Securing Australia's Future - Project 9 Translating research for economic and social benefit: country comparisons

Sweden

A Study of Measures to Encourage the Translation of Public Sector Research for Economic and Social Benefit in Sweden

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1. Introduction

Population: 9.6 million (2013)
GDP per capita: €32,700 (2012)
R&D intensity (GERD/GDP): 3.41% (2013)
Private sector share of R&D: 68% (2012)[1]

A century ago, Sweden was among the poorest countries in Europe. Today, it has achieved an enviable standard of living under a mixed system of high-tech capitalism and extensive welfare benefits, and is a world leader in innovation. Timber, hydropower, and iron ore constitute the resource base of an economy heavily oriented toward foreign trade. Privately owned firms account for the vast majority of industrial output. Sweden's economy experienced modest growth in 2014, with an adjusted real GDP growth that averaged 2.3%. In these uncertain times for the Euro, it should be noted that Sweden did not join the Eurozone because of concerns with the impact on the country's economy, welfare system and sovereignty.[2]

In the early 1990s Sweden suffered a severe recession. Together with Sweden's accession to the European Union, this led to institutional changes in areas such as product and capital market liberalisation, wage formation and procurement rules. Investment started to shift from physical goods towards intangibles (such as R&D). Various reforms and adjustments helped turn around Sweden's economic performance in the 1990s, and growth of GDP and productivity accelerated. Sweden then continued on a successful path during most of the first decade of the 21st century. Like other open economies around the world, Sweden was hit by a contraction in external demand during the financial and economic crisis of 2008-09. However, Sweden has shown a high degree of resilience, weathered the crisis better than other countries and rebounded rapidly. Following the recession Sweden's economy has grown significantly faster than that of the OECD area as a whole.[3]

The Swedish national innovation system is "characterized by internationalized research; industrial orientation towards resource-intensive industries; rapid adoption of new techniques; high expenditures on education; and a relatively costly financial system. Large authorities aided by small ministries dominate the governmental part of this system. The authorities are independent units whose task is to carry out the plans of the government, but also to initiate relevant projects of their own, aiming at a specific goal. Most of the responsibility is allocated to the authorities rather than the ministries."[4]

The largest Swedish firms are highly internationalised and conduct increasing amounts of their activities, including R&D, outside of Sweden. BERD is still high at 3.41% of GDP though it has fallen slightly in recent years. The proportion of public research funded by industry is close to the OECD median. The relatively small share of patents filed by universities and public research institutes is attributed to the 'professor's privilege' which entitles researchers, rather than institutions, to patent their inventions. International collaboration indicators paint a mixed picture: a high 55% of scientific articles are produced with international co-authorship, while a below OECD average 19% of patent applications are produced with international collaboration. This reflects in part Sweden's industrial structure of large firms which are likely to retain technology development in-house.[5]

The OECD Review of Sweden's Innovation Policy notes that Sweden's innovation performance is one of the best in the world. A SWOT analysis was performed to assess this further. The results are shown below in Table 0.1[6]. Of relevance to the objectives of this SAF09 project are the findings that

some features of their research translation are relatively poor, including a suboptimal system of academic IP, University centres of competence/excellence are relatively small which can reduce their impact, and insufficient links between traditional universities and SMEs.

Table 0.1. SWOT (strengths, weaknesses, opportunities, threats) analysis of Sweden's innovation system

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. • 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.	• 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. • 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.

In order to address these challenges, the OECD Review recommends:

- Providing Swedish business with world-class framework conditions and business environment as well as world-class infrastructure, including in ICT, 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 PRI sector. These can help anchor Swedish and foreign-owned enterprises in the Swedish innovation environment.
- Further fostering internationalisation in order to be at the forefront of science, technology and innovation 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.[7]

Like most OECD countries Sweden has two main government ministries responsible for science, technology and industry policy.

