the SIO is closer to the technology-driven model than the problem-driven model. In future, however, lessons can be learnt from the UDI programme in terms of including a broader range of participants nearer the end-user part of the spectrum and developing an even stronger orientation towards societal challenges.

Links with other initiatives

All the SIPs are expected to be well informed about activities in the other SIPs and to interact with them in a complementary and synergistic manner. The SIO itself, on the other hand, is not formally linked with any other initiative, either within the VINNOVA portfolio or elsewhere. It is nevertheless relevant to consider its conceptual, informal, unintentional and potential links with other policy strands – especially the SFOs – and procurement initiatives in general.

As noted earlier in the chapter, part of the rationale for the SIO stemmed from a perception that providing additional support to universities operating in SFOs had not resulting in improved links with industry. This was confirmed during the interviews conducted by the *Review* team with industry representatives, many of whom lent their support to universities during the bidding process for the SFOs in the expectation of greater links that failed to materialise. One research institute representative also noted that SFOs had allowed academics to focus once again on core academic research to such an extent that it had allowed the research institutes to step into the breach and improve their own links with industry.

Interviewees from academic settings had a rather different story to tell. Many noted that the additional money received had not been used to strengthen core competences (by allowing existing staff to devote

more time to core research activities), but had been used instead to hire additional staff funded partially out of external sources, thereby increasing the demand on universities to raise the additional resources necessary to feed these staff increases. In other words, rather than use the additional SFO funds to diminish the reliance on external sources in key areas, many universities took the opposite tack and increased this dependence. It is therefore possible to argue that the SIO programme offered an opportunity for academics to gain access to the additional funds they needed to maintain their expanded research capabilities, though the lack of overlap between the SIO and SFO areas makes this unlikely.

Just as no formal link exists between SIO and SFO initiatives, no formal link exist between SIO and procurement initiatives. VINNOVA itself has no funds for public procurement, which will be supported (but not funded) by a new agency in September 2015. Thus, the SIPs are not formally linked with public procurement initiatives, although the new agency will advise all other government agencies. The potential also exists for future liaison with VINNOVA in general, and with SIO and UDI in particular, given their orientation towards societal challenges. These could build on the involvement of local authorities in the UDI projects and innovation-friendly pilots being conducted under the auspices of the Swedish Competition Authority, which encourages "early dialogue" between actors on the supply side (e.g. the Association of Swedish Engineering Industries [Teknikföretagen]) and local authorities on the demand side.

4.3.4 Assessment of the SIO initiative

Goal attainment

Given that the SIO initiative was only announced in 2012 and that the first SIPs only came into existence in late 2013, it is too early to determine the long-term impacts on international competitiveness and the resolution of major societal challenges – i.e. the high-level goals of the initiative mentioned in the 2012 Research Bill. It is also not possible to say whether the initiative has stimulated innovation to a considerable extent, again because it is too early to enumerate or assess the outputs and outcome of projects launched in the SIPs. It is possible to state, however, that the SIO has achieved its initial objective of stimulating innovative activities by enhancing collaboration between an extensive range of innovation stakeholders in areas deemed strategically important by both VINNOVA and a significant proportion of Swedish innovation stakeholders.

Monitoring and evaluation

Funding for the SIPs lasts three years in the first instance, with possible renewal after a review. While the main purpose of the reviews is to provide learning support for strategy development within each SIP, they should also focus on impact assessment. Correspondingly, in order to assess the long-term impacts of the SIO, these reviews should be designed as integral components of a longer-term monitoring and evaluation framework capable of defining, collecting and assessing the data needed to determine whether higher-level objectives have been met.

Issues with SIOs

Although it is certainly true that the different groups of innovation stakeholders responsible for designing strategic innovation agendas and SIP proposals considered their proposed work areas to be strategically important, the agencies in their capacity as budget holders were ultimately responsible for making funds available to 16 separate SIPs, each with its own strategic innovation agenda. This raises the vexing issue of granularity. If too many areas are designated as strategically important, the term "strategic" becomes meaningless; on the other hand, nominating too few strategic areas is also risky if the chosen areas are too generic.

In much the same way that a number of people interviewed by the research team felt that the term "strategic" had been devalued by the decision to support 24 SFOs within universities, they made similar comments about the number of SIPs selected.

In the longer term, it is quite probable that the number of SIPs supported will decline as the need for them fades or mergers and realignments occur, but this number could also increase as new needs arise and new priorities assert themselves. Hence, more thought should be given to the continued use of the term "strategic".

A more serious criticism of the process that led to the constitution of 16 SIPs is that bottom-up strategy formulation processes (even those tempered by top-down control by VINNOVA over the eventual number of SIPs selected) can frequently reflect the short-term needs of particular sets of actors (e.g. different industrial communities) at particular points in the innovation spectrum and fail to reflect the longer-term needs of society as a whole. Broadening the consultative base for each SIP proposal acted as a counterbalance to selected communities' dominance over proposals, but a helicopter view of how all the different proposals fitted together and matched with broader societal aspirations and technical drivers was missing.

This problem can be rectified by a meta-analysis of the different innovation agendas and roadmaps that continue to be produced by the existing SIPs. Such an analysis could in turn inform future decisions about the evolving composition of the SIO portfolio over time.

Exclusion

No matter how inclusive initiatives like SIOs strive to be, some communities are always excluded during prioritisation exercises. While exploring the extent to which various communities of innovation stakeholders were excluded – or even exploring this issue in any depth – was outside the scope of this review team, it remains an issue that VINNOVA should investigate. Topics that are incipient today often become tomorrow's "hotspots", but there is always a danger that a lack of funding opportunities can drive out of the country the communities excluded by the prioritisation exercises as they search for funds elsewhere.

Ring-fencing

While the SIO represents a shift away from a historical focus on "conventional" sectoral programmes within the overall portfolio of VINNOVA support initiatives, continued government commitment to providing support for some sectors outside the SIO framework – e.g. continued support for firms associated with the automobile industry through the Strategic Vehicle Research and Innovation programme – is still apparent. Similarly, continued support for specific themes (e.g. health and healthcare, and transportation and the environment) can also be considered an example of top-down prioritisation outside the SIO framework.

Conversely, although the 2012 Research Bill called for a specific focus on the mining and steel sectors, these have been dealt with under the SIA umbrella.

It is too early to comment on the comparative merits within the VINNOVA portfolio of "top-down" versus "bottom-up" initiatives. Both have merits on paper, and it is probably wise for any portfolio to contain elements of both to allow governments to respond to both their own specific priorities and those reflecting the broader needs of multiple research and innovation stakeholders. As experience with SIO mounts, however, due consideration will need to be given to the desirable balance between top-down and bottom-up initiatives in the VINNOVA portfolio.

Spread and scale

One of the aims of the SIO was to reach an expanded target audience, both in terms of their involvement in the preparation of research and innovation agendas, and their subsequent involvement in SIPs. The SIO achieved this aim, and all interviewees commented on the greater number of people actively involved in SIO-related activities. However, this has not happened without drawbacks. One drawback involves the inability to fulfil raised expectations: when responding to the calls launched by SIPs, larger numbers are competing for quite limited financial pots (SEK 30-50 million per SIP), with the result that many are unsuccessful and receive no funding, while even those that are successful can receive relatively small amounts. While it is often the newcomers to the expanded innovation communities that are disappointed, in some instances "core members" of particular stakeholder communities talked of "new" members "hijacking" agendas.

There are always winners and losers in competitions for financial support; furthermore, change is never welcomed by all, so some of the complaints about the disruptive effects of the SIO are not unexpected. The challenge is how to manage expectations in the future, which will require giving more thought to attractive risk-reward ratios. Stakeholders are unlikely to maintain interest in an initiative when the probability of success and the resulting financial support levels are low.

Although it was not the specific intention of the SIO to link with research activities supported by the SFO initiative within universities, this is likely to have occurred as a consequence of universities using SFO funding to fund extra staff that were partly dependent on external funding. While the alignment of core university research strengths with the more innovation-oriented agendas of broader innovation communities is to be welcomed, an open-ended, serendipitous ratchet mechanism of this nature is unsustainable in the longer term. Ideally, the levels and forms of support for research and innovation provided by the two main ministries responsible for these activities (the Ministry of Education and Research and the Ministry of Enterprise and Innovation) and the interactions between these support mechanisms should be less dependent on chance.

Links with capacity development

A significant proportion of the VINNOVA budget over the past decade has been expended on capacity development programmes. Because it supports collaborative ventures between industry and academia, the SIO can be seen as a complement to capacity-development programmes (Innovative SMEs) aimed at SMEs and enhanced interaction between research, innovation and education (Knowledge Triangle). There is also a strong conceptual link with *Individuals and Innovation Milieus*, which is aimed at the creation of strong innovation networks, infrastructures and milieus, but in practice the links between some of the centres created through this initiative (the Berzelii and VINN Excellence Centres) and with initiatives supporting regional development (VINNVÄXT) are tenuous and serendipitous rather than the result of overt planning. There is scope, therefore, for a more considered approach to the involvement of these centres and regional developments in SIO-related activities if their full potential within the Swedish innovation system is to be realised. There is potential for this to occur as a new round of centre funding is being planned.

Outsourcing

The devolution or outsourcing of some of the administrative burden associated with programme management through the constitution of mini-VINNOVAs is one of the characteristics of the SIO programme. VINNOVA and the other agencies still carry some of the burden (in that they are responsible for handling applications and facilitating selection processes), but external programme management is

responsible for "mobilising" actors in the different innovation areas to a far greater extent than would be possible if programme management resided within the agencies.

While this gives innovation stakeholders in the SIPs a great degree of control over the content and focus of public support, final selection decisions for SIPs and their projects remain the responsibility of the independent expert panels appointed and overseen by VINNOVA (and the other agencies). In some instances, there was early opposition to VINNOVA's insistence that it retain oversight of the selection process for calls launched by the SIPs,[14] with SIP participants arguing that the SIP management teams were in a better position to make such judgements. VINNOVA appears to have listened sympathetically and adjusted its procedures to allow SIP members a greater say in these decisions, while still retaining overall oversight of the selection process. This flexibility is welcome, but should not be overdone. Checks and balances are needed between benefactors and beneficiaries to meet demands for public accountability.

Transience and renewal

One of the short-term aims of the SIO programme was to stimulate collective research and innovation agenda-setting among a broad community of actors, and in this respect the initiative has been successful. However, an important issue to be considered for any government policy initiative is whether it has stimulated activity that is transient and unlikely to be repeated, or whether it has stimulated activity of a more permanent nature. In turn, this raises a number of questions about the process and frequency of agenda-setting, which has implications for the long-term viability of the SIO.

Many programmatic interventions follow the normal logic of strategy formulation and agenda-setting, followed by implementation and action, with the cycle repeating itself after a set period of a few years. While there is much to recommend this pattern of behaviour, the dynamic nature of scientific and technological change, and constantly evolving societal and market needs, argue for a more continuous form of horizon-scanning and agenda-setting, even though activity of this nature is time- and resource-consuming. Scope therefore exists for striking a balance between "cyclical" and "continuous" agenda-setting.

Within the SIO, this balance needs to be considered at two levels. At the level of each SIP, processes need to be in place to continually update the agendas that inform the calls being launched. It was gratifying to note that many of the SIP participants interviewed mentioned the existence of activities designed to update roadmaps and innovation agendas – an explicit VINNOVA requirement. It was also interesting to observe that VINNOVA has encouraged SIPs to share lessons, providing opportunities for comparing agendas, cross-fertilising and achieving synergy.

That said, triggering a continuous process of collective research and innovation agenda setting among a broad community of actors leaves some scope for steps designed to:

- encourage all SIPs to start thinking in terms of continuous modes of agenda-setting
- encourage existing SIPs to establish links with other SIPs and involve their actors in future rounds of agenda-setting
- ensure that actors not currently engaged in SIPs are involved in future agenda-setting activities
- encourage SIPs to think globally rather than nationally, taking note of agenda-setting activities abroad (e.g. in the European Union); become involved in advocacy platforms (as some have already done); and even think about including cross-border actors in agenda-setting activities

- build links between the actors involved in other innovation system domains covered by VINNOVA – e.g. with the Berzelii and VINN centres, and with the communities involved in initiatives such as CDI, Innovative SMEs and the Knowledge Triangle

- explore how agenda-setting within the SIP communities can both influence and be influenced by other relevant activities outside the sphere of VINNOVA's responsibilities, e.g. research agenda-setting within individual universities

- explore links with the activities of the new agency established to deal with innovation-friendly public procurement.

At the level of the SIO as a whole, scope exists for articulating an "agenda-renewal" strategy outlining intentions concerning the "granularity" of the SIO (in terms of the number of SIPs within it) and the periodicity and form of overarching agenda-setting exercises that could inform related decisions. A review of each of the SIPs is currently scheduled after three years, and it is likely that decisions taken at this review point will affect the overall number of SIPs as some stagnate or reach the end of their natural lifetime, some are merged with others, and some continue to survive and blossom. But no stated plans, schedules or criteria currently exist for assessing desirable levels of granularity against holistic roadmaps of scientific and technological changes or overviews of pressing societal needs. The danger, therefore, is that the SIO landscape evolves piecemeal, rather than in a process informed by a higher-level overview of Swedish needs. This needs to be avoided inasmuch as possible.

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[1] Many of these concern the existence or not of a "Swedish paradox" that questions why high R&D intensity does not show up in high-tech exports, though this is fairly easily explained (a) by the fact that much of the R&D performed in Sweden by multinationals feeds into goods manufactured elsewhere; and (b) by noting that a large part of the R&D conducted by the business sector concerns vehicles, which are not classified as high-tech products.

[2] In Figure 4.1, R&D activities performed by private-sector industrial institutes are classified alongside those of private-sector firms.

[3] The information technology cluster in Stockholm is in fact made up of two rather different parts: the long-established Ericsson-centred cluster in telecommunications and a new developing cluster of Internet-based service companies (e.g. Skype, Spotify, Klarna, Mojang, King) that are highly international and sometimes no longer headquartered in Sweden. Nevertheless, they must be considered as a newly emerging high technology cluster.

[4] It is not clear from the Malm Commission documents whether they were also expected to handle the sector-specific needs of government, but this was certainly the case by the 1970s.

[5] VINNOVA currently provides the bulk of funding for the SIO, with other contributions coming from Formas and the Swedish Energy Agency (Energimyndigheten).

[6] While recognising that Formas and Energimyndigheten also provide funding for areas within their remits, we shall henceforth refer only to the primary government agency involved in funding activities within the SIO, unless otherwise specified.

[7] The structures shown for the third wave are those indicated in programme applications.

[8] Figure 4.8 does not show Innovair, since its constituent parts (NFFP 6 and Green Demo) where already in place and funded when the SIP Innovair was established and provided with funding for its Programme Office.

[9] Figure 4.9 does not show 'Innovair', since its constituent parts (NFFP 6 and Green Demo) where already in place and funded when the Strategic Innovation Programme Innovair was established and provided with funding for its Programme Office.

[10] The terminology used here (Thematic, Capacity development and Co-operation programmes) differs from that used by VINNOVA on its website (http://vinnova.se/en/Our-acitivities/). This is intended to avoid confusion, e.g. between "strategically important areas" (Thematic programmes) and "strategic innovation areas" (a subset of the "cross-border co-operation" category).

[11] In Swedish, "challenge-driven innovation" (CDI) is "*utmanningsdriven innovation*" (UDI). This began in 2011 and thus had a zero budget in 2010.

[12] The challenge areas are very broad, but it is important to note that the projects within them have to address specific societal challenges and involve the "users" and the "owners" of the challenges.

[13] That said, issues related to environmental impacts, and the efficient and sustainable use of resources, did figure prominently in the first round of programmes as these are important from an industrial perspective, and "lightweight SIP" is totally motivated by the desire to reduce energy consumption and climate impact.

[14] Albeit through the appointment of independent expert panels.

CHAPTER 5. RESOLVING SOCIETAL CHALLENGES IN SWEDEN

Sweden's role in the development of the Lund Declaration while it held the presidency of the European Union in 2009 raised expectations about the role of research and innovation – and in particular, the role of Sweden – in tackling major societal challenges.

This chapter tracks the historical development of links between research, innovation and societal challenges in the United States and Europe before focusing on two areas of Swedish activity signalled in the 2012 Research Bill: the launch of a national UDI initiative and measures designed to improve Swedish engagement with co-operative research and innovation activities in Europe, especially those relevant to societal challenges.

5.1 Research, innovation and societal challenges

5.1.1 Models of research and innovation policy

Research and innovation policy since the Second World War has successively been based on three models:

- **The "linear" model** is based on the premise that basic research results drive applied research and the eventual application of new knowledge to innovation and society. The policy implication is that – provided basic research and the scientific community more broadly are well funded – this would generate a societal return ensuring economic and social development.

- **The "interactive" or "coupling" model** (discussed these days in terms of "national innovation systems") emphasises the role of knowledge demand as well as supply in the industrial innovation process, the multi-actor nature of innovation and the role of learning and institutions in successful innovation. The policy implication was that the state had to ensure that multiple actors and processes work and interlink well if an innovation system is to perform well. It triggered the birth of innovation agencies, collaborative research funding and a range of capacity-building measures to improve the overall operation of the innovation system. The large number of actors involved implied a need for strategic intelligence and policy co-ordination that was not so strongly implied by the previous model.

- **The "societal challenges" model** is now emerging, featuring a new driver for science, research and innovation policy. This means looking beyond impulses and opportunities stemming from research and signals about innovation needs from markets to launch policies founded on perceived societal challenges, which need tackling at the international and national levels. Resolving these societal challenges is likely to involve significant transitions in social and technological systems; neither science alone nor the market provides an adequate guide to needs, and the problem of forming and implementing strategies across multiple disciplines and sectors of society is implicitly more complex than in the "interactive" model. If strategy, governance and co-ordination were important under the previous model, they are doubly so now.

These three models are not alternatives, in the sense that *all* research and innovation funding moves from the old to the new model each time the model shifts. Growth in basic research funding continued as

innovation policy was overlaid on traditional research policy. In doing so, it attracted additional basic research activity in some areas, thereby affecting the "shape" of the basic as well as the problem-oriented research effort, but the "linear model" form of R&D funding was not abandoned despite the growth of innovation-related funding. Similarly, a shift to the third model is also unlikely to lead to wholesale abandonment of earlier models, but it will undoubtedly lead to some changes, not all of which can presently be foreseen.