- The *Ministry of Enterprise, Energy and Communication* is responsible for mainstream innovation policy and a number of instruments to improve regional innovation systems, but these form a very small component of the Ministry's responsibilities. The ministry is responsible for 24 government agencies, including VINNOVA, the Patent Office, the Transport Research Institute and the National Space Board.
- The responsibilities of the *Ministry of Education and Research* include schools, universities and science/research policy. The Minister leads on all questions to do with research and can act to co-ordinate overall research and innovation policy. It also has a number of agencies, including the Swedish Research Council.[8]

Generally, the role of the Ministries in setting national research priorities is somewhat limited; governance of the Swedish public R&D system is still rather decentralised and a great degree of influence over priority setting still lies with the universities. The actual distribution of research funding to different areas, is not the result of policy initiatives but rather determined by path dependence and a "composite crystallization" of priorities on lower levels in the governance system.[9]

Most innovation policy issues are handled by the Ministry of Enterprise, while VINNOVA executes innovation policy on a national level through funding of needs-driven R&D as well as strengthening networks. This work is complemented by the Knowledge Foundation and the Foundation for Strategic Research, two semi-public research foundations. Policy issues concerning universities are handled by the Ministry of Education and Research, while the Swedish Research Council is the main body for funding curiosity-driven research.

At the national level, the responsibility for policy concerning business development is distributed between Innovationsbron (The Innovation Bridge) which handles commercialisation of research and provides limited pre-seed funding, the Industrial Fund which is a public venture capital investor, and the Invest in Sweden Agency which promotes inward investment.[10]

The Swedish Government presents a 'Research and Innovation Bill' once during its mandate period (every four years), which describes the priorities for the Government's research and innovation policy for the coming years. This is the most central policy document; it forms the basis of steering and sets the financial framework for the national research and innovation funding agencies. Subsequently, the "The Ministry of Education and Research and the Ministry of Enterprise, and concerned national agencies, have since been busy turning the bill's words into action."[11]

In the 2008 Research and Innovation Bill, it was announced that Investments in research and innovation would entail successive increases in central government support during the period 2009-2012, to reach a permanent increase of €500m in 2012. The largest increase in resources took the form of direct appropriations to universities and higher education institutions, but the Swedish Research Councils and the Swedish Agency for Innovation Systems (VINNOVA) were also to benefit from significant increases in appropriations.[12]

In addition, the government identified twenty research areas of strategic importance for Swedish science, society and business, and invested SEK 1.8 billion a year[13]. These were:

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

The goal of the 2012 Research and Innovation Bill was to strengthen Sweden as a successful industrial and service nation, but also as a welfare society. Research must maintain highest international quality, and research initiatives should focus on areas that are of importance for human wellbeing and industrial competitiveness. The bill highlights the importance of more basic research that can stimulate R&D investments in the business sector. Also the importance of initiatives that focus on high-quality research that is innovative and internationally competitive is emphasised. The bill identifies three broad areas: medicine, technology and the climate that will receive increasing funding.[14]

An additional SEK 300 million was invested in areas of strategic importance for society and business.

Six weeks after the issuing of the research bill in 2012, the Minister for Enterprise presented the National Innovation Strategy for Sweden. This strategy document offered a clear vision of Sweden in 2020 and the need for purposeful and nationwide mobilisation within its entire innovation system. The production of this innovation strategy document involved a wide range of private and public sector stakeholders.

The National Innovation Strategy laid out the broader goals for the Swedish innovation system, but few concrete policy measures. The implementation of the strategy in direct policymaking and legislation followed in a series of steps from 2013 onwards. This measure "marks a major milestone in the implementation of the strategy since it creates much needed coherence in the innovation activities of the governmental authorities. Furthermore, by this directive the government signalled its intention take a holistic view on innovation and engage several sectors of society, represented by these governmental agencies, in Sweden's innovation efforts."[15]

The Strategy starts by identifying urgent societal challenges in Europe 2020:

- Health, demographic change and wellbeing;
- Challenges for European bioeconomy: Food security, sustainable agriculture, marine and maritime research;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, resource efficiency and raw materials.
- Secure societies: Protecting freedom and security of Europe and its citizens.[16]

Specifically, an Innovation Strategy was needed by Sweden in order to:

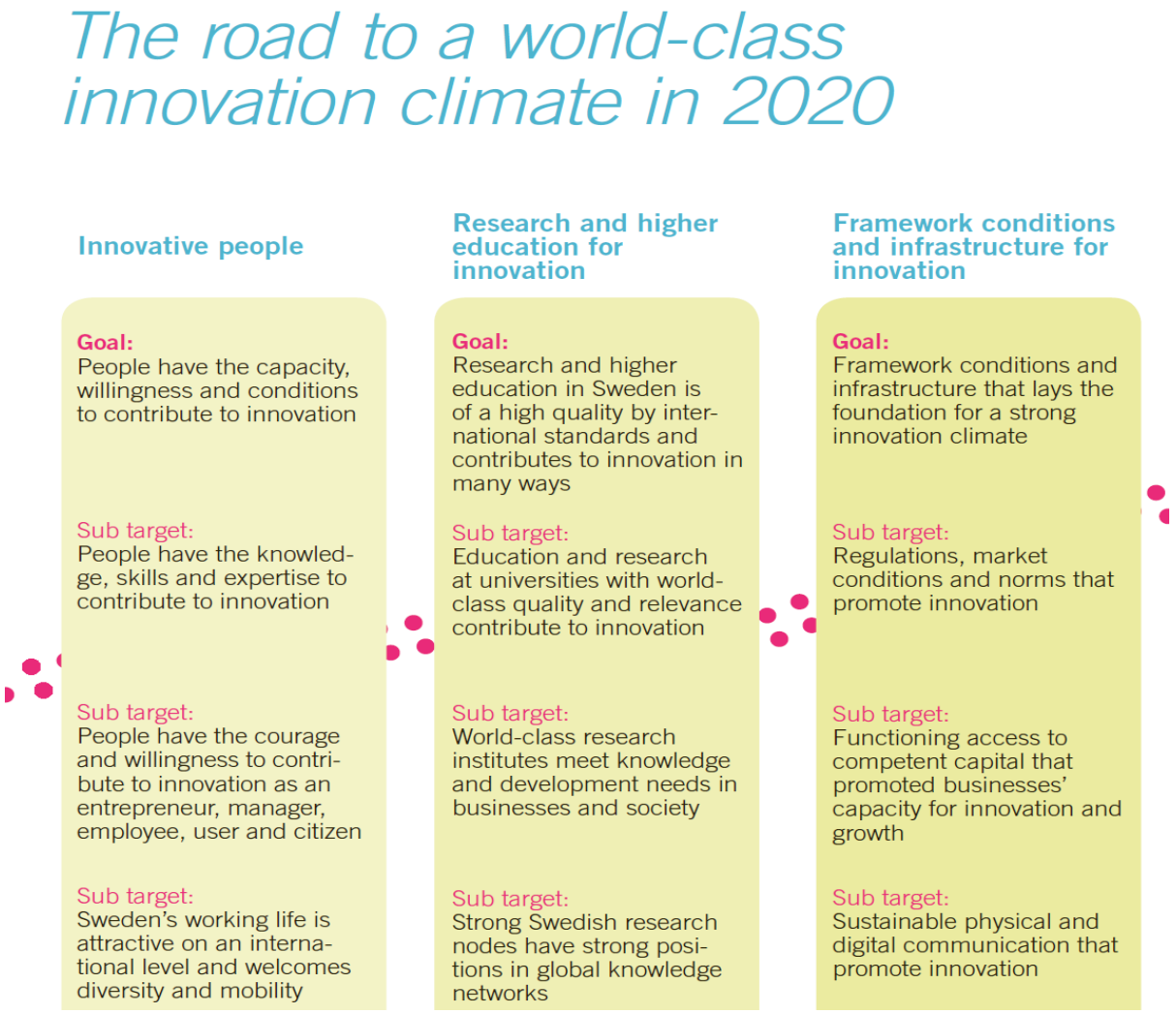
- meet global societal challenges;
- increase competitiveness and create more jobs in a global knowledge economy; and
- deliver public services with increased quality and efficiency.