5.1.2 The US approach to societal challenges

Government support for research directed at social purposes is by no means a new phenomenon. In the United States, the much discussed post-war "endless frontier" social contract between science and society (see Bush, 1946), under which science was seen as a self-governed community dedicated to generating knowledge with minimal government steering, only relates to one part of the picture. During the five years or so between the publication of Bush's report to the President of the United States and the formation of the National Science foundation, the mission-oriented federal executive departments successfully argued that their own research needs would not be met under a system of researcher governance and that they needed to control their own research budgets and agencies if they were to play their appointed roles in society. The major share of government R&D funding during this period was allocated to programmes and organisations established to support the mission of specific government agencies or departments. Such programmes have existed, and indeed dominated government R&D budgets, across many OCED countries at least since the 1950s (Mowery, 2009).

Mission R&D has been described as "big science deployed to meet big problems" (Ergas, 1987). In the United States, government mission R&D has had a bias towards "high technology", particularly defence and space technology (Lundvall and Borrás, 2005) but also massively health, through the National Institutes of Health (NIH). In an influential analysis, Ergas (1987) contrasted the "mission-oriented" technology policies of the United States, France and the United Kingdom with "diffusion-oriented" policies in Germany, Switzerland and Sweden. The first group of countries was characterised by central decision-making, a focus on national sovereignty and defence-related R&D investments, while the second group used decentralised systems and focused on diffusing technology in order to realise social goods. In reality, a significant share of Swedish research funding went to defence-related R&D; for many years, the Swedish Defence Research Agency was by far the largest institute, and most government funding of industry R&D was – and still is connected to defence- equipment procurement.

Two iconic examples of mission programmes in the United States are the Manhattan Project – designed to build the atomic bomb in order to aid the war effort during the Second World War – and the Apollo Project – which occurred in the context of the "space race" during the Cold War and resulted in the first manned expedition to the moon.

Other mission programmes are more recognisable from the perspective of current debates on societal challenges in areas such as health, agricultural policy and energy. One significant area of government funding, for example, has been biomedical research: the NIH agency has been a major source of science funding since the post-Second World War period and is the largest US federal government research funder. The NIH balances a variety of demands, funding biomedical science but also accommodating calls from policy makers and advocacy groups to address health issues. For example, "big-push" funding in the 1960s and 1970s was allocated to disease-specific research such as the Artificial Heart Program and the War on Cancer, both inspired by the Apollo programme (Sampat, 2012).

Debate is ongoing, however, about the contribution of US mission-oriented programmes to resolving current societal challenges. As one prominent observer has pointed out, while the United States managed to

put a man on the moon, they did not make much progress with childhood education in "the ghetto" (Nelson, 2011).

The Apollo and Manhattan programmes have been invoked in current debates. Policy makers and others have pointed out the need for a Manhattan-style project for climate change, carbon-free power technologies or biofuels (Mowery et al., 2010). The White House declaration on Grand Challenges cites the Apollo programme as one of three past examples to imitate (Obama, 2013). However, these programmes arguably provide poor models for current challenges: whereas the Apollo and Manhattan programmes were centrally managed with government as the sole costumer, current challenges are much more complex, relying on a multitude of actors for both funding and implementation. Indeed, while the two programmes focused on the *supply* of a specific technological solution to a well-defined problem, solutions to current challenges must involve policies promoting the *demand* for and *adoption* of new technologies (Foray, Mowery and Nelson, 2012; Mowery, Nelson and Martin., 2010).

Foray, Mowery and Nelson (2012) argued that mission R&D and societal challenges are indeed related. While they concede that the Manhattan and Apollo programmes do not provide good models for the kind of societal challenges policy makers face today, many other mission programmes were much broader and more complex. In effect, they treated societal challenges as a type of R&D mission. The authors argue that many mission R&D programmes can inform current decisions on societal challenges.

Examples of potential lessons to be drawn are as follows:

- Defence: the use of public procurement was vital, but since government was the sole costumer, the "adoption environment" was different than the environment faced in many current societal challenge areas; there was no need to work with users to encourage technology adoption (Mowery, 2012).

- Agricultural research: this area is characterised by close collaboration with users, but also carries the risk of "agency capture", which can lead to an undue focus on short-term, incremental improvements of existing technologies as opposed to long-term transformation (Wright, 2012).

- Health research: the NIH exemplifies the tension between fundamental research and more concrete efforts to improve health by addressing specific diseases or problems. The mission agency has successfully navigated the various pressures and balanced demands (Sampat, 2012).

- Energy research: a comparison of the United States, the United Kingdom and China shows that energy R&D can be organised very differently, responding to multiple missions rather than a single mission (Anadón, 2012).

Nonetheless, mission programmes have similarities with programmes aiming to tackle societal challenges. They are demand-driven, and defined by a need identified in society, and they often involve linking up basic and applied research from multiple disciplines and user interaction (e.g. agricultural R&D) and/or public procurement (e.g. defence).

The main difference between post-Second World War mission programmes in the United States and today's efforts to combat societal challenges is that the post-war programmes strongly identified the mission with specific agencies or Departments of State (Hicks, 2014,). One of the key features of societal challenges is the broad, horizontal nature of the problems and the need to co-ordinate among sector ministries and in many cases with local and regional public (and private) actors. While the mission perspective has a limited set of actors, as well as a narrower focus on R&D and funding, and "achieving the mission", the open-ended nature of many of today's societal challenges' precludes such narrow

approaches (Kuhlmann and Rip, 2014). Nevertheless, envisaging societal challenge initiatives as "missions" arguably provides them with a much-needed focus.

The "challenge" vocabulary was first used in US science policy in the early 1990s by the Office of Science and Technology Policy (OSTP), initially in relation to a technological challenge with multiple applications rather than a specific societal challenge, and later with reference to ten Grand Challenges: forecasting severe weather; cancer genes; predicting new superconductors; air pollution; aerospace vehicle design; energy conservation and turbulent combustion; microsystems design and packaging; biosphere; high-speed networks; and education-using networks (Hicks, 2014).

Beginning in the late 1990s, the "challenge" vocabulary was adopted more widely, notably by the National Academy of Sciences and the Bill and Melinda Gates Foundation. A decade later, it made its way into the White House's 2009 Strategy for American Innovation which proposed a list of eight challenges. Following a Request for Information for "Grand Challenges of the 21st Century", a new list of five challenges was included in the 2011 update of the innovation strategy under the heading "Catalyze Breakthroughs for National Priorities". The list covers areas such as clean energy, Health Care and educational technologies. In 2012, a White House official defined the Grand Challenges as possessing the following key elements (Kalil, 2012):

- Grand Challenges have major impacts in areas such as health, energy, sustainability, education, economic opportunity, national security and human exploration.
- They must be ambitious, but achievable.
- They are compelling and intrinsically motivating, and should capture the public's imagination.
- They should have measurable targets for success and timing of completion.

5.1.3 Evolution of the societal challenges concept in the European Union

Societal challenges in areas such health and environment have been policy concerns of the European Union almost since its formation. However, by the mid-1990s, despite the important role scientific research had played in identifying and describing phenomena such as climate change, very limited discussion had taken place of the broader R&D and innovation policies that would be needed in the future to further define societal problems and help society deal with them. To rectify this, the European Commission decided to stimulate a policy discussion on the topic. In the field of climate change, for example, it set up an Expert Group to consider "Climate Change and the Challenge for Research and Technological Development Policy" (European Union, 1998).

Momentum built throughout the early 2000s in a context where the Commission was attempting to construct a European research area ([ERA] see European Union, 2000) and foster the formulation of coherent, holistic policy mixes responding not only to the challenge of raising R&D intensity, but also to the broader need to nurture and maintain healthy research and innovation ecosystems (European Union, 2003). In 2008, societal challenges took centre stage in policy discussions with the publication of a Green Paper reviewing the rationale behind the ERA (European Union, 2008).

In the Green Paper (European Union, 2008; see also Georghiou and Cassingena Harper, 2007; and Georghiou, 2008), the Expert Group recommended making "grand challenges" the central element of a new ERA strategy. It argued that previously expressed rationales for the ERA focused too one-sidedly on failures within public research systems, e.g. issues of "fragmentation" or "lack of co-ordination". Instead, the Expert Group argued that research and innovation policy should be seen as part of a broader "European

research and innovation ecosystem" or as a set of "research friendly ecologies" linked to societal and economic spheres well beyond the confines of research itself. Grand Challenges were meant to "capture the imagination" of researchers, policy makers and the wider public by focusing on the contribution of research to areas with obvious social and economic benefits. The grand challenges described in the Green Paper presented the following characteristics (European Union, 2008):

- The challenges are "both economic and more broadly concerned with social and environmental goals".
- Grand challenges can help "shift perceptions as well as focus from deficit to opportunity".
- They concern demand-side as well as supply-side conditions.
- EU-level grand challenges can act as catalysts for "larger efforts from Member States and partners in business and societal groups".
- Grand challenges must be of "sufficient scale and scope" to gain attention, and be "few in number at any moment".
- Grand challenges are selected on the basis of relevance to Europe and to R&D, and to the feasibility of tackling them via approaches involving R&D and innovation.

EU policy makers and stakeholders quickly embraced the "challenge" approach. In July 2009, a year after the initial Expert Group report, the so-called "Lund Declaration" was published during the Swedish EU presidency. In the Declaration, representatives from research organisations, public research funders and private businesses declared their support for the "grand challenge" approach and called on the European institutions to develop viable ways of implementing such an approach. Another EU Expert Group then published a report on "The Role of Community Research Policy in the Knowledge-based Economy" (European Union, 2009), which again recommended focusing European Community policies on the direction and rate of technical change, focusing in particular on channelling EU and national research funds towards resolving societal challenges.

The following year, an EU Communication on the Innovation Union (European Union, 2010a) and an accompanying Commission Working Paper (European Union, 2010b) presented a framework for future EU R&D and innovation policy, stressing the importance of a strong focus on societal challenges. The Communication noted in particular that Europe must develop its own distinctive approach to innovation, building on its strengths and capitalising on its values by focusing on innovations that address major societal challenges, strengthen leadership in key technologies, reap the potential these markets offer for innovative businesses and enhance EU competitiveness. It argued that innovation must become a key element in EU policies, and that the European Union must use the public sector's strong potential in areas such as energy and water, health, public transport and education to bring new solutions to the market (European Union, 2010a).

In the eighth EU Framework Programme for Research and innovation, H2020(2014-20), the challenge approach – with the prefix "societal" instead of "grand" – was adopted as one of the three main priorities, alongside "Excellent science" (i.e. the European Research Council) and "Industrial leadership". "Societal challenges" accounted for almost EUR 30 billion (euros) of the Framework's EUR 77 billion budget (Official Journal of the European Union [OJEU], 2013). In the context of Horizon 2020, "societal challenges" should:

- respond directly to the policy priorities of the European Union's overarching strategy, Europe 2020
- not only address societal issues, but also represent major economic opportunities
- bring together resources and knowledge across different fields, technologies and disciplines
- directly support the corresponding sectoral policy competences at EU level, where appropriate
- contribute to the overarching objective of sustainable development.

5.1.4 Recent societal challenge developments in Sweden

The Lund Declaration on European Grand Challenges was published under the Swedish EU presidency in 2009. As such, the expectation in many quarters was that Sweden would take the lead in pioneering the search for viable means of implementing societal-challenge approaches across its R&D and innovation portfolio. To date, however, even though thematic and sectoral priorities in Swedish government funding include typical "challenge" areas (e.g. environmental and energy research), the "societal challenge" concept has not been used in overtly to frame overall policy (Hallonsten, 2014). Swedish R&I funding stemming from the government is mostly "generic" and to a large extent goes directly to universities. A consequential use of the concept can be found at the agency level, where VINNOVA in particular has adopted a programme specifically aimed at UDI. The next sections cover this development and Sweden's overall response to EU-level developments.

5.2 The Challenge-driven Innovation (UDI) initiative

5.2.1 Origins and objectives of UDI

A conference entitled "New World - New Solutions" was organised during the Swedish presidency of the European Union in 2009. One outcome was the Lund Declaration, which placed great emphasis on the need to gear STI activities to resolving major societal challenges in the areas of global warming and access to energy, food and water, the ageing population, health, pandemics and security. This Declaration, which built on the recommendations of the ERA Rationales Expert Group (European Union, 2008), emphasised the importance of the following characteristics:

- a shift towards a focus on societal challenges and away from rigid thematic approaches
- the adoption of an approach including global public and private stakeholders
- the evolution of a process "owned" by the European Union, but involving the alignment of national initiatives.

The OECD has also stressed the need for innovation strategies based on these global societal challenges that necessitate collaboration between the worlds of politics, business and research (OECD, 2014).

Following the Lund Declaration, a conference was organised in Sweden to discuss the Swedish response, with VINNOVA identifying the need to develop more effective support for UDI. After a thorough strategy review in 2010 and a series of different workshops organised in early 2011, VINNOVA launched the new UDI (*Utmaningsdriven innovation*).

UDI was stuctured around four societal challenges – – all areas where there was potential for internationally pioneering innovation – identified during the course of consultations with a broad range of stakeholders in the Swedish innovation system. They were:

- **Future healthcare** – stimulating business opportunities and social benefits for better health and care
- **Sustainable attractive cities** – fidning new solutions in areas such as environment, energy, transport and community building
- **Information society 3.0** – developing new and secure IT solutions and services that can be accessed by more users
- **Competitive production** – attaining flexible, resource-efficient and integrated production of sustainable goods and services.

This list does not immediately match widespread conceptions of commonly accepted societal challenges, although all topics are pertinent to a range of scientific and technological challenges and problems that will need to be resolved in order to tackle if a host of societal challenges. At first glance, the elements dealing with Information society 3.0 and Competitive production, for example, sound more like conventional support for industry and sector-based research and innovation, but it is also true that significant advances in the development of adequate solutions to many societal problems will need to be made in these areas.

The list's composition can best be explained by the fact that the consultation exercise it relied on was also tempered by some pragmatism within VINNOVA. The new UDI programme was planned over the budget period defined by the two Research and Innovation Bills of 2008 and 2012. Consequently, resources for this period were committed and there was little in reserve to design and launch a completely new programme prior to announcing the contents of the 2012 Bill. The relatively new management team within VINNOVA therefore decided that since the challenge areas partially overlapped the areas of responsibility of four VINNOVA divisions, reconfiguring and re-orientating some existing programmes within the VINNOVA portfolio was the most realistic way of capturing the benefits of low-hanging fruits, with the further prospect of building on and strengthening the societal-challenge orientation if the 2012 Research Bill allocated budgets for this purpose.

The goals and objectives of the UDI programme are numerous. According to information provided by VINNOVA, the "impact goals" of UDI are :

- generate solutions that contribute to green and socially sustainable growth
- generate solutions that can be sold on the international market
- create new business opportunities/market segments or realise radical cost savings by developing new goods, services, processes or other solutions
- strengthen Sweden's attractiveness for conducting research and innovation and attracting foreign direct investment
- increase Swedish participation in EU research programmes aimed at increased competitiveness and societal challenges (e.g. Horizon 2020) or other international initiatives.

The basic objectives of the UDI programme have remained constant since its inception in 2011. They are in line with the overall objectives of VINNOVA.Three high-level general objectives have additionally been defined:

- less fragmentation and improved operational focus and resource mobilisation, mobilsiing . actors so that they have the capability and networks to work in a challenge-driven manner
- innovative cross-sector solutions that turn threats into opportunities and unleash undiscovered innovation opportunities on the market
- Increased user- and demand-driven innovation initiatives that balance traditional supply-based science and technology schemes.

These impact goals and objective are very broad. Rather than define highly specific goals, VINNOVA specified the principles of a challenge-driven approach (Box 5.1). VINNOVA requires each project to "convincingly and coherently explain and illustrate the project's impact logic (i.e. activities, results and effects) and its relation to the programme's more general goals and objectives". In other words, project leaders have to take responsibility for defining both the specific challenges addressed and the associated project goals. Three aspects of UDI projects in particular are important to VINNOVA: the projects' cross-sectoral dimension; strong early-stage customer involvement in projects; and the production of implementable results.

Box 5.1. UDI principles

VINNOVA has specified the attributes and principles of a challenge-driven approach as follows:

- Demand in focus, not technology: technology is only one component of the solution portfolio. The needs addressed should be critical for society and industry, and users/customers should be actively engaged in the project.
- A cross-functional and cross-sectoral approach must be adopted, since solutions to societal challenges are rarely found in one traditional sector or a single research field.
- A systemic approach is needed in order to ensure that solutions can be implemented, and resistance from the system in which the challenge has emerged can be overcome.
- Projects must take responsibility for long-term effects that will occur many years after project closure, and not just short-term results that can be realised within the timeframe of the project. This may, for example, mean that projects need to engage in discussions with politicians and civil servants.
- Innovation must be at the centre of attention, not developing new knowledge or producing high-ranked scientific papers.

Source : VINNOVA.

5.2.2 Implementation

Overall management

VINNOVA is responsible for managing the UDI programme. Other relevant agencies play an active part in some projects, e.g. the Swedish Transport Administration Trafikverket is involved in several traffic and city-related projects. VINNOVA is advised by a programme committee, an externally appointed group that assists with strategic development and assessing applications.

Project stages and selection procedures

The UDI programme currently involves a three-stage process:[1]

- **Stage 1: initiation**. The goal of this stage is to refine a project idea and develop the network of actors around a societal challenge. Proposals are solicited for projects within the four broadly defined challenge areas (Future healthcare; Sustainable attractive cities, Information society 3.0; Competitive production). This stage lasts six to nine months and the funding from VINNOVA is limited to SEK 500 000 (kronor), making up at most 80% of the total project cost.

- **Stage 2: collaboration**. The goal here is development and integration. The stage can last from 24 to 30 months and funding from VINNOVA is limited to SEK 10 million, making up at most 50%of the total project cost.

- **Stage 3: follow-up investment**. The objective at this stage is to test, implement and utilise the results of the project. This stage lasts at most 24 months. Funding from VINNOVA normally ranges between SEK 5-20 million, making up at most 25-40% of the total project cost.

This is a stage-gate model. For Stage 1, the calls are open. For the other stages, only projects that have completed the previous stage are invited to present proposals.[2] Currently, open calls for proposals are launched twice a year. VINNOVA attends all project-selection meetings and is strongly involved in project follow-up.