The vision for the innovative climate in Sweden 2020 is outlined as "Sweden is a creative country characterised by pioneering ideas and new ways of thinking and doing in order to shape our future in a global community. People in all parts of Sweden can and want to contribute to creating value for people, the economy and the environment through new or improved solutions.

A strong innovation climate by 2020 will enable:

- People and actors, by being more innovative, to contribute solutions to big societal challenges, in Sweden as well as globally.
- Businesses and environments, by being more innovative, to create value, increase their competitiveness and attract expertise, investments and cooperation partners from around the world.
- Actors in the public sector and their partnership with private and civil society organisations, by being more innovative, to supply public services of a high quality and efficiency."[17]

The specific goals are described in the graphic below[18]:



As a major part in the implementation of the 2012 National Innovation Strategy, the National Agency for Innovation Systems (VINNOVA) was chosen to act as central coordinator of the effort of several other governmental agencies to cooperate in their innovation activities. Eleven governmental agencies were required by this directive to report their innovation activities to VINNOVA. They are: the Swedish Board of Agriculture, the Swedish Environmental Protection Agency, the Swedish Post and Telecom Authority, the Swedish Competition Authority, the Swedish Patent and Registration Office, the Geological Survey of Sweden, the Swedish Transport Administration, the Air Navigation Services of Sweden, the Swedish Companies Registration Office, the Swedish Agency for Economic and Regional Growth, and the Swedish Institute.

In addition, two major new initiatives were announced[19]. VINNOVA, together with the Swedish Energy Agency and The Swedish Research Council (Formas) launched a new initiative called Strategic Innovation Areas. Funding for SIA was around SEK 145 million in 2013, including SEK 20 million from the private sector. It was proposed to increase to SEK 1.25 billion for 2016, with around 50% from the private sector.

VINNOVA also launched a related program, Challenge-Driven Innovation to address specific social challenges and international competitiveness through 'systems innovation'. This followed the Swedish Presidency of the European Union in 2009 which saw the publication of the Lund Declaration, which called on European research to focus on the "Grand Challenges of our time" and to move beyond rigid thematic approaches.

The goal of the initiative was to contribute to a significant increase in sustainable growth by transforming and using sector-wide innovation in new processes, products and services that met specific social needs. Four societal challenges were identified where Sweden was considered to have good prospects for internationally pioneering innovation:

- Future Healthcare – stimulating business opportunities and social benefits for better health and care
- Sustainable Attractive Cities – for new solutions within areas such as environment, energy, transport and community building
- Information Society 3.0 – for new and secure IT solutions and services that can be accessed by more users
- Competitive Production – for flexible, resource-efficient and integrated production of sustainable goods and services.[20]

In both initiatives, the development of precise agendas and defining of targets were passed to the main end users in industry and the public sector to develop.

Since 2012, the government has given SEK 9 million a year to VINNOVA to develop competence, support systems and networks for pre-commercial innovative procurement. From 2014, the Swedish Competition Authority took the main responsibility for practical support for public procurement, including innovative procurement. VINNOVA continues to encourage agencies and municipalities to identify and specify their strategic development needs and targets, and this may eventually lead to innovative procurement.[21]

"The Research and Innovation Bill 2013-2016 proposed an additional SEK 4 billion for the period on top of the current budget appropriations for research and innovation. This is a continuation of the expansion strategy initiated in the 2008 bill. The main beneficiary is academic research and HEIs will obtain considerable additional funding. Stepwise the additional annual funding will reach SEK 900 million by 2016. These extra means will be distributed on the basis of quality criteria and more peer review. This procedure will also apply to a higher share of existing university block funds. These incentives will be accompanied by two major new VR funding programmes to boost frontier research, mainly to attract top young researchers to Sweden.