Reactions to the programme among relevant Swedish stakeholders appear positive. From the perspective of VINNOVA, the stage-gate model appears to have exerted positive pressure on participants to develop a high degree of genuine and purposeful co-operation.

VINNOVA uses external experts to evaluate project proposals but is itself responsible for the final decisions.

An evaluation takes place at each stage of the model. The screening process is extremely thorough. To date, 257 proposals have entered Stage 1, but only 18 are currently in Stage 3.

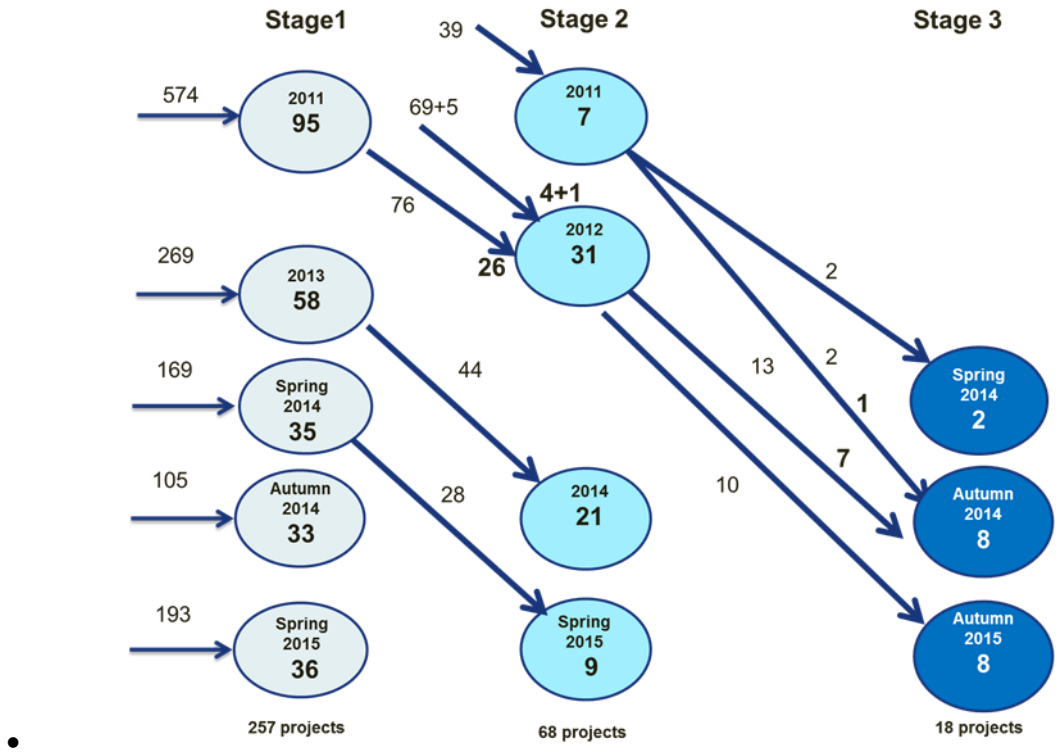
The small number of Stage 3 projects is the combined result of attrition at each stage-gate and the time it takes for projects to work their way through the stages. Of the Stage 2 projects started in 2012, only one was submitted for Stage 3 in the autumn 2015 call and is currently being evaluated. Where the Stage 2 projects funded in 2014 are concerned, applications for Stage 3 are not expected until the spring of 2014 at the very earliest ,and probably later in most cases.

Much discussion about suitable indicators for assessing the progress and eventual success of the programme projects has taken place during the evaluation meetings. To date, no general conclusions have been drawn, largely as a consequence of the highly varied nature of the projects selected to date. The

pressure is now mounting to determine the indicators, as the first Stage 3 projects are due to be completed in early 2016.

Figure 5.1 illustrates the funnel logic of the UDI selection process, with a very broad range of applications for Stage 1 projects resulting in a much smaller number of well-articulated and funded Stage 3 projects.

Figure 5.1. Number of applications and granted UDI projects



Source: VINNOVA (2015).

To date, VINNOVA has launched 5 calls and received 1324 applications for Stage 1, of which 257 have been accepted – a success rate of almost 20% (19.6 %). Of this cohort of 257, 144 out of the 188 selected in the first 3 calls were subsequently considered as eligible for Stage 2, but only 56 actually became Stage 2 projects. This smaller number is a consequence of some of the consortia's decisions not to proceed with projects even when successful in Stage 1. Decisions are still pending concerning progression to Stage 2 for the 69 projects deemed eligible during the last 2 calls.

In addition to these projects passing through Stage 1 of the process, 114 direct applications for Stage 2 projects were made in the first call of the initiative, of which only 12 were accepted. Thus, the total number of Stage 2 projects to date is 68.

Of this cohort of 68, 27 of the 38 projects resulting from the first call (for both Stage 1 and Stage 2 projects) were accepted as potential Stage 3 projects, with 16 actually proceeding to Stage 3. Decisions concerning the eligibility of the 30 remaining projects in the cohort have still to be made. Thus, , the number of Stage 3 projects to date remains 18.

Experience to date suggests that about 80% of the Stage 1 projects apply for Stage 2, and that 75% of Stage 2 projects apply for Stage 3.

Budgets

Table 5.1 shows the funds allocated over 2011-14 and budgeted for 2015-16 for the 257 Stage 1, 68 Stage 2 and 18 Stage 3 projects .

Table 5.1. Funds allocated or budgeted by VINNOVA for the UDI programme (2011-16)

	2011	2012	2013	2014	2015	2016
	Allocated	Allocated	Allocated	Allocated	Budgeted	Budgeted
VINNOVA	86	112	208	192	219	224

Source: VINNOVA.

In total, the financing of the UDI projects decided before the end of June 2015 amounted to SEK 2 077 million[3], of which VINNOVA contributed SEK 952 million (46% of total budget costs). Table 5.2 shows the financing breakdown for the different stages.

Table 5.2. Financing of UDI projects by stage and source of funding for all projects approved by end of October 2015 (million SEK)

Stage	Number of projects	VINNOVA contribution		Partners' contribution		Total financing	
		Total amount	Average per project	Total amount	Average per project	Total amount	Average per project
Stage 1	261	151.78	0.58	56.45	0.22	208.24	0.80
Stage 2	68	589.89	8.73	698.67	10.27	1292.56	19.01
Stage 3	18	206.52	11.47	369.93	20.55	576.45	32.02
All Stages	347	952.19		1125.05		2077.24	

Source: VINNOVA.

In Stage 1, the average VINNOVA contribution per project is SEK 580 000 (it was higher – SEK 750 000 – at the beginning of the programme). VINNOVA finances 73% of the costs of projects in Stage 1. For Stage 2 projects, the upper limit of VINNOVA's contribution is SEK 10 million and the requirement is for at least equal funding from project partners. VINNOVA finances 39% of project costs in Stage 2. The average size of a Step 3 projects is about SEK 32 million and at this stage VINNOVA contributes about one-third (36%) of the total funding, a lower proportion than for the Stage 2 projects.

Project types

Table 5.3 shows the distribution of projects across stages and UDI challenge areas (Future healthcare; Sustainable attractive cities, Information society 3.0, Competitive production).

Table 5.3. Number of funded projects per challenge area and per stage

	Future healthcare	Sustainable attractive cities	Information society 3.0	Competitive production	TOTAL
Stage 1	63	86	43	60	257
Stage 2	18	22	13	15	68
Stage 3	7	6	2	3	18
TOTAL	88	114	58	78	338

Source: VINNOVA.

Box 5.2. Themes covered in UDI challenge areas

Future healthcare: examples include home care or other care at a distance; more active participation by patients in their care; improved security; and efforts to reduce healthcare-associated infections. information and communication technology (ICT) plays a central role in many of these projects.

Sustainable attractive cities: examples include transport (passenger and freight transport); ecosystem services (ensuring sufficient green space and biodiversity in urban areas); water and sanitation projects (to detect and repair leaks in water systems); power generation (through the use of biomass); energy efficiency (exploitation of waste heat for biomass cultivation); and ecosystem services (management of storm water and water-related projects). As in the Healthcare area, ICT use is commonplace.

Information society 3.0: projects in this area are not easily clustered thematically; unlike some of the ICT projects within the three other societal challenges, projects in this area cover a wide range of application areas or are of very generic technical nature.

Competitive production: examples include resource efficiency; facilitating and increasing recycling; and developing new materials and products based on renewable raw materials, usually from the forest.

Source : VINNOVA.

In both Stages 1 and 2, one-third of the approved projects are related to Sustainable attractive cities.

Future healthcare and Competitive production each account for around one-quarter of the projects in Stage 1 and Stage 2. Information society 3.0 contains the lowest number of financed projects.

In Stage 3, where only 18 projects have been granted, Future healthcare accounts for 39% and Sustainable attractive cities for 33% of awarded projects.

Competitive production and Information society 3.0 have smaller numbers of projects in Stages 2 and 3 compared to the two other challenge areas.

The project classification into the four societal challenge areas is problematic. Some projects in Future healthcare, for example, have a strong ICT focus that makes them eligible for inclusion in Information society 3.0. Similarly, many of the projects in the Sustainable attractive cities category have a large digital component. Indeed, most of the UDI projects are to some extent based on ICT.

Given the ubiquity of ICT in modern society this is not surprising. What is surprising, however, is the definition of projects considered for inclusion in Information Society 3.0. Projects included in this category are “primarily projects concerning the problems associated with information of a more generic nature and

without a clear connection to a specific field of application". In contrast to areas such as Future healthcare or Sustainable attractive cities, which are clearly important societal challenges, Information society 3.0 is more focused on technological issues linked with information than on a specific field of application related to well-identified societal issues.

Participants

Table 5.4 shows the range of participant types and average numbers of participants at different stages of the projects. The average number of participants in Stage 1 of the UDI projects is 4.3, but rises to 12.3 in Stage 2 projects and 16.0 in Stage 3 projects. Planning and consortium-building occurs in Stage 1, which accounts for the lower average participant count.

Table 5.4. Average numbers of participants in UDI projects approved by end of December 2014, by stage and organisation type

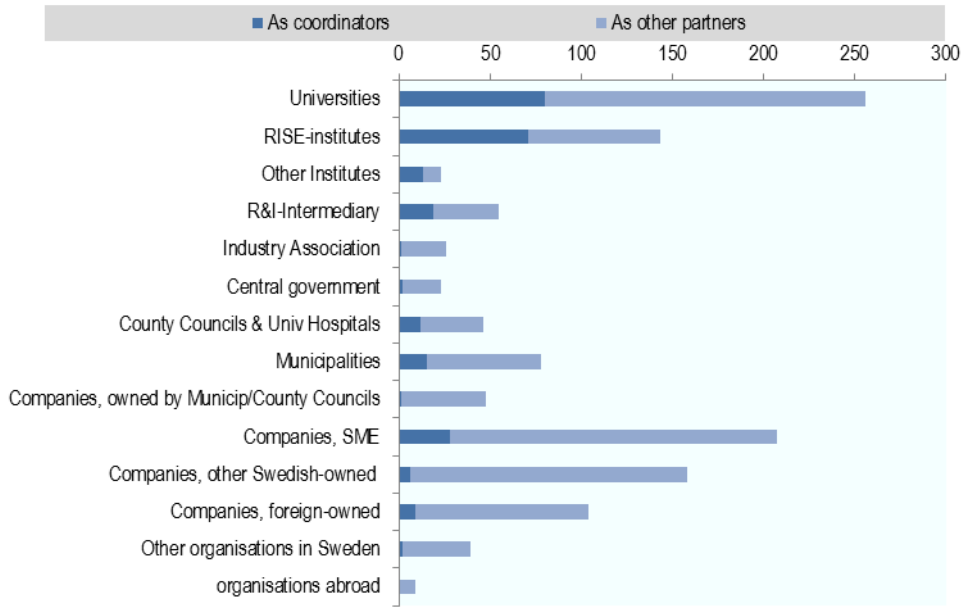
	Stage 1	Stage 2	Stage 3	All Stages
Universities	0.9	1.5	1.9	1.1
Research institutes	0.5	0.7	0.6	0.6
Companies	1.9	7.7	9.2	3.3
Public-sector organisations	0.6	1.4	3.3	0.8
Other	0.4	0.9	0.7	0.5
All types of actors	4.3	12.3	15.7	6.3

Source: VINNOVA.

Stage 1

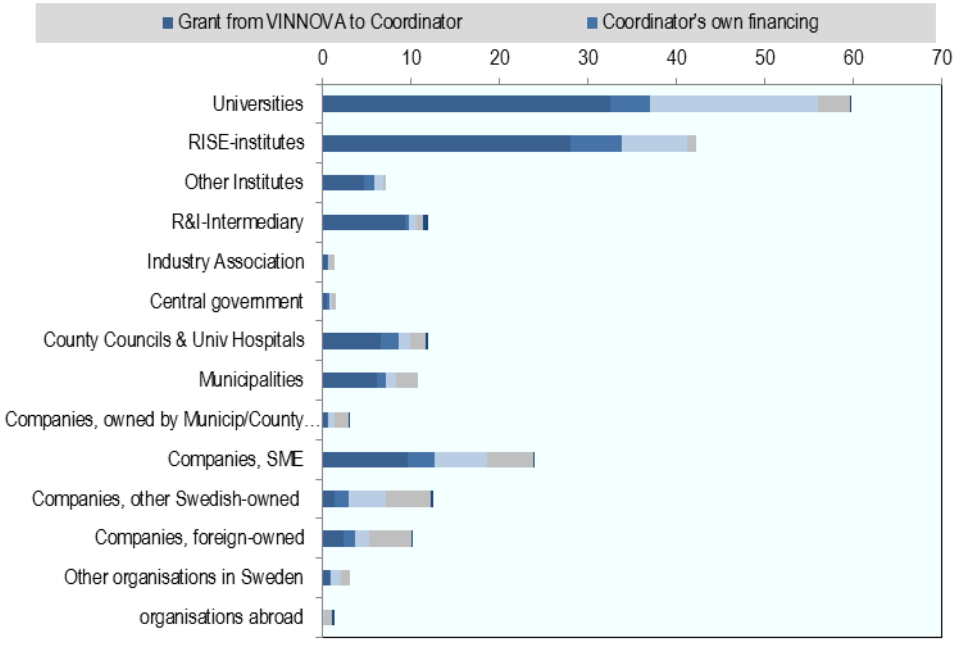
Figures 5.2 and 5.3 provide details on project participations and funding in Stage 1 projects as of July 2015.

Figure 5.2. Distribution of project participations, by type of actor and role in projects – Stage 1 (257 projects, as of July 2015) – Number of participants



Source: VINNOVA.

Figure 5.3. Allocation of funds by type of actor and role in projects – Stage 1 (257 projects, as of July 2015) (million SEK)



Source: VINNOVA.

Most actors involved in Stage 1 were small and medium-sized enterprises (SMEs); companies owned by municipalities or county councils; other Swedish-owned companies; and foreign-owned companies. The higher education and research institutions (universities, RISE institutes; other institutes; and research and innovation intermediaries) were almost as numerous, and together co-ordinated 70% of the 257 projects. Hence, they played a major role in generating, managing and conducting the Stage 1 UDI projects. Municipalities, county councils and hospitals – many of which are likely to be future users of challenge projects results – accounted for only 10% of participants and co-ordinated 10% of projects.

In terms of funding, VINNOVA covered most of the costs of organisations such as universities and research institutes; many companies typically made matching contributions (up to 50%).

Stage 2

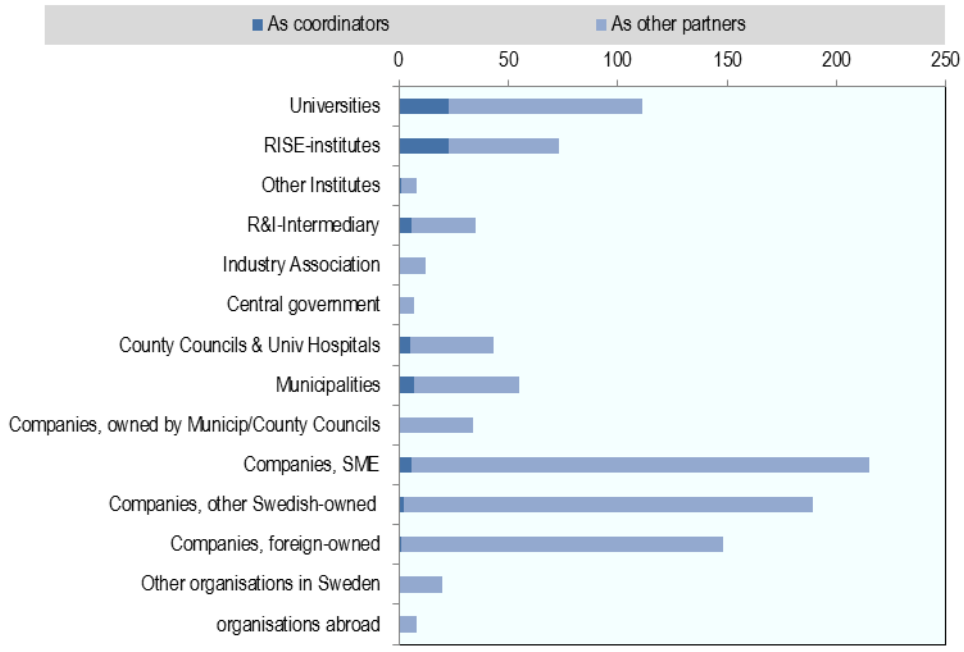
Table 5.5 and Figures 5.4 and 5.5 provide details on project participations and funding in Stage 2 projects, as of July 2015.

Table 5.5. Distribution of co-ordinators and all partners among different types of actors in the 68 Stage 2 UDI projects approved by July 2015

	Co-ordinators %	All partners (Incl. Co-ordinators) %
Universities	31.08	11.59
RISE institutes	31.80	7.62
Other institutes	1.35	0.84
R&I intermediaries	8.11	3.65
Industry associations		1.25
Central government		0.73
County councils and university hospitals	6,76	4,49
Municipalities	9,46	5,74
Companies, owned by municipal/county councils		3,55
Companies, SMEs	8,11	22,44
Companies, other Swedish-owned	2,7	19,73
Companies, foreign-owned	1,35	15,45
Other organisations in Sweden		2,09
Organisations abroad		0,84
TOTAL	100	100

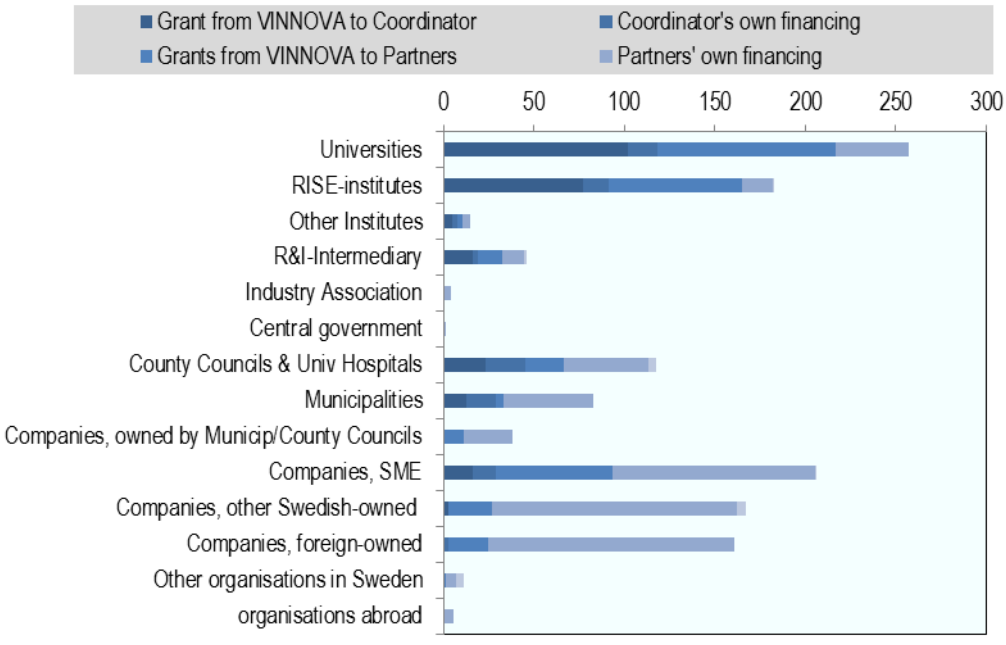
Source: VINNOVA.

Figure 5.4. Distribution of project participants, by type of actor and role in projects – Stage 2 (68 projects, as of July 2015) – Number of participants



Source: VINNOVA.

Figure 5.5. Allocation of funds by type of actor and role in projects – Stage 2 (68 projects) (million SEK)



Source: VINNOVA.

As in Stage 1, the most numerous actors involved in Stage 2 projects were companies (SMEs; companies owned by municipalities or county councils; other Swedish-owned companies; and foreign-owned companies). The higher education and research institutions (universities; RISE institutes; other institutes; and research and innovation intermediaries), which were almost as numerous in Stage 1 projects as companies, made up a lower share in Stage 2 as more and more companies were drawn into the projects. However, these organisations did co-ordinate about one-third of all Stage 2 projects.

County councils and hospitals represented the same share of participants as in Stage 1 (around 10%), but their presence as project co-ordinators increased from 10% in Stage 1 to 16% in Stage 2.

VINNOVA financed most of the involvement of universities and research institutes in these Stage 2 projects. Municipalities and companies other than SMEs essentially funded their own participation. SMEs, county councils and university hospitals covered about two-thirds of their costs, with VINNOVA covering the remainder.

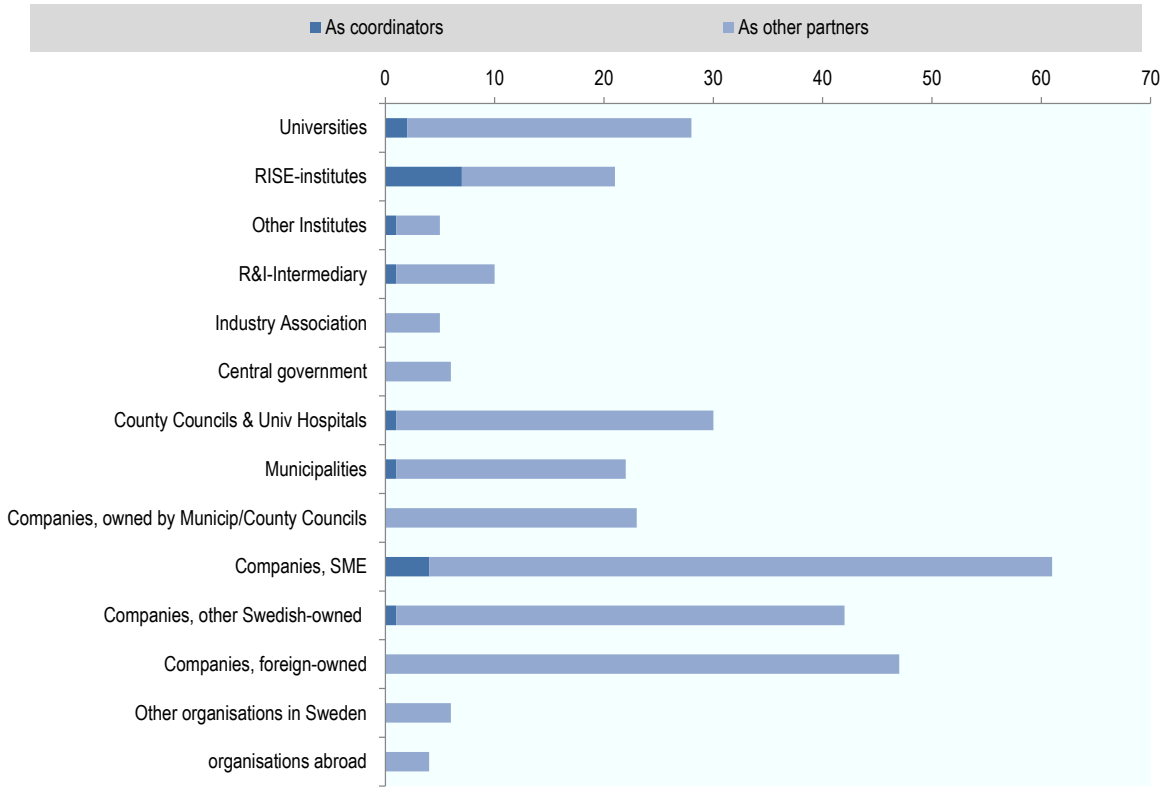
Table 5.6 and Figures 5.6 and 5.7 provide details on project participation and funding in Stage 3 projects as of July 2015.

Table 5.6. Distribution of co-ordinators and all partners among different type of actor in the 18 Stage 2 UDI projects approved by July 2015

	Total participations	As co-ordinator
RISE institutes	21	7 projects
Companies	173	5 projects
Universities	28	2 projects
Municipalities, counties and hospitals	52	2 projects
Other institutes	5	1 project
R&I intermediaries	10	1 project

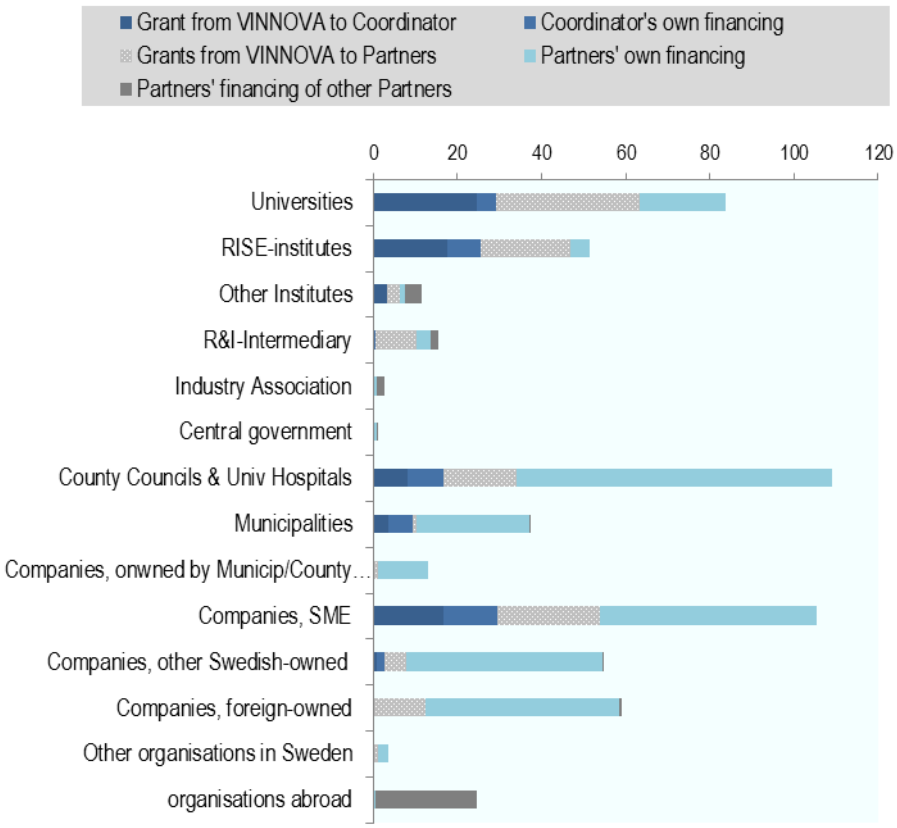
Source: VINNOVA.

Figure 5.6. Distribution of project participations, by type of actor and role in projects – Stage 3 (18 projects, as of July 2015) – Number of participations



Source: VINNOVA.

Figure 5.7. Allocation of funds by type of actor and role in projects – Stage 3 (18 projects) – (million SEK)



Source: VINNOVA.

As in Stages 1 and 2, companies made up the bulk of actors involved in Stage 3.

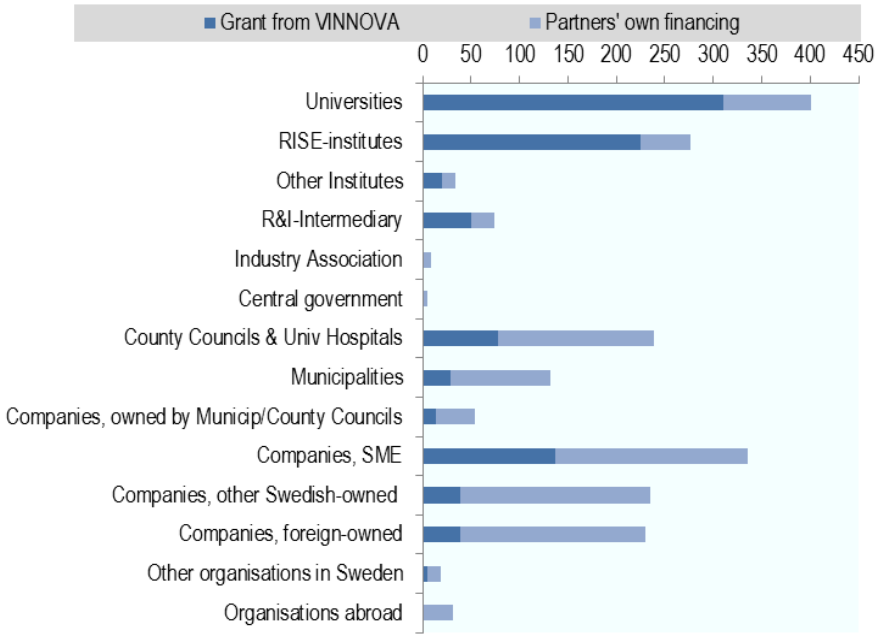
The higher education and research institutions, which had a similar number of participants as companies in Stage 1, accounted for only 16% of participants in Stage 3. As in Stage 1 and 2, however, they co-ordinated half of all the Stage 3 projects, with the RISE institutes leading seven of these projects.

Municipalities, county councils and hospitals had a higher share of participants ((17% in Stage 3) than in Stages 1 and 2 and co-ordinated two projects.

In terms of financing, VINNOVA financed most of the involvement of universities and institutes (as was the case in Stages 2 and 3). Municipalities and companies other than SMEs largely funded their own involvement. SMEs, county councils and university hospitals received significant contributions from VINNOVA, but largely financed their own participation.

Figure 5.8 and Table 5.7 summarise the funding of UDI projects at all stages.

Figure 5.8. Allocation of funds by type of actor and source of funding – All stages (257 projects approved by end of December 2014) (million SEK)



Source: VINNOVA.

Table 5.7. Allocation of funds by type of actor and source of funding – All stages (257 projects approved by end of December 2014) (million SEK and %)

	Granted by VINNOVA	Financing by partners	Total	% from VINNOVA
Universities and university colleges	275	83	358	77
RISE institutes	186	38	224	83
Other research institutes	15	11	26	58
Companies, owned by Municipalities or County Councils	4	24	28	14
Companies, SMEs	96	155	251	38
Companies, other Swedish-owned	33	168	201	16
Companies, foreign-owned	24	155	179	13
Central government agencies	2		2	100
County councils and university hospitals	71	154	225	32
Municipalities	21	68	89	24
R&I intermediaries	43	13	56	77
Industry associations	1		1	100
Other organisations in Sweden	2	9	11	18
Organisations abroad	6		6	100
Unspecified				
TOTAL	779	878	1657	47

Source: VINNOVA.

5.2.3 Assessment

Novelty

Many aspects of the UDI programme offer no real novelty. Like many other countries, Sweden has conducted other research and even innovation-oriented programmes involving collaboration among many actors in areas that are pertinent to societal challenges. The involvement of users and emphasis on co-production was nothing new either: Sweden has a long history of involving public authorities in innovation-related activities, with public procurement acting a major driver of innovation and economic development for an important part of Sweden's history. This manifested itself particularly in the existence of "development pairs" involving business firms and public-private partners – some of them engaged in very long-term relationships, e.g. ASEA-Vattenfall (development of electricity transmission systems) and Ericsson and Televerket (development of AXE digital switches and the GSM standard). The use of stage-gate procedures was also not particularly novel.

What was new was the combination of all these elements in a package deliberately designed as a response to Lund, focusing on problems defined by societal needs rather than technological targets and placing greater emphasis on widespread co-production than had historically been the case in many of the other technology development programmes financed by VINNOVA.

Spread

While the programme certainly focused more on topics defined by societal challenges than other comparable programmes and initiatives within VINNOVA's portfolio of support instruments, its inclusion of Information technology 3.0 and (to a lesser extent) Competitive production as two of the four key challenge areas is superficially suspect, since some of the projects in these areas appear closer to the technology-led model rather than the societal need-led model. This inclusion can be explained to some extent by pragmatic considerations at the programme outset. There is little doubt that many of the related projects will yield results with important implications and uses in areas relevant to a range of societal challenges. However, future incarnations of this programme would do well to focus more on specific challenges, especially if these efforts can be linked to technology-led sub-projects that feed into the overall project design, and to other technology-led programmes and initiatives in generic areas such as ICT.

Size

UDI project budgets are modest. Individual projects within each of the very broad challenge areas must be related to a particular societal challenge. They also provide "niche" solutions to parts of very complex societal problems, and projects are not conceived or organised in clusters that are part of a broader strategy to solve these complex problems. The UDI programme as a whole also has a relatively small overall budget, though it did grow from SEK 86 million per year in 2011 to SEK 192 million in 2014 and is set to increase to SEK 224 million in 2016. This is still modest compared in relation to the overall budget of VINNOVA (Figure 4.11, Chapter 4). It is arguably minuscule in terms of the gargantuan effort that will be needed nationally and internationally to tackle many of today's societal challenges. There are also some concerns about the visibility of the programme within the Swedish R&I community generally. Nevertheless, the UDI programme is a welcome start. While there is obvious scope for expansion in the area of societal challenges, it has proved to be a source of collective learning and a successful test-bed for future initiatives.

Composition

The UDI programme succeeded in both attracting a significant number of project applications and launching increasingly focused and substantial projects involving a broad range of R&I stakeholders across

Sweden, including a significant proportion of end-users in co-production processes. Programmes designed to tackle problems defined by societal needs doubtless benefit from the involvement of parties representing multiple sectors of society. In Sweden:

- The UDI programme brought together new combinations of people, institutions and sectors, and allowed them to focus on the collective skills needed to tackle specific societal challenges.

- In particular, the UDI programme involved public-sector authorities in the R&I activities supported by VINNOVA to a far greater extent than in the past. This is likely to become increasingly important as cities become 'test-beds' for innovative solutions to societal challenges and greater efforts are made to encourage 'system innovation' (see OECD, 2015)[4].

Participant roles

Companies were the most prevalent type of organisation in UDI, but other actors also played important roles. Universities played a critical role in project design and the construction of suitable consortia, especially in the proposal-preparation phase and Stage 1. The ratio of universities to companies dropped off in later project stages, but this was a function of more companies joining in as the emphasis on innovation increased, rather than of universities leaving. Research institutes consistently punched above their weight given their historically marginal position in the Swedish national innovation system, especially in terms of co-ordinating later-stage projects.

Interestingly, research institutes tended to substitute for universities rather than collaborate with them in the later-stage projects, which generally included either universities or research institutes. The significant number of Stage 3 projects led by research institutes may reflect their close historical links with SMEs and the fact that their rewards are likely to be higher than universities' because "new" research is not a major aspect of UDI projects (which focus more on integrating and adapting available knowledge, know-how and technologies). It may also reflect the weaker links that have traditionally existed between research-oriented universities and SMEs engaged in downstream innovation activities, or some universities' difficulties in working in multi-disciplinary teams, but the recent development of many university-based excellence and competence centres that adopt multi-disciplinary approaches and work closely with industry has improved this situation.

In future, however, it might be useful to look more closely at the dynamics of the UDI projects to explore ways of enhancing interactions among participants. As noted earlier, participants had developed a high degree of genuine and purposeful co-operation, but there is still scope for exploring how to fully realise the potential of the different types of participants within different project contexts.

Project management

A number of factors appear to be associated with the successful management and operation of UDI projects. First, the involvement of a strong project champion or leader is vital – although this is also true for most other R&I projects. A key feature of this leadership is the effort put into co-ordinating across the many different types of actor sand activities involved in these projects. Second, openness to a broad range of innovation actors, – especially the key involvement of end-users in the early design phases of projects as well as in later co-production phases – is essential. Third, the overall governance structures and procedures of projects are also critical, displaying effective communication, rapid feedback and flexibility to re-orient project objectives. A focus on system integration rather than(though not to the exclusion of) technological breakthroughs also appears to be a key success factor.