Thematically, the life sciences will be strengthened and critical mass is to be built through initiatives such as the SciLifeLab in Stockholm, which will receive SEK 200 million, a third of the special life sciences appropriations of SEK 600 million. Such initiatives will help offset recent losses in industrial research facilities. Another academic initiative, the ESS and MAX IV large infrastructures in Lund, will also obtain generous funding. Further additional innovation funds will be channelled to VINNOVA's

"strategic innovation area" programmes, to some strategic areas and to innovation offices at universities."[22]

VINNOVA's funding of research and innovation will increase in 2013-2016 by €200m (SEK1.7b) and shall include increased spending on strategic innovation areas.

In the preparation of this Bill, the major research financiers – the Swedish Research Council Formas, VINNOVA, the Swedish Council for Working Life and Social Research, the Swedish Energy Agency and the Swedish National Space Board presented a number of proposals for increasing the quality and applicability of research. In particular, to:

- formulate a new national system for the distribution and redistribution of block funding that rewards and encourages quality and not quantity;
- improve opportunities for universities and university colleges to run local innovation work by means of continued development towards increased autonomy;
- include, in a new block funding system, incentives that reward quality in the application of research at universities and university colleges;
- provide continued and expanded core support to the innovation offices;
- increase resources for verification and concept validation;
- encourage universities and HEIs to expand their contacts with small and medium-sized enterprises by reprioritising current funds.[23]

The main actors in the Swedish support system for innovative starts-ups and entrepreneurship are VINNOVA, the Industrial Fund, the University holding companies, the Swedish Agency for Economic and Regional Growth, the 'Innovation Bridge', and ALMI Business Partner, the latter two of which were recently merged.

2. VINNOVA

As Sweden's Innovation Agency, VINNOVA finances research and innovation projects and provides support in the form of networks, meetings and analyses. VINNOVA's vision is for Sweden to be a world leader in research and innovation and an attractive place to invest and do business in. **T**heir target is Swedish organisations and individuals who are important to the country's innovative capacity, such as knowledge-intensive companies, universities, research institutes and the public sector. Most VINNOVA projects require co-operation between different organisations and co-financing.

VINNOVA and its predecessors have since 1995 funded research centres with an effort to build bridges between science and industry in Sweden by creating excellent academic research environments in which industrial companies participate actively and persistently in order to deliver long-term benefits. The mission is to strengthen the crucial links in the Swedish National Innovation System between academic research groups, industrial R&D and public sector actors.[24]

The major areas of VINNOVA's activities are historically described as development of research and innovation strategies for specific fields and sectors in close dialogue with key players in the Swedish innovation systems through:

- strategic R&D programs usually involving cooperation between universities and companies in six major fields – ICT, Services and IT implementation, Biotechnology and Life Sciences, Manufacturing and Materials, Transport and Automotive Systems, Working Life Science;
- Supporting the building up of strong research and innovation environments through VINN Excellence Centers and other COEsat universities and Regional Innovation Systems (VINN Growth program); and
- Strengthening of the functions for commercialization of research at universities:
  - Development of the institute sector in Sweden
  - Support for R&D aiming at radical innovations in SMEs
  -Supporting international cooperation
  - Knowledge and research about innovation systems
  - Informing the broader public about research and innovation.[25]

VINNOVA currently invests 2.7B SEK each year in about 2400 research and innovation projects. The breakdown of major recipients is: Universities - 44%, private companies - 28%, research institutes - 15%, other- 13%. The requirement that project participants provide co-financing more than doubles the amount of funds invested.[26]