Outputs/impacts

While the first Stage 3 projects will not be completed until 2016, four types of output can already be identified:

- All projects have conducted tests and trials in "real" settings (e.g. IT-support for Advanced Care in the Home has tested solutions both within hospitals and in patients' homes).

- Several projects have led to spin-off projects (e.g. Forestchemistry, which aims to replace fossil-based chemicals with bio-based chemicals, has led to seven spin-off projects involving the forest and chemical industries; it also contributed to the formation of the BioInnovation strategic innovation programme based on co-operation between the forest, chemical and textile industries.

- Some projects (e.g. Expert Diagnostic Networks, which targets distributed healthcare work and increased patient safety) have attracted significant further investments.

- One firm involved in a UDI project has reportedly signed an international business contract worth SEK 10 million "as a direct consequence of the results produced".

Additionality

One of the aims of government interventions in the research and innovation sphere is to steer activities in particular directions and facilitate actions that would have been difficult to undertake without the intervention. This is called additionality. In the case of UDI, the aim was to steer activities towards societal-challenge areas and to allow a host of stakeholders to seek ways of confronting these challenges. Discussions with participants confirmed that many of their UDI projects would not have materialised in the absence of the initiative. It is also likely that the initiative stimulated a far higher level of activity related to societal challenges than the number of Stage 3 projects launched to date would indicate. In January 2015, VINNOVA sent a questionnaire to applicants whose applications had been rejected or who had not proceeded to make formal applications for involvement in the later-stage projects. Many of these applicants confirmed they subsequently undertook related projects, though not within the context of the UDI programme. Indeed, VINNOVA has estimated that 90% of projects rejected at Stage 2 did in fact continue, but with a narrower scope and often with fewer partners. Thus, the amount of additional effort in stimulated by the initiative societal-challenge areas is significant.

Future requirements

Based on discussions with participants in UDI projects and other interested R&I stakeholders, when moving forward with the UDI concept and practice Sweden should consider:

- clearer definitions of a more diverse set of challenge areas

- clearer selection criteria at each stage of the three-stage model, with adequate feedback mechanisms to rejected applicants

- clearer objectives in each challenge area

- a strong emphasis on the importance of effective communication and co-ordination mechanisms and processes within projects

- better indicators and tools to monitor and evaluate project progress

- a greater focus on potential complementarities between participants and the inclusion of all relevant actor sets

- enhanced budgets both for individual projects and more critically, the initiative as a whole

- the initiation of a debate on the legal and regulatory hurdles that could affect the uptake and diffusion of project results

- greater attention to the steps needed to link national UDI activities to similar activities being conducted internationally, especially within European P2Ps.

- a strong focus on formulating UDI activities within a conceptual framework emphasising the importance of adopting a "systems innovation" approach to resolving many societal problems, i.e. a framework that recognises the need for "a horizontal policy approach that mobilises technology, market mechanisms, regulations and social innovations to solve complex societal problems in a set of interacting or interdependent components that form a whole "socio-technical system" (OECD, 2015). In the terminology developing around the concept of "systems innovation", UDI projects develop "niche-level" solutions that need to be integrated into broader strategies aimed at "system transition".

5.3 Sweden's role in the European Union context

The 2009 Lund Declaration stated that the EU must focus on the grand challenges of our time:

- European research must focus on the Grand Challenges of our time moving beyond current rigid thematic approaches. This calls for a new deal among European institutions and Member States, in which European and national instruments are well aligned and co-operation builds on transparency and trust.

- Identifying and responding to Grand Challenges should involve stakeholders from both public and private sectors in transparent processes taking into account the global dimension.

- The Lund conference has started a new phase in a process on how to respond to the Grand Challenges. It calls upon the Council and the European Parliament to take this process forward in partnership with the Commission. (Lund Declaration, 2009)

Among other things:

- The identification of the Grand Challenges must engage the major stakeholders including the European institutions, business, public services, NGOs and the research community as well as interaction with major international partners. Meeting the challenges should involve public-private partnerships, including SMEs, with their potential to develop excellent and sustained problem-solving capacity. It will require Member States to develop more proactive strategies on research priorities at regional, national and Community level. The FP for Research must also respond to these demands. Therefore the Commission and the Member States together should, based on a broad consultation process, agree on the most appropriate and efficient division of labour when designing future programmes (Lund Declaration, 2009).

5.3.1 Swedish involvement in EU activities

Sweden's response to the declaration made under its own presidency of the European Union should be considered in the context of Sweden's overall involvement in EU R&D and innovation activities,[5] broadly divided into two generic categories used to describe a country's involvement:

- **Researcher-led**. This involves researchers bidding for competitive funds directly to the European Union, whether to become involved in individual collaborative research projects in the various programmes falling under the H2020 banner (formally Seventh Framework Programme for Research and Technological Development [FP7] and its predecessors); in excellence projects falling under the auspices of the European Research Council; in establishing shared infrastructures through the European Strategy Forum on Research Infrastructures (ESFRI); and in some of the activities falling under the auspices of the European Union's Joint Research Centre.

  All of these depend on researchers' bottom-up efforts; the main role of national governments is to ensure that national policies supporting researchers will guarantee they are in a prime position to compete for funds. A secondary – but nevertheless important role – is to provide researchers with any assistance they might need when making applications for funds and implementing projects, e.g. through help-desks and guidelines. Given the current orientation of H2020 to societal challenges, researchers could enhance Swedish efforts to orient national research towards these challenges. A tertiary role of government is to ensure that a Swedish voice is heard in EU policy discussions and debates.

- **Agency-led**. Since the early 2000s, countries across the European Union have increasingly striven to focus on activities of mutual interest by forming P2Ps. These generally involve arrangements between national (and regional) agencies – sometimes together with the European Union – to support joint activities within schemes such as ERA-NETs (in all their various forms); Joint Programming Initiatives (JPIs); and Article 185 (formerly Article 169) initiatives. The main roles of governments (and their agencies) are to select appropriate P2Ps; ensure adequate funding arrangements are in place to finance the endeavours of researchers bidding for funds within the activities launched by the P2Ps, especially (but not exclusively) indigenous researchers; and oversee the administration of the P2Ps both within national boundaries and across the P2Ps by acting as, or nominating, the P2P project co-ordinators. Other roles are similar to those included in the researcher-led category, e.g. provide advice and assistance to researchers responding to P2P calls, as well as influence EU policy discussions to ensure that Swedish interests are well represented and ultimately reflected in EU priorities and work programmes, and the formation of future P2Ps. Given that many of the currently active P2Ps operate in societal- challenge areas, active involvement of Swedish agencies and researchers in these networks is an important potential means of orienting Swedish and European efforts towards societal challenges.

Swedish participation in FP7 was well above the average for all EU Member States. This is not surprising, given the strengths of Swedish research organisations, the presence of a large R&D-intensive industry and the level of national investment in R&D. Sweden also collaborates more closely with countries endowed with similar science and innovation capabilities than with others. For example, Sweden is part of a cluster of countries in Northwest Europe that collaborate with each other more than the average. Swedish organisations especially work with organisations from the United Kingdom and Germany, as well as Finland. Their collaboration with Greece, Spain and Italy (which form a separate cluster, together with Portugal) is below average. Sweden was also a "favourite country" of the United Kingdom, Finland, Denmark and Norway for FP7 collaborations. Other countries participating in this cluster of collaborating countries Northwest Europe include the Netherlands, Belgium and France.

Tables 5.8 and 5.9, which present data for the other countries in this cluster, put into perspective Swedish participation in EU-related activities in FP7 prior to the onset of H2020.

Table 5.8. Swedish Involvement in FP7: A comparative perspective

	Sweden	Austria	Belgium	Denmark	Finland	Netherlands	Norway	Germany	France	United Kingdom
GDP, billion USD PPP	0.42	0.38	0.46	0.24	0.21	0.73	0.34	3.5	2.45	2.33
GERD as % GDP 2011	3.4	2.9	2.2	3	3.6	2.2	1.7	3	2.3	1.7
GBAORD 2012 million EUR	3581 (7)	2473.6 (10)	2489.6 (9)	2517 (8)	2064.2 (11)	4664.9 (6)	3,099.90	24034.8 (1)	15134.9 (2)	11040.9 (3)
GBAORD / capita 2012 million EUR	377.7 (4)	294,2 (5)	244.4 (9)	451.1 (2)	382.2 (3)	278.8 (7)	621.7	293.7 (6)	231.7 (8)	173.9 (10)
Nr of FP7 applicants	18555	15057	21544	11055	12281	30725	n/a	71609	47694	73877
(%EU-28)	3.57	2.9	4.14	2.13	2.36	9.2		13.77	9.17	14.21
Nr of successful FP7 applicants	4357	3368	5676	2674	2622	784	n/a	17263	11996	16768
(% applications)	4.26	4.47	3.8	4.13	4.68	3.92		4.15	3.98	4.41
(%EU-28)	3.89	2,99	5.04	2.37	2.33	6.96		15.33	10,65	14,89
Nr of FP7 co-ordinators	722	675	919	503	355	1634	n/a	3121	2657	6941
(%EU-28) (aver. 19,10%)	16.02	19.2	16.84	18.26	13.4	20.05		17.25	21.1	17.24
EC contributions in EUR millions	1707.86	1184.21	1814.89	1060.6	876.14	3329.97	n/a	7136.48	5142.71	5080.00
(%EU-28)	4.24	2.94	4.51	2.63	2.18	8.27		17.73	12.77	28.93
ERC grants in host institution all	179	130	175	106	80	452	52	760	666	1128

years %total	3.43	2.49	3.35	2.03	1.53	8.66	1.00	14.56	12.76	21.61
ERC grants in host institution 2014	14	13	18	22	14	61	9	123	80	120
%total	2.14	1.99	2.75	3.36	2.14	9.33	1.38	18.81	12.23	18.35
Publications per researcher 2000-11	3.30 (7)	2.3 (19)	3.40 (6)	2.60 (14)	2.4 (17)	4.70 (1)	2.5	2.40 (18)	2.7 (13)	3.00 (8)
Co-publications within the European Union by researcher 2000-11	0.60 (6)	0.6 (8)	0.80 (3)	0.50 (11)	0.4 (17)	0.90 (2)	0.5	0.30 (24)	0.4 (20)	0.40 (21)
No of ESFRI res. infrastructures involved in with financ²ial commitment	16	4?	5?	12	13	7	8?	18	13	9

Source: OECD Innovation Platform Statistics, European Union (2015a), ERA Facts and Figures 2014, http://ec.europa.eu/research/era/pdf/era_progress_report2014/era_facts&figures_2014.pdf; Seventh FP7 Monitoring Report (2013).

Note: PPP= purchasing power parity; ERC= European Research Council.

The salient points concerning Swedish involvement in **researcher-led** FP7 activities are as follows:

- The number of FP7 applications is to some extent a function of the overall size (by GDP) of a country, with the larger economies (Germany, United Kingdom, France) making the most applications.

- The larger countries make relatively more applications than the smaller countries, which is not surprising given the larger size of their research populations. In the case of both larger countries and especially smaller countries, however, there appears to be a relationship between R&D intensity and the number of FP7 applications – with applications decreasing with R&D intensity – suggesting that high levels of national funding are associated with less dependence on the FP7 programmes as a potential source of funding.

- In terms of a country's successful applications as a share of total applications, Sweden is relatively successful, ranking fourth among the comparator countries.

- In terms of project co-ordinators, Sweden is below the European average, though not significantly so.

- In terms of funds received by countries from FP7, the larger countries get the larger share, but the returns for smaller countries are greater when taking into account GDP, with Sweden then ranking fourth behind the Netherlands, Denmark and Finland.

- In terms of ERC grants received by host institutions, Sweden leads the field over all years compared to countries of a similar size (in terms of GDP), but slipped behind Denmark and Belgium in 2014.

- Concerning publication behaviour, Swedish researchers ranked highly over 2000-11 in terms of both publications per researcher (7^{th}) and co-publications within the European Union per researcher (6^{th}).

- Swedish involvement in ESFRI infrastructure projects was high. It ranked second only to Germany's (which has a much larger research system) and significantly higher than other mid-sized scientific research systems (e.g. the Netherlands and Belgium).

Another salient point is that Swedish participation in EU Framework Programmes is dominated by academic researchers, who received about 63% of FP7 funding as of October 2014 (European Union, 2015b). Among the comparator countries, this percentage was only higher in the United Kingdom. This result reflects the dominant position of academics in the Swedish research system. Conversely, the share of grants received by Swedish SMEs was lower (14.76%) than in any of the other comparator countries. This is slightly surprising, in that the Swedish SME sector has demonstrated above-average performance and stable development in recent years and does particularly well in terms of gaining access to finance and internationalisation (European Commission, 2013), but it may reflect a relative paucity of medium-sized firms in the SME category compared to the other benchmarked countries.

Table 5.9 looks more closely at **agency-led** involvement in P2Ps. These are important from a societal-challenge perspective, because approximately one-half (i.e. 133 out of 223) of the P2Ps listed in the European Union's ERA-LEARN database operate in research fields closely related to these challenges (e.g. biotechnology, energy, environment, food and agriculture, health, security and defence and transport), and many of the P2Ps operating in other areas have more indirect links with societal challenges.

- Sweden has been involved in 59.6% of the 223 P2Ps listed in the ERA-LEARN database and is currently involved in 51 active P2Ps. In terms of areas directly pertinent to societal challenges (defined in terms of areas listed above), it has participated in 67 out of 133 networks and 26[6] out of 51 current networks.

- The larger countries are generally involved in more networks than smaller countries like Sweden. This is not surprising given their size, but Swedish levels of involvement are comparable with those of countries of a similar size.

- The number of organisations involved follows the same pattern, with Swedish levels again comparable with countries of a similar size.

- The biggest difference between Sweden and other countries lies in the number of P2Ps led by Swedish agencies. Sweden has only led one such initiative, the ongoing JPI on Antimicrobial Resistance. By comparison, Austria has led 13, Finland 14, and the Netherlands 24. In many ways, this must be recognised as a missed opportunity in terms of Swedish national agencies leading the way in establishing Sweden as a beacon, both in the P2P domain and as a country at the vanguard of efforts to tackle societal challenges.

- Another interesting comparison is with Denmark, which has participated in a smaller number of networks (98, compared with 133 networks for Sweden) but has led more of them (6 networks, compared with 1 for Sweden). Its internationally co-ordinated R&D as a share of responsive funding is also much higher (18.30%) than in Sweden (3.90%), with similar ratios (16.30% for Denmark and 2.80% for Sweden) for jointly defined research agendas within non-national EU organisations as a share of responsive funding. In short, Denmark's participation in P2Ps is both much more focused than Sweden's and more embedded within a national effort geared towards taking full advantage of the existence, synergies and benefits of P2Ps.

Table 5.9. Swedish involvement in European P2Ps: A comparative perspective

	Sweden	Austria	Belgium	Denmark	Finland	Netherlands	Norway	Germany	France	United Kingdom
Number of P2P networks in which country has been involved (with %)	133 (59.6%)	139 (62.3%)	141 (63.2%)	98 (44.0%)	125 (56.1%)	161 (72.2%)	112 (50.2%)	190 (85.2%)	184 (82.5%)	158 (70.9%)
Number of active P2P networks in which country is involved	51	45	61	38	43	54	43	66	65	45
Number of co-ordinators in all networks to date	1	13	8	6	14	24	3	49	47	23
Number of joint calls in all networks to date	57	95	56	16	38	37	49	97	67	49
Number of organisations involved to date	31	32	46	37	32	45	14	66	87	65

Share of responsive funding, transnationally co-ordinated R&D	3.90%	2.10%	2.70%	18.30%	6.90%	11.30%	n/a	5.10%	7.90%	2.80%
Share of responsive funding, jointly defined research agendas within non-national EU orgs	2.80%	1.90%	2.60%	16.30%	5.30%	9.20%	n/a	0.80%	5.30%	0.90%

Source: ERA-LEARN portal, https://www.era-learn.eu/network-information/countries/se; *OECD Innovation Platform Statistics*, *ERA Facts and Figures 2014*, *Seventh FP7 Monitoring Report*, (2013).

5.3.2 Government strategies and intentions

Much debate has taken place in recent years on the importance of participating in EU activities and the implications for government policy. Within most national research systems, European funding has traditionally been perceived as an additional funding source for actors in the national research system, complementing non-competitive and competitive funding from the state, its various councils and agencies. The onus has therefore been on individual researchers to bid successfully for FP funds.

The gradual growth of the FP budget has increased the importance of this source of additional funding and focused the attention of policy makers on helping research communities improve success rates. Perhaps even more critically, attempts by the European Union to stimulate the formation of cross-border P2Ps in order to align research agendas, enhance efforts and establish critical masses in key research and innovation areas have alerted policy makers to the importance of developing strategies to make the most of these opportunities.[7]

As a consequence – and especially in smaller countries that feel they need to make strategic choices to maximise the returns from national investments – the relationship between national and EU R&I policies has often become intertwined, with EU policy influencing national policy, and greater efforts made by some countries to influence the development of EU policies and formation of new P2Ps.

This phenomenon has led to the following developments:

- National contact points have provided increased and improved information and support services to promote the success of national researchers and research organisations in EU competitions. All countries provide such services, although significant differences exist across countries (Siune, Kalpazidou Schmidt and Aagaard, 2005).

- Some countries have explicitly aligned national priorities to EU priorities, and other countries have made greater efforts to "export" national science policy priorities to the EU level.

- National funding bodies have participated more overtly and strategically in P2Ps.

- Performance schemes have been created that effectively reward national researchers' success in gaining access to external EU funds by granting complementary funding. Schemes in the Netherlands and Switzerland that reward success in ERC competitions have led some universities to actively target ERC success as part of their overall strategies (European Union, 2012).

In essence, this constitutes a switch from what Langfeld et al. (2012) have termed the "centrifugal model" to the "co-ordination model":

- The **centrifugal** model is a model in which R&D institutions and other sub-national actors bypass national systems and interact directly with the European level. The expected effect is fragmentation of national

administration and research efforts into two components – the national component and the European Union/international component.

- The **co-ordination** model is a model where the state encourages, facilitates and rewards increased participation of researchers in EU activities, thereby gaining a new opportunity to "steer" national R&I activities. Another facet of the co-ordination model is that it encourages state agencies to co-ordinate with each other in order to maximise the benefits of participating in P2Ps, and evolve positions and strategies promoting national agendas in EU policy circles. (Langfeld et al., 2012)

In Sweden, two independent reviews have examined recent policies geared towards participation in EU activities. Arnold et al. (2008) analysed the impacts of Swedish involvement in the FP and concluded that while the centrifugal model of interaction had an impact on the strategies of individual researchers and research groups, it had little impact on the strategies of universities themselves:

- The FPs have had more influence at the level of individual research groups than they have had on overall university strategies. They clearly added size and scope to researchers' networks, probably increasing quality and including them in more international "invisible colleges" that make them "insiders" in groups of researchers working at or near the leading edge in their fields. (Arnold et al., 2008)

- Strategic participation benefits were also missing at the national level, with consequences for Sweden's ability to influence activities at the EU level: "Where the FPs have had limited strategic impact (at the national level), this is because there are not many strategies to impact. This is a vicious circle: in the absence of national strategy, it is difficult to articulate how the FP strategies should change in order to serve the national interest" (Arnold et al., 2008).

- The lack of an adequate national strategy dealing with the broader issue of internationalisation was also highlighted in the 2012 OECD *Review* (OECD, 2013).

- Sweden has yet to develop an overarching internationalisation strategy in the area of research and innovation… and to ensure that public policy interventions add value to the extensive international collaboration that already exists between individuals, organisations and businesses. Among these are a long fruitful history of Nordic co-operation, strong participation in the European Union's Framework Programmes, bilateral agreements with leading and emerging scientific powers and the research programmes of the Swedish SIDA. (OECD, 2012)

In this context, the Swedish Research and Innovation Bill of 2012 signalled a change in ambitions for Swedish participation in European R&I activities. While it noted that the ambition must be to maintain a high level of participation in H2020by Swedish researchers, companies, institutes and other actors , it also signalled that a change in direction was needed, arguing that historically high levels of participation were no guarantee of future success, and that different types of interventions were required at a national level.

The 2012 Bill specified two main measures recognising the increased importance of P2Ps and the relevance of shifting to what Langfeld et al. (2012) termed the "co-ordination model":

- The Bill announced the addition of SEK 200 million to the VINNOVA budget over 2014-16 to finance the participation of Swedish funding bodies in P2Ps launched within the framework of European R&I co-operation.

- The Bill also signalled the introduction of a national co-ordination function, with a separate secretariat based within VINNOVA, to enable government research funders to prioritise Swedish participation in P2Ps; co-ordinate and strengthen strategic and proactive work within European R&I co-operation; and promote synergies between EU initiatives and national investments in R&I.

The 2012 Bill – which places involvement in European activities within a broader strategy for international co-operation in research and research-based innovation (which was first mentioned in the 2008 Bill) also mentions other aspects of European co-operation. These include:

- the importance of the European Research Council and the need to improve the recruitment of outstanding researchers to Sweden and Europe as a whole – an area in which Sweden was not particularly successful

- the need for RISE to participate more actively in EU research programmes and exploit its links with SMEs in order to involve them in H2020 and the collaborative platforms of the European Institute of Innovation and Technology

- the need for universities and colleges to make greater use of EU structural funds to improve their regional engagement

- the importance of Sweden's role in three large infrastructural projects located in Sweden: the European Spallation Source (ESS), the synchrotron MAX IV and the SciLifeLab.

The 2012 Bill particularly acknowledged the need for a broad international co-operation strategy and particularly for financing and co-ordinating involvement in P2Ps. However, the Bill did not emphasise the opportunity presented for a keener focus on enhanced Swedish involvement in societal-challenge areas aspect. Indeed, given the seminal role Sweden played in the forging of The Lund Declaration in 2009, perhaps the most remarkable facet of the 2012 Bill was the distinct absence of an overt emphasis on how Sweden might rise to the challenge of Lund, either at a national, European or broader international level.

5.3.3 Assessment

The increased budget for P2P participation announced in the 2012 Bill and the establishment of an overt co-ordination function provided Sweden with a window of opportunity not only to take greater advantage of the leverage benefits P2Ps provide to participating countries tackling topics of mutual interest, but also to align national (and international) efforts to tackle societal challenges. At least half of the P2Ps in existence during FP7 operated in areas directly related to societal challenges. Given

the much stronger emphasis than previously on societal challenges and the realisation by most European countries that joint efforts on an international scale are sorely needed to make headway, this percentage is set to increase within H2020.

The budget for P2P involvement was made available to VINNOVA (and to other funding bodies through VINNOVA), resulting in the increases shown in Figure 4.11 (see Chapter 4). A national co-ordination function (EU-SAM) was also established by VINNOVA in co-operation with the Swedish Energy Agency, Forte, the Space Board and the Swedish Research Council. A secretariat was established within VINNOVA to work with representatives from the different bodies involved. The main aim of EU-SAM is to work with all the bodies concerned to prioritise Swedish involvement in P2Ps; strengthen strategic capacity by performing relevant analyses; and promote synergies between national and EU-related activities. EU-SAM is also responsible for disbursement of the funds made available for agencies to participate in P2Ps.

To date, EU-SAM has fulfilled its remit by conducting analyses tracking the development of the ERA; co-ordinating interactions between relevant agencies, including the transmission of relevant information and sharing of experiences; making recommendations to government concerning priorities; and distributing funds accordingly.

According to representatives of some of the agencies involved in this process, this co-ordination has changed the mindset of funding bodies towards the European Union. Whereas some of these bodies once felt they were being "dragged into" participating as a consequence of the activities and initiatives of individuals within their organisations,[8] decisions on participation are now made on the basis of strategic considerations after consultation and discussion among relevant funding bodies. That said, the relative position of internationalisation strategies within the overall strategies of some funding bodies is uncertain, with the strong suspicion that they remain marginal rather than mainstream concerns.

Table 5.10 examines Swedish involvement in P2Ps, especially active networks commencing in 2012 or later and those directly related to societal challenges.

Table 5.10. Swedish involvement in European P2Ps

All P2Ps to date in which Sweden has been involved	133
Active P2Ps	51
- commencing after 2011	37
- and with a societal challenge orientation	31
of which:	
Active 169/185s	5
- commencing after 2011	4
- and with a societal challenge orientation	2
Active JPIs	8
- commencing after 2011	3
- and with a societal challenge orientation	3
Active ERA-NETs	33
- commencing after 2011	28
- and with a societal challenge orientation	25
Active “Other”	5
- commencing after 2011	2
- and with a societal challenge orientation	1

Source: ERA-LEARN portal, https://www.era-learn.eu/network-information/countries/se.

Over time, Sweden has been involved in 133 networks, 51 of which are currently active. Of these, 37 commenced in 2012 or later, and 31 are directly connected to societal challenges. These 31 networks comprise 2 Article 185 initiatives (AAL 2: Active and Assisted Living; EDCTP2: European and Developing Countries Clinical Trials Partnership); 3 JPIs (JPI MYBL: More Years, Better Lives; JPI Climate: Connecting Climate Knowledge for Europe; JPI AMR: Antimicrobial Resistance); 25 ERA-NETs under one form or another; and 1 characterised as “other” (EUPHRESCO: European Phytosanitary Research Coordination). For the first time, Sweden is also leading one P2P, JPI AMR.

The degree to which the decisions to join these particular P2Ps resulted from a strategic approach rather than separate decisions made by individual agencies or individuals cannot be ascertained with certainty, though it does appear likely that these decisions benefited from a more strategic approach, given the comments of the people involved about changed mindsets. What is noticeable is Sweden’s strong involvement in P2Ps featuring a societal-challenge orientation (31 out of 37) launched during or after the 2012 Bill, and its leadership of JPI AMR.

The signs are therefore encouraging, in that that attempts at co-ordination are gradually enhancing strategic involvement in European P2Ps and the focus on societal challenges. Table 1.A5 in Annex 5 compares overall approaches to societal challenges in a number of OECD countries and highlights their greater centrality in other contexts. In particular, there is scope for improving attempts to ensure that both European co-operation and societal challenges become (both collectively and individually) mainstream concerns for agencies. Similarly, as many societal challenges have a broad international dimension and are not solely the preoccupation

of European countries, there is ample room for expanding the work of a body like EU-SAM to co-ordinate Sweden's participation in global alliances tackling societal challenges.

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ANNEX A5.1

Table 1.A.5. Approaches to societal challenges in selected OECD countries

○	challenges in policy discourse	areas	governance/co-ordination	programmes
Sweden (VINNOVA)	• Limited use in policy discourse. • VINNOVA's UDI programme set up to address societal challenges.	• Societal challenges identified by VINNOVA: • Future healthcare • Sustainable attractive cities (environment, energy, transport and community building) • Information society 3.0 • Competitive production • Societal challenges defined by VINNOVA's agency mission.	• Limited central steering in the Swedish system, but horizontal co-ordination between a large number of agencies. System characterised by "medium-sized" activities.	• The **UDI** programme (EUR 20 million per year).
Japan	• "Policy challenges" used as a guiding principle in the government's revitalisation plan.	• Five main "policy challenges" (2014): • Clean energy • Aging society • Infrastructure • Industries • Earthquake recovery	• Top-down, "strong" co-ordination of cross-ministerial challenges through the Council for Science Technology and Innovation.	• **Cross-ministerial SIP:** integrated initiatives from sector ministries to addresses the five major policy challenges identified in the STI plan (JPY 50 billion [yen] per year. • **Impulsing Paradigm Change through Disruptive Technologies (ImPACT):** supports high-risk, high-return programmes to enhance

○	challenges in policy discourse	areas	governance/co-ordination	programmes
				competitiveness and societal wellbeing (JPY 55 billion yen per year).
Norway	• Government long-term R&D strategy has "major social challenges" (*Store samfunnsutfordringer*) as one of three priorities.	• Challenges mentioned in government strategy: • Climate change and environmental impact • Demographics • RCN priority areas based on societal challenges (2013): • Climate change • Green technology • Bio-economy • Healthy ageing • Research infrastructure	• "Weak co-ordination" at government level (Ministry of Culture and Research) in sector-based system. Research Council of Norway (RCN) co-ordinates input from sector ministries.	• "Large programmes" bring together contributions and instructions from different sector ministries to address challenges.
United Kingdom	• "Challenge" rhetoric used in a variety of contexts and in different ways.	• No overarching government definition but "challenges" used in different contexts: • Eight "great technologies" • Six cross-council programmes • EPSRC grand physics challenges • Innovate UK challenges	• Horizontal co-ordination between funding bodies and user organisations. Ad hoc organisation depending on the specific challenge.	• Research Council programmes • Digital Economy • Energy • Global Food Security • Global Uncertainties, now (2014) Partnership for Conflict, Crime and Security Research (PaCCS) • Lifelong Health and Wellbeing • Living with Environmental Change
United States	• "Grand challenges for the 21st Century": federal government promotes grand challenges and supports four specific initiatives.	• Definition of grand challenges offered by government officials: • Grand challenges have major impact in areas such as health, energy, sustainability, education, economic	• Consultation to identify challenges • Direct support for four challenges through existing agencies • "All-hands-on-deck" approach,	• Federal government: • Brain initiative (NIH, DARPA, NSF) • "Sunshot" (solar energy) (DoE) • Asteroid (NASA)

○	challenges in policy discourse	areas	governance/co-ordination	programmes
		opportunity, national security and human exploration. • They must be “ambitious but achievable”. • They are “compelling and intrinsically motivating” and should “capture the public’s imagination”. • They should have measurable targets for success and timing of completion. • Government use of grand challenges emphasises “excitement factor”.	encouraging private actors to identify and pursue grand challenges.	• Development (USAID) • Private: • Global health (Gates) • Engineering (NAE) • Artificial Intelligence (IBM) • Self-driving cars (Google)

Source: Technopolis.

[1] In the first call for proposals, submissions for both Stage 1 and Stage 2 proposals were allowed.

[2] Except for the first phase of the programme, when (as noted above) some projects were allowed to enter directly into Stage 2 of the process.

[3] SEK 1 equals approximately EUR 0.1.

[4] OECD (2015), System Innovation: Synthesis Report, Paris

[5] Sweden's involvement in EU regulatory and legislative activities concerned with societal challenges should also be taken into account, but this report focuses on R&D and innovation-related support activities.

[6] This figure rises to 43 on closer inspection of the range of activities conducted within P2Ps lying outside of this classification system. See Table 5.9 for an analysis of Sweden's current involvement in active P2Ps with a societal challenge orientation launched since the 2012 Bill.

[7] The first strategic review of the ERA-NET scheme in 2006 (European Union, 2006) noted that participation in the first rounds of the initiative had generally been agency-led rather than guided by any overt national strategies for participation, but the subsequent involvement of many countries in both ERA-NETs and other types of P2Ps has generally been guided by strategic discussions at a horizontal or higher level.

[8] This is reminiscent of the early days of the ERA-NET scheme, described in European Union (2006).

CHAPTER 6 PRIORITIES, STRATEGIES AND GOVERNANCE OF INNOVATION IN SWEDEN

Many of the topics covered in this *Review* deal with issues of prioritisation and their relationship to strategies for developing the Swedish innovation system. Governance modes are also an issue. The SIO initiative aimed to prioritise R&D projects within specific areas and programmes largely dictated by the research-performing community. The UDI initiative, a strategic response to the policy challenge articulated in the 2009 Lund Declaration – aimed to prioritise work with a distinct focus on societal challenges. The VINNOVA has played a large role in the overall governance of these schemes, with distinct differences in the ways in which they have been handled. Similarly, the SRA scheme involved prioritising work within universities in specific research areas. The steps taken to increase Sweden's involvement in EU-driven initiatives, and public-to-public (P2P) research and innovation networks across Europe, were part of a broader internationalisation strategy prioritising involvement with particular countries and groups of countries.

This Chapter revisits some of these prioritisation, strategy and governance issues, examining the efficacy of the initiatives described and their implications for future policy formulation. It begins with a brief review of the notion of prioritisation, and its manifestation in research and innovation policies in Europe and elsewhere. It then focuses on Swedish initiatives. The two final sections then look at the implications for prioritisation, and more generally the governance across the Swedish research and innovation system.

6.1 Prioritisation in perspective

Prioritisation involves choosing between alternatives - whether in terms of areas, activities or themes. In the world of STI policy, priority activities have been defined pragmatically as "any activity that receives special attention and thus special treatment as regards funds and/or other incentives" (OECD, 1994). Thus, policies in which a process of priority-setting has resulted in a focus on certain priority areas are often termed prioritisation policies.

Prioritisation policies are pursued in the STI domain for several reasons. Typically, governments make choices for economic or political reasons when they have to, or for reasons usually connected to change strategies when they want to. Five rationales identified in the literature (Boekholt, Arnold and De Heide, 2007; Dachs et al., 2003; OECD, 2013) are as follows:

- *science-push*: to profit from new or emerging scientific or technological paradigms
- *policy-pull or new mission*: to react to new societal challenges
- *anticipated market-pull*: to ensure a strong position on emerging or future markets
- *industrial mission*: to promote strategically important industrial sectors
- *fast second-mover*: to quickly follow and adapt to international STI trends

- *Smart specialisation*: to focus countries/regions on their respective comparative advantage in order to strengthen complementarities at the international level.

May countries have adopted STI prioritisation policies because they regard them as economically beneficial to society. Prioritisation results in specialisation patterns that foster economies of scale and scope. It can be undertaken at various levels – not only the national level, but also increasingly the local or regional level (OECD, 2013).

However, prioritisation imposes certain risks to national economies. A high degree of specialisation can result in an economy that is more vulnerable to external shocks, and volatility in priority areas can have a stronger impact on national economies than fluctuations elsewhere. Table 6.1 summarises other arguments for and against prioritisation policies (Boekholt, Arnold and De Heide, 2007).

Table 6.1 The pros and cons of prioritisation policies

Pros	Cons
More suitable for stimulating structural changes than generic policies	Works mostly on basis of picking winners, and governments are not always good at selecting winners
More suitable in emerging technological fields where players are less well organised	Markets are best at selecting most promising R&D investments
Mobilises a larger critical mass of support, so the effect of intervention on specific fields is broader	Risks of "betting on the wrong horse"
More efficient bundling of scarce government resources	Risk of lock-in in existing positions or industries that are no longer vital
Can stimulate R&D investment towards societal issues that cannot be resolved by market forces	Creates market distortions
Alignment with international trends and international programmes	Specialisation makes national economies more prone to external shocks and swings in the market
Can help generate technological leadership in a certain niche	Scarce government resources are not sufficient to bring about structural changes
Allows taking advantage of complementarities at the international level	Vested interests in government and industry could interfere with a rational process
	Risk of hampering the diversification process

Source: adapted from Boekholt, Arnold and De Heide (2007), The use and effectiveness of programmatic policies: Some strengths and evidence from around the world.

Gassler et al. (2004) have described a number of phases in the evolution of rationales for prioritisation in the STI domain after the Second World War, each dominant over a period of time, but all co-existing at present (Gassler, Polt and Rammer, 2007).

- The *classic mission-led approach* evolved during the 1940s and the 1950s, which were characterised by war and the threat of nuclear conflicts. Unsurprisingly, this approach focused mainly on key military technologies, and the need prioritise and pool resources to build large scientific infrastructures, resulting in "big science".

- In the 1960s, the mission-led approach extended into the civil domain. The *industrial policy* approach, which broadened the focus of prioritisation efforts to include key technologies of interest to industry, emerged as a new paradigm.

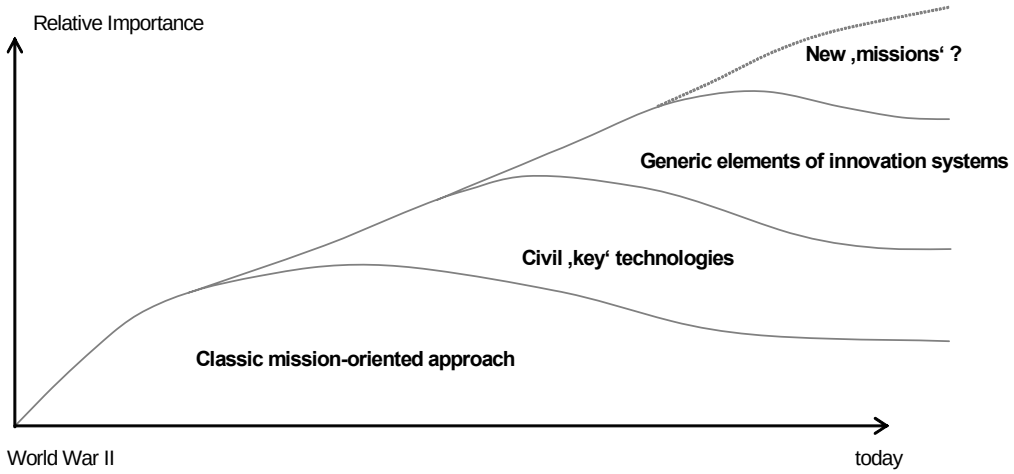
- During the 1980s and 1990s, policy makers increasingly adopted a national innovation framework. Associated with this new framework was a *systems-oriented approach* prioritising

activities related to the functional aspects of innovation systems. Prioritisation began to focus on activities that either built on innovation systems' existing strengths (e.g. efforts to further key areas within the science base) or rectified potential or actual weak spots radically affecting their performance (e.g. by strengthening sub-optimal links between the science base and industrial innovation).

- Since the beginning of the 21st century, a *new mission-led approach* has appeared, involving the prioritisation of scientific and technological developments that can be deployed to tackle various "grand" or "societal" challenges (see Chapter 5).

All four approaches can be found today in prioritisation policies around the world (see Figure 6.1). Gassler, Polt and Rammer (2007) have argued that the five largest OECD countries (in terms of gross domestic product) use a mix of these paradigms.

Figure 6.1 Trends in prioritisation approaches



Source: Gassler, Polt and Rammer (2007), Priorities in Science & Technology Policy: An International Comparison.

In addition to these evolving paradigms, various authors have attempted to distinguish between different types of priority areas (Gassler et al., 2004; Dachs et al., 2003; Glod, Duprel and Keenan, 2009; OECD, 1991). These include:

- *functional (or structural) priority areas*, which address the functions and functional elements of innovation systems, including the establishment of research infrastructures, the development of research and innovation-friendly higher education strategies, initiatives aimed at the valorisation of research activities and mechanisms designed to improve start-up dynamics

- *thematic priority areas*, which relate to particular scientific and technological fields, societal or public issues or concerns, or industrial areas and sectors.

Deuten and Boekholt (2009) distinguish between four types of thematic priorities:

- *scientific priorities*, aimed at creating and promoting international strengths in the national science system

- *economic priorities*, aimed at creating and fostering strong sectors and national competitiveness

- *societal priorities*, aimed at finding solutions to societal (often global) challenges
- a combination of the above.

As the four prioritisation paradigms distinguished by Gassler et al. (2004) evolved, the focus shifted from thematic priority areas to functional priority areas. Similarly, thematic priorities shifted from focusing on scientific and technological strengths to tackling societal challenges (Deuten and Boekholt, 2009). Today, societal priority areas are common (Gassler, Polt and Rammer, 2007), with priority areas often expressed in terms of societal challenges (OECD, 2013).

Based on an overview of 2011-12 innovation policies in the European Union, Izsak and Griniece (2012) concluded that almost all EU Member States focus on certain themes, key technologies or sectors to varying degrees. In some cases, this focus appears to exist only within the sphere of policy rhetoric.

Izsak and Griniece (2012) also found that prioritisation mainly concerns future key technologies, cross-cutting themes and grand challenges, with specific support for sectors or industrial groups falling out of favour – an example of "picking the challenges, not the winners". Based on their analysis of research and innovation (R&I) strategies and thematic programmes, they concluded that most countries had chosen themes related to energy, information and communication technology (ICT), new materials and sustainable development. Only a few countries had developed and implemented prioritisation policies focusing on specific sectors or industries, and only 31% of all support measures were sectoral or thematic.

Prioritisation strategies differ not only in terms of rationales and targets, but also in the way they are implemented and institutionalised in national and regional innovation systems. Despite a long history of priority-setting in research, there is still no single best way (OECD, 2010).

6.2 Prioritisation issues

A number of related issues affecting the formulation and implementation of prioritisation strategies in Sweden and elsewhere can be identified:

- alignment
- inclusiveness
- transparency and communication
- governance.

6.2.1 Alignment

Prioritisation occurs in many different quarters and at many different levels. Central government can set priorities, but so can individual ministries and agencies. Outside of government, institutional actors such as firms and universities are frequently affected by ministries and agencies' prioritisation exercises, but they also have their own strategies and priorities that are not always perfectly aligned with government's. Similarly, individual and groups within these institutional settings (e.g. researchers at universities) can have their own preferences and priorities.

Within the context of modern knowledge societies, many governments are attempting to devise policies that influence the performance of their national innovation systems alongside parallel initiatives by institutional and individual actors within these systems to protect, maintain, evolve or improve their own

activities. In such situations, the onus is on government to ensure that strategies and prioritisation exercises devised and implemented in different quarters and at different levels interact constructively rather than destructively, which in turn calls for a degree of alignment between them.

On one hand, aligning strategies and priority-setting exercises at the governmental, departmental, institutional and individual levels to improve overall system performance might seem desirable; the polar opposite – non-alignment – bears all the hallmarks of anarchy. On the other hand, complete alignment carries overtones of authoritarianism, whereas non-alignment represents the rule of individual choice and free will.

The scene is therefore set for conflict, with multiple trade-offs and compromises needed at many different levels if innovation systems are to function effectively. Adequate mechanisms are required to ensure these compromises can be both attained and maintained.

6.2.2 Inclusiveness

A corollary of the need for alignment is the need to include all relevant sets of stakeholders in efforts to bring it about. This is necessary when setting priorities at different levels; meshing often competing sets of priorities during the alignment process; and transitioning to the implementation phase. The goal is to ensure that the priorities of multiple actors at the different levels continue to be adequately represented as the transition is made.

6.2.3 Transparency and communication

Alignment and inclusiveness are crucially dependent on transparency and adequately communicating the rationales, goals and objectives of the different stakeholders agreeing on priorities and implementing the resulting activities.

6.2.4 Governance

Prioritisation, as well as strategy formulation and implementation, demand the existence of adequate governance structures and processes. Guy (2007) distinguished between "top-down" and "bottom-up" needs in priority-setting exercises involving actors at different levels. From the bottom-up perspective, structures need to be in place to allow "lower-level" actors to identify, articulate and develop the rationale for their priorities, and communicate them to "higher-level" actors to enlist their support. Conversely, once these higher-level actors have internalised, accepted and taken into account the lower-level actors' priorities when formulating their own priorities, the focus shifts to ways in which they can articulate and communicate them to the lower-level actors. Critically, adequate governance structures and mechanisms must also be in place to effect and maintain a consensual agreement on the continued alignment of stakeholder priorities.

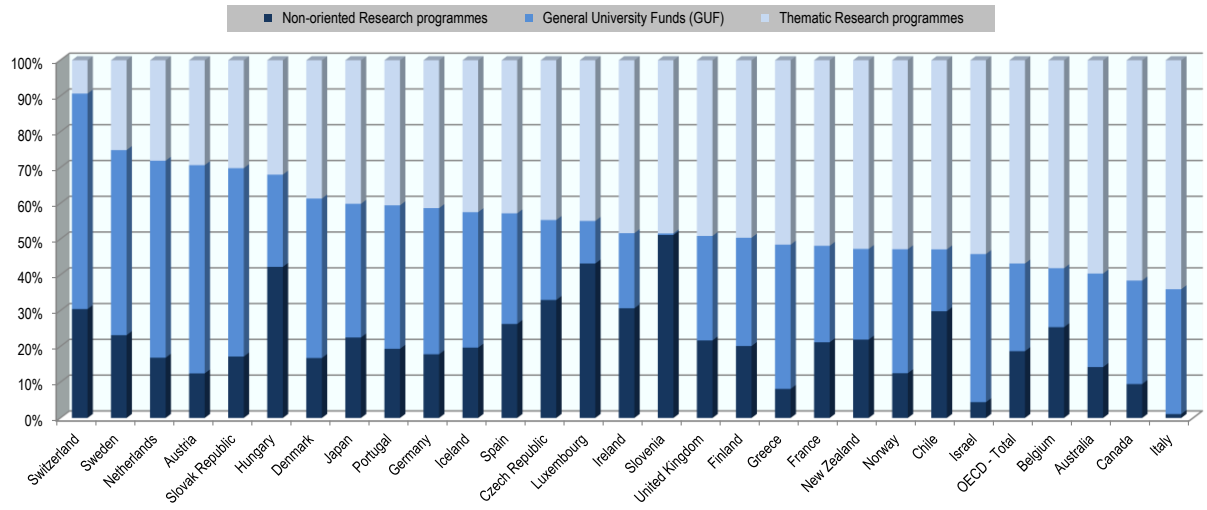
These governance structures and mechanisms can take many forms, i.e. delegating responsibilities to existing bodies or authorities or creating new bodies and arrangements. Where "vertical" co-ordination between upper and lower levels is concerned, agencies are often the intermediaries between overall government policies and the ultimate beneficiaries of support packages, e.g. the R&I community. When there is a need for "horizontal" communication between actors at the same level – e.g. across different agencies concerned with prioritising actions designed to tackle societal challenges – co-ordination activities can either be delegated to an existing agency or to a new body responsible for overseeing related efforts.

6.3 Prioritisation of innovation in Sweden

Discussion of prioritisation is less open and overt in Sweden than in many other countries. In the Netherlands, for example, the elaboration of the "Top Sectors" approach put priority-setting at the heart of the government's STI-related policy making (OECD, 2014a). Similarly, the launch of the National Research Prioritisation Exercise in Ireland was an important strand of the government's attempts to re-launch an R&I strategy that had been blown off course by the financial crisis of 2008. By contrast, Sweden's relatively strong historical position across many scientific and technological fields, and the robust innovation performance of its highly diverse industries, has not thrown the need for prioritisation into the spotlight.

Among OECD countries, Sweden comes only second after Switzerland in terms of the proportion of R&D expenditures dedicated to non-thematic research. Although this category of expenditures – which includes GUFs and all other types of non-oriented research programmes – cannot be taken as a perfect indicator of the extent of prioritisation in a given country, it gives at least a fair indication of the margin for orienting R&I activities.

Figure 6.2. Thematic and non-thematic government budget appropriation (GBAORD), 2013



Source: OECD, Research and Development Statistics, http://dotstat.oecd.org/Index.aspx?DataSetCode=IPP_NEW

Note: GBAORD= Government budget appropriations or outlays on research and development.

This does not mean, however, that prioritisation has not occurred; it simply means it has been implicit, rather than explicit, in many quarters. The historical emphasis on excellence in university research is one form of prioritisation, to be balanced with universities' role in performing their societally relevant "third mission". Sweden's efforts to build international links and collaborations in the R&I domain have also resulted in prioritisation strategies identifying target countries.

Many of the initiatives covered in this *Review* can also be seen as prioritisation exercises of one form or another. These are reviewed below.

6.3.1 GUF increases, performance-assessment schemes and SRAs

Chapter 3 focused on efforts to enhance the science base. Both the increase in GUF and the SRA initiative flagged in the 2008 and 2012 Bills involved attempts to improve the overall performance of higher education institutions through mechanisms designed to allow them to build on existing strengths. Universities were expected to use the additional GUF money to give researchers greater freedom to follow their own agendas rather than be committed to the agendas of TPF bodies. Similarly, while the new performance-assessment scheme rewarded – and to some extent incentivised – success in raising TPF, the additional funds gained were also considered a form of compensation that could be used to fund academics' individual research interests. Finally, the SRA specifically prioritised research endeavours in a very broad range of areas, giving universities an opportunity to bid for money they could channel into areas they deemed "strategic", typically reinforcing existing strengths.

None of these initiatives can be considered truly effective. GUF certainly increased, but the viciously circular link between GUF and TPF was not broken. Rather than using the money to allow individual researchers to follow "non-tied" or "open" lines of enquiry, the funds were often used to hire new recruits whose salaries partly depended on raising additional "tied" funds from TPF sources. The mechanics of the performance-assessment scheme and the proportion of GUF affected by the scheme (10% in the 2008 Bill, rising to 20% after the 2012 Bill) also meant that the relative increases and decreases for individual universities resulting from the scheme's implementation were mostly marginal. Finally, as noted in Chapter 3, the external evaluation of the SRA concluded that universities with overt strategies had benefited most from the scheme, but that relatively few universities possessed such strategies.

The common thread is the absence of adequate governance mechanisms to ensure that high-level priorities and goals meshed effectively with the low-level goals of the academic research community. Academics generally value the freedom to conduct research wherever their interests take them, and this sentiment is especially strong in Sweden. By contrast, government often has a civic responsibility to gently steer research, sometimes to satisfy broader societal needs, but also often to instigate performance improvements and ensure that expenditure of public funds results in value for money. In academic circles, the universities are key institutional intermediates in the process of reconciling often competing top-down and bottom-up priorities. The relative weakness of many Swedish universities in terms of strategic leadership (as discussed in Chapter 3) is thus an important impediment to effectively realising government priorities for the university sector.

6.3.2 The strategic innovation areas (SIO) in focus

The SIO (covered in Chapter 4 of this *Review*) set out to prioritise areas considered strategic to Swedish interests, and to launch support programmes for R&I programmes and projects. One of its characteristics was its emphasis on the bottom-up construction of the strategic innovation agendas (SIAs) formulated in these priority areas and SIPs launched under them, with stakeholders within new constellations of industrial, academic and RI stakeholders playing key roles in setting and operationalising these priorities.

No overt prioritisation of particular areas took place from a top-down, governmental perspective. Responsibility for orchestration was handed down to the agency level – first to VINNOVA alone, and subsequently to VINNOVA and two other funding bodies. VINNOVA deployed funds to support preparing the SRAs and encouraged the broad involvement of new configurations of stakeholders spanning multiple disciplines, fields, sectors and organisational types, who were then invited to submit proposals for SIPs in line with the SRAs. External evaluators assess these proposals, and VINNOVA (and the other two agencies) disbursed funds to them.

VINNOVA's role in this process was to issue guidelines specifying the criteria to be followed by applicants preparing submissions and by external evaluators selecting appropriate initiatives. These guidelines placed considerable emphasis on widespread support by multiple stakeholders for programmes aligned with the associated SRAs – a precondition for submitting an SIP proposal.

The guidelines did not involve any overt top-down specification of particular priority areas. Nevertheless, the funding agents did exert some influence on the number and construction of SIPs, by encouraging resubmissions when competing proposals for SIPs overlapped or demonstrated potential for synergy. This was seen as an example of "bottom-up integration" through a process that was only very softly influenced by VINNOVA and the other agencies.

Similarly, once SIPs were launched the participants organised the calls, and the agencies facilitated the evaluation of project proposals by external evaluators. The only exceptions involved a small number of typically large and complex "strategic" projects within each SIP that initiated the open calls. In these instances, the agencies involved took direct responsibility for sanctioning these projects, assessing whether the process of developing the proposals had been sufficiently open to interested parties.

The effect of funding a portfolio of academic-industrial consortia selected bottom up (as is the case with SIO) is inherently conservative. The evaluation of the Swedish Competence Centres programme (which currently corresponds to the VINN Excellence Centres) pointed out that generating proposals for such consortia using a stage-gate process – where small grants are available to support consortium-building and proposal-writing – is a time- and resource-intensive process. A consequence of using consortia is that they reflect strengths and interests of both the academic and industrial sides, so a bottom-up competition provides a snapshot of potentially interesting and strong areas – but is also considerably backward-looking. Hence, the consortia need to be complemented by policy instruments that are more forward-looking, addressing less well-established areas of potential future interest (Arnold, Clark and Bussillet, 2004). VINNOVA appears confident that a strong emphasis on the continued evolution of strategic research agendas within new configurations of actors from different sectors and disciplines will suffice, but additional efforts may be needed to ensure these are sufficiently forward-looking.

The agencies consider their adamant non-involvement in specifying top-down priorities as a strong point of the initiative and a retreat from earlier in-house practices that gave the agencies a much stronger say in specifying top-down policies. In some respects, however, it can be seen as a high-risk strategy. Ceding control to bottom-up priorities is certainly one way of ensuring that key stakeholders develop a strong interest in the resulting programmes, but it underestimates the importance of maintaining a system of checks-and-balances between top-down and bottom-up priorities, and diminishes the role of the state in maintaining such a balance. Left to their own devices, academic researchers tend to opt for longer-term projects closer to the basic end of the spectrum, while industrial researchers tend to opt for shorter-term, more applied projects nearer the market end of the spectrum. The newly created SIP constellations certainly hold potential to become self-regulating in terms of finding an effective balance between the types of projects that will satisfy all the different types of participants, but without a stronger agency role in ensuring such a balance, fragmented portfolios or the capture of whole portfolios by the stronger factions is more likely. This is what happened in Finland, where the external evaluators of the SHOK Strategic Centres for Science, Technology and Innovation identified strong "tensions between the short-terms interests of industry and the longer-term perspective required in the promotion of cutting edge or "breakthrough" scientific research" (Finnish Ministry of Employment, 2013). These tensions eventually led to the closure of the SHOK initiative. It bears noting that the design of the SIO was greatly influenced by the design of the SHOK programme.

Successful prioritisation efforts often depend on the existence of mechanisms that effectively mesh the priorities of different sets of stakeholders operating at different levels. Moreover, the successful

translation from high-level priority-setting to effective lower-level implementation critically depends on the existence of mechanisms at all intermediate levels that can establish and maintain a consensus concerning mutually agreed sets of priorities at all of these levels.

6.3.3 The research institute sector

The historical development of the RI sector traced in Chapter 4 can be interpreted as an example of functional prioritisation, with increasing emphasis on the development of a sector capable of playing a vital role in the Swedish innovation system. The Swedish innovation landscape originally comprised many small specialised institutes serving specific sectoral needs and (given the "third mission" role of universities) occupying a very marginal position in the national innovation system. Since the 1990s, policy makers have attempted to consolidate and strengthen the role of the RIs, through the formation of RISE (announced in the 2008 Bill) and further measures aimed at consolidating and strengthening the role of the RISE institutes (announced in the 2012 Bill). This attempt at consolidation and growth marks a recognition that the functions of RISE institutes are significantly different from those of universities, and that neither the RIs nor the universities can alone meet all the needs of local and international firms within a flourishing innovation ecosystem.

Progress towards the establishment of a strong RI sector that will play a pivotal rather than marginal role in the Swedish innovation system has been slow but steady. Some progress needs to be made in transitioning from branch-focused research associations with membership-based governance structures to a truly polytechnic organisational form for RISE that can address wider industrial and social needs. This transition may require changes to the existing governance structure of RISE to allow it not only to satisfy the needs of its traditional sectoral interests (i.e. the bottom-up needs of its existing customer base), but also the state's top-down needs for an organisation that can play extended a larger role in the Swedish innovation system as a whole.

6.3.4 Challenge-driven Innovation (UDI), Europe and societal challenges

The initiatives addressed in Chapter 5 can all be seen as a response to the prioritisation of societal challenges signalled by the Swedish Presidency of the European Union and the 2009 Lund Declaration. The UDI programme involved specifying themes relevant to societal challenges at an agency level, while providing funds for greater involvement in European P2Ps and the establishment of a co-ordination mechanism across agencies allowed Sweden to take a more strategic approach to align international efforts tackling societal challenges. Furthermore, the latter stages of the SIO initiative described in Chapter 4 have a distinct societal-challenge flavour.

That said, although many aspects of these responses to the Lund Declaration (e.g. greater involvement of end-users as co-production agents in the UDI) are laudable, the limited scale of these efforts, and their relatively low level of visibility in the 2012 Bill, are puzzling. In response to the Lund Declaration, Sweden had an opportunity to place efforts designed to tackle societal challenges at the heart of a very distinctive national R&I strategy that would have signalled to the world it was prepared to lead by example. This did not happen. The 2012 Bill, like many previous R&I bills, included a broad range of actions designed to improve performance in many of the interdependent domains that constitute a modern national innovation system. This is fitting and necessary, but the Bill as a whole provided no overall vision of how the system might develop, and the direction it might take. In particular, it gave no indication of how a strong emphasis on societal challenges might fit into an overarching long-term support strategy capable of satisfying the needs of all relevant stakeholders.

The Swedish system of R&I governance does not appear to favour a "challenge" approach. It is characterised by "weak" vertical co-ordination, as ministries have relatively limited ability to steer the

large number of government agencies. Instead, agencies are in a position to define and develop their own roles. Horizontally, agencies co-ordinate activities among themselves; many concrete programmes are managed and funded by several collaborating agencies. However, this also results in committing budgets, thereby limiting agencies' strategic room for manoeuvre. The 2012 OECD *Review* concluded that the Swedish system tends to favour "a multitude of medium-sized activities and to abstain from larger policy missions" and that policy makers "seem reluctant to seek new ways of tackling grand challenges on a national level" (OECD, 2013).

6.4 Prioritisation, strategy development and vision

Many attempts have been made in Sweden to select priorities and align different institutional actors' strategies through policy initiatives designed to improve different aspects of the innovation system's performance. Similarly, institutions (e.g. universities) have made many attempts to align the activities of individuals within them to broader institutional strategies. By and large, however, few of these alignment efforts have been successful. Universities have seen widespread resistance at the individual level to attempts to "limit academic freedom", while similar resistance has occurred at the institutional level to efforts that are perceived as affronts to the concept of "institutional autonomy". Moreover, there have been sustained criticisms that different government departments conceive and implement their policies without the benefit of an overarching strategy for developing the innovation system as a whole. To complicate matters even further, the concept of selecting a "strategy" appears to differ from one quarter to another, with "strategic areas" selected through top-down and bottom-up processes in different areas and implemented in ways that defy the prioritisation logic. This has led to criticism pointing to a non-strategic approach to priority-setting and system-goal attainment.

Each of the three generations of social contracts and innovation-policy models referred to in Chapter 5 implies a different form of prioritisation in R&D funding:

- The **linear model** builds on an explicit rejection of any societal role in prioritising state research spending in the wake of the Second World War, where many felt science had been co-opted for highly undesirable societal purposes (e.g. fascism and socialism). Based on Vannevar Bush's famous "Science, the Endless Frontier" manifesto (Bush, 1945), the linear model asserts that progress stems from basic research; since only scientists can fully understand this, only the scientific community is in a position to prioritise in this area. Because there are no-intra-scientific criteria for prioritising among different thematic areas, such prioritisation should preferably not be attempted, or else only by the state – and only in terms of disciplines, rather than societal problems or objectives. A central tenet of this model is that "the results of research cannot be ordered" (i.e. specified in advance). Historically, while it has huge rhetorical and policy significance, this "basic" research-funding tradition has in fact co-existed with strong mission research (such as defence, energy and heath) – which has been funded by different institutions than basic research.

- The **interactive or coupling model** involves more than the extension of "mission" thinking into more research domains. It implies that thematic priorities derived from societal needs should influence the work of the research community at some level. In context, this largely means there should be connections between basic research and innovation – particularly that growth should take place in "relevant" research explicitly intended to focus on innovation. A new and growing part of research funding is therefore driven by societal problems, rather than by scientific impulses or the desires of principal investigators. In innovation funding, both industry and the state started to influence funding priorities, mostly by allocating additional resources to R&D funding rather than reducing funding for basic or self-initiated research.

- The **societal challenges** model shifts the level and type of problem focus involved in R&I funding from the research and industrial communities to the societal level. Scientists and companies remain important stakeholders, but society also needs to define needs at the level of the whole-of-society or significant segments of society. For example, climate change will not be resolved through the addition of individuals' basic research ideas or of individual companies' desires. Rather, it requires a collective effort, in which basic research will be encouraged in certain areas, and companies learn how to make money out of preventing – rather than causing – climate change. This can only be organised at a "higher" societal level than that of scientists or companies. Thus, the societal challenges seem to require new forms of R&D funding governance and co-ordination mechanisms that can prioritise at the societal level. They also require levels of financial commitment that signal the importance of this policy reorientation.

As noted in Chapter 5, these three models can co-exist. Funding for basic research has continued to grow alongside funding for problem-oriented research, and both modes are likely to thrive even as the focus on societal challenge research continues to grow.

Many R&I debates in Sweden have taken place as if the first (linear) and second (interactive or coupling) models were mutually exclusive. Perhaps the most conspicuous case is that of the Research 2000 committee (headed by the chancellor of the Swedish universities) which proposed that the state should stop funding innovation-related research and place all research funding under academic control (SOU 1998:128, 1998). In practice, they co-exist. However, it is less clear that the third (societal challenges) model can simply be added on top of the other two. First, that would raise state resources for R&D to a very high level, which is especially problematic in the present economic context. Second, it would not necessarily address the need to co-ordinate across different types of research. Perhaps the way the Research Council of Norway (RCN) started to work in the early 2000s provides an image of the three-layer future. Following its first evaluation, RCN was reorganised into three major blocks:

- The science division funded self-initiated research and some types of centres of excellence.

- The innovation division funded academic-industry partnerships (especially with RIs rather than universities) aiming at innovation.

- The "large programmes division" contained a slowly evolving set of programmes of national strategic relevance. Several of these programmes followed integrated strategies across researcher-initiated and innovation-related research, using a mixture of basic, applied and innovation-oriented funding instruments. Many, but not all, of the large programmes cut across different sectoral interests and addressed societal challenges, such as climate change and renewable energy.

Because the large programmes division had become too big and unwieldy in relation to the internal organisation of RCN, the Council recently split the large programmes division into two thematically oriented divisions, but with the same purpose.

Of course, other organisations are not obligated to merge a wide range of funders into a single organisation in order to co-ordinate across different types of research, provided appropriate cross-sectoral co-ordination mechanisms can be found. While inventing such a co-ordination mechanism that will function in the Swedish context is a significant policy design challenge, it is difficult to see how a significant amount of social R&D resources can be oriented towards resolving societal challenges without such a mechanism.

The corollary is that while co-ordinated efforts are needed to address the societal challenges, overly co-ordinating national research funding would be unwise. While both research and innovation are of course important in terms of societal challenges, the dynamics of both also demand that there be dedicated "excellence" (Model 1) and "relevance" (Model 2) funding.

Such co-ordination would involve setting priorities, and yet this *Review* confirms the longstanding impression this is very hard to do the Swedish state R&D system. While university rectors are not formally elected in Sweden, they often struggle to develop strategies and set internal priorities. Institutionally, prioritising by the research councils is impeded by the strong governance role of elected academics. Advisory councils and governments themselves have consistently avoided prioritising. The recent case of the Strategic Research Areas (SFO) programme illustrates this conundrum in its choice of 20 "strategic" areas for allocating increased core funding to universities. To the foreign observer, such a wide range of themes looks, much more like "distribution policy" – where everyone gets something – than a serious attempt at prioritising. This tendency to "share out", rather than strongly prioritise, resources is encouraged by a Swedish tradition of using relatively small funding instruments. For example, Swedish centres of excellence typically receive smaller absolute amounts of money than those in other small countries that prioritise more strongly. Successful prioritisation must involve not only fewer priorities, but also the use of larger funding instruments to implement them.

Prioritisation is especially difficult in the absence of a common vision about what needs to be prioritised, or a mechanism for generating such a vision. One possible mechanism is foresight. Sweden was a comparative latecomer to technology foresight (*Teknisk Framsyn*), running its first exercise in 1999-2000 (Arnold et al., 2005). The Swedish Foundation for Strategic Research and the industry ministry funded the exercise, which laid out a broad technological agenda. The 2000 Research Bill cited extensively from the *Teknisk Framsyn* reports, though it is not clear that there was any direct influence on policy. Rather, *Teknisk Framsyn* appears to have documented and brought together current thinking among those in Sweden who shape policy. A second foresight exercise was run four years later, in hopes of influencing the 2004 Research Bill. It updated the first technology foresight and produced a much wider societal analysis, linking research policy to broader issues in society. As a result, it struggled to find an audience and was generally ignored, though some of its conclusions were subsequently reflected in the industry ministry's" Innovative Sweden" innovation policy.

International experience with foresight is mixed. In some cases, it has provided a useful way to set or reinforce priorities. In others, it has served more to strengthen networks among stakeholders with interests in related areas of research and technology. Whether foresight in practice can be made more effective in creating a common vision in Sweden is an open question. However, the Swedish R&I system appears to lack an effective way to reach a common vision today. Especially in the light of the growing need to co-ordinate parts of the national R&I effort, Swedish policy makers should strive to devise and implement a national visioning mechanism that can build greater consensus about major priorities, without excluding the other research and innovation efforts that are necessary to a well-functioning innovation system.

Prioritisation has a bad name in many quarters. One reason is that it runs against the typical desire of the scientific community to set its own priorities. Another stems from the overlap between innovation and industry policy that characterised in many countries the early years of the second research-funding model (interactive or coupling model) discussed above in this section.

The technological optimism of the 1960s and 1970s prompted a number of conspicuous but ill-thought-out state-sponsored technology projects, such as the UK-French Concorde supersonic airliner or the British Advanced Passenger Train (APT). Concorde typified one kind of mistake: namely, concentrating on the technology and ignoring the economics and the market. While the Anglo-French consortium focused on extrapolating the trend towards faster planes, Boeing focused on extrapolating the

trend towards reducing costs per seat-mile. As a result, Concorde was trapped in a very small high-cost market niche serving rich people, while the 747 expanded the market for air transport to people with lower incomes. The APT, on the other hand, failed for technological reasons before it reached the market: at the time, it was not possible to build sufficiently sophisticated electronic controls to allow the train to go fast by leaning into bends without making the passengers sick. Later, leaning trains such as the X2000 and the Pendolino largely solved this problem thanks to better controls. Other state-sponsored projects (such as Airbus Industrie) are less discussed – perhaps precisely because they were successful. At the same time, many European countries were struggling with changes in international markets that rendered their "rust-belt" industries uncompetitive, yet they carried on subsidising areas like shipbuilding and steel, despite the fact that market forces meant these efforts were doomed.

Despite these bad experiences, the Swedish state has a very strong history as a driver of - and partner in - innovation. Sweden, like other countries, has a strong history of "development pairs", where the state acted a co-developer and lead customer for complex technical systems such as locomotives, telecommunication systems, defence equipment and power stations. The model began to go wrong when it was extended beyond situations where the state was a monopoly lead customer. When Concorde was on the drawing board, for example, many airlines were under state control and were able to maintain very high prices; by the time Concorde entered production, they faced a much more competitive market, and even the state airlines could no longer ignore market forces.

A key lesson for subsequent prioritisation has been to avoid betting on single firms, or otherwise trying to oppose market forces. Priorities have therefore been defined in terms of enabling technologies, challenges, clusters and networks, without trying to pre-judge the competitive outcome. As in other parts of R&I policy, governance is essential. In particular, while stakeholder involvement in R&I policy is often important, it must be sufficiently balanced to avoid "capture" of the priority and its implementation by one stakeholder or group.

6.5 Governance

Articulating visions, priority-setting and strategy development are all influenced by the governance structures in place in a country. Similarly, effective strategy implementation is affected by governance arrangements at many different levels within R&I ecosystems.

This *Review* points out in many places the critical role of governance arrangements in enabling or preventing reform and performance improvement in the Swedish system. It has documented how the implementation of measures designed to strengthen the academic research base has been compromised by a lack of strategic leadership in many universities, as well as the lack of any governance mechanisms facilitating an effective meshing of top-down and bottom-up priorities. Similarly, the governance arrangements for the SIO initiative – while allowing a broad swathe of academic, research-institute and industry stakeholders to take the lead in determining the content of an important support measure – may ultimately weaken the state's ability to steer or influence this content or the initiative's strategic direction. There is also scope for improving RISE governance arrangements in order to realise its full potential within the Swedish innovation system.

In the same vein, the relatively weak response to the threats (and opportunities) presented by societal challenges perhaps reflects a systemic weakness in the overall governance arrangements for R&I in Sweden. Sweden has a "veneer" system of governance, with a relatively thin, lightly staffed layer of ministries overseeing a thick layer of well-staffed agencies. This means that while ministries can ask agencies to co-ordinate activities requiring concerted action across agencies, the ministries themselves have little scope to play a significant role in these co-ordination activities.

These are not new issues. Indeed, some have persisted at least since the time of the Malm Commission in 1942.

One key area is university governance, which (despite a number of reforms) generally continues to be dominated by the academic community. Clearly, it is important that teachers, researchers and students should have some say and representation in the governance of their organisations, just as workers' rights to representation in the governance of other organisations are enshrined in law in many continental European countries. Academics' freedoms to inquire into what they like (and more or less to say what they like) is bound into the nature of universities – though it is worth noting that these freedoms originally developed as a way to oppose the power of the Church and of absolute monarchs, and has a different meaning in democracies. Autonomy (under various definitions) has also been key to the idea of a university. Swedish reforms in recent decades have sought to increase this autonomy, which is also encouraged by the principles of the "new public management", which seeks to devolve decision-making to the lowest sensible level in any hierarchy of state organisations. The corollary of growing autonomy is that the state offers a range of incentives – for excellence, for relevance, for addressing sectoral and societal challenges – to encourage the autonomous universities to act in ways consistent with the interests of taxpayers and wider society. None of this contradicts the right of academics to write freely about any topic they choose.

However, a form of governance that impedes the university from developing its organisation and strategy in order to address the changing needs and demands of society is clearly problematic. Such inability is as visible in several universities' limited ability to exploit the SFO scheme as it is in universities' longstanding failure to implement the "Swedish model" adequately. The precise governance changes needed to make universities more responsive, while continuing to exercise their right (duty) to be independent and (at times) inconvenient to the authorities are difficult to specify in detail without more intimate knowledge of the minutiae of the Swedish system than is available to this kind of review.

The academic majorities in the governing bodies of the research councils (VR, Forte and FAS) have similarly proved to hinder change and prioritisation. This is consistent with widespread international experience that beneficiary-governed organisations tend to become locked-in and reluctant to change. Indeed, academic governance was probably a factor in the fragmentation and lack of dynamism of the Swedish research-funding system identified by the OECD in 1964 (OECD, 1964) and was a clear problem in the early years of the Swedish Board for Technical Development, which effectively began to act as a change agent only after the power to make funding decisions was transferred from the academic committees to the programme officers. Academic governance explains the low rate of change in the Swedish Research Council and its inability to act as a change agent, as well as the process of driving out more applied research from FAS and the former Formas (Sandström, 2008).

However, there is little point in transferring power from the elected academics if the funding agencies themselves have nothing to contribute to funding decisions. The Swedish Board for Technical Development's ability to be a change agent relied not only on ultimate control by the programme officers, but also on the fact that they were largely scientists and technologists able to consider longer-term needs and strategies, and to pursue an intelligent dialogue with the academic and industrial stakeholders involved in its programmes and projects. Similarly, the "administration" of effective research councils is not inert, but on the contrary has some power to initiate change. The US National Science Foundation, for example, has a tradition of allowing programme managers to initiate smaller exploratory calls for proposals without the need to seek the approval from the academic committees, exploring possibilities before throwing the entire might of the Foundation's funding into a new area. A key to their ability to do so is that many of them are seconded academics, so they actually know what they are talking about.

VINNOVA has continued its predecessors' tradition and tried to innovate in the realm of R&I funding. A good example is VINNOVA's identification and satisfaction of a need for capacity building in

the research and higher education sector through its "Actors Group". However, the recent trend towards encouraging the beneficiaries of support initiatives to specify more clearly the thematic content of programmes and projects, and the growing use of peer and expert review in funding decisions, weaken the "countervailing force" previously provided by the project officers.

Various efforts have been made over the years to remedy deficiencies in governance arrangements in various parts of the Swedish R&I system and across the system as a whole. These efforts included appointing in the 1960s a council to play a significant role in the co-ordination of Swedish research strategies – which was abolished after a few years. No effective council or committee has subsequently been able to bring together a wide enough set of stakeholders to establish a usable consensus on R&I policy. The new Innovation Council set up by the current prime minister may have the potential to support the type of policy co-ordination required, but the Council's remit does not extend to research. There is little reason, therefore, to expect it to be more successful than its predecessors unless its remit and powers are broadened and its budget increased commensurately. Currently, however, it is not clear that an effective mechanism for co-ordinating activities across the R&I domains exists. Certainly, no scheme currently exists to ensure adequate oversight of all the interconnecting domains of a fully functioning innovation system, which demands a degree of coherence between policies affecting education, research, innovation and even market development.

If Sweden is to rise to the twin challenges of improving performance across the whole innovation system and mounting a serious response to societal challenges, there is scope for a comprehensive review of the governance structures that need to be in place across the whole of its innovation system.

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