The strength and influence of VINNOVA's role have been commented on in the OECD Review of Sweden's Innovation Policy:

> "The situation of VINNOVA is important in this context. To the outer world – at least outside Sweden – VINNOVA is a synonym for technology and innovation funding in Sweden. On the one hand, the agency has been given (and continuously gives itself) very ambitious goals and claims to influence and change the innovation system. This review sees VINNOVA as a bold, risk-taking and central actor in the Swedish system which it seems to want to change and further develop. The agency is much more open and reflective about its goals and instruments and about the impact of its work than the dominant science policy actors. On the other hand, legacy commitments are very strong and budgets are limited. About half of the programmes VINNOVA is involved in are co-managed and co-financed with other agencies. This can undoubtedly be described as a strength and as a remarkable example of integrated policy making, but it also raises some concerns. Expectations of the agency do not match its resources and it is difficult to develop a strong individual profile. The problem is the crowded arena of actors, the weak position of innovation policy in Sweden and the lack of an appropriate budget for VINNOVA when compared to its aspirations."[27]

They also comment on the relatively modest budget of VINNOVA:

> "With an annual budget of about EUR 220 million, VINNOVA will have to work hard to reach these ambitious goals. In comparison, Austria and Finland also emphasise improving innovation systems and fund firms through dedicated agencies. However, the Austrian Research Promotion Agency (FFG) has more than twice VINNOVA's budget for funding and

Finland's Tekes, an even more dominant actor, has a budget three times higher (Table 4.1). While Sweden also has a broad array of other funding agencies, their missions focus on specific themes or academic research and lack VINNOVA's broad innovation system perspective.[28]

Table 4.1. Innovation system agencies: VINNOVA compared to Finland's Tekes and Austria's FFG

	VINNOVA	Tekes, Finland	FFG, Austria
Approximate budget (EUR)	220 million (2011)	600 million (2011)	550 million (2010)
Direct budget appropriations for firms; Note: actual shares higher (centres, etc.)	30%	60-65%	65%
Budget per million inhabitants	24 million	110 million	65 million
Share of funding for firms with fewer than 10 employees in overall portfolio of firms funded	Approx. 25% (VINNOVA estimation)	31% (2007-2010)	Approx. 15% (FFG estimation)
Share of funding for firms with fewer than 250 employees in overall portfolio of firms funded	66% (9% for 50-249)	65% (8% for 50-249)	46%
Significant funding of HEI/PRI (in consortia)	Yes	Yes	Yes
Number of individual programmes	Medium to high	Medium	Very high
Number of agencies with overlapping missions (but no system agencies)	Very high	Medium	Medium (regional actors)
Degree of co-design/finance with other agencies	Very high	Low to medium	Low
Claim to change the innovation system	High	High	Medium

Sources: Van der Veen *et al.* (2012), VINNOVA (2010, 2012), FFG (2011).

3. Specific Programs

VINNOVA has three broad and multi-component programs, which will be examined in detail below:

- Strategically Important Knowledge Areas - programs for developing new knowledge and expertise within strategically important areas
- Innovativeness of Specific Target Groups - programs for strengthening the innovative capacity of specific target groups including small and medium-sized companies and for the public sector
- Cross-border Cooperation - programs aimed at pooling of resources by connecting actors within different industries and areas of knowledge with a focus on societal challenges.[29]

In addition, under the Research and Innovation Bill 2008, the Government established an Innovation Offices Program[30] to establish technology transfer offices at eight universities promoting innovation, and the use and transfer of knowledge in order to facilitate commercialisation of research results. This also will be examined.

3.1. Strategically important knowledge areas

http://www.vinnova.se/en/Our-acitivities/Strategically-important-knowledge-areas

Four strategically important knowledge areas have been identified:

- ***Health and Healthcare Objectives***: to find new solutions to meet the challenges with a rapidly increasing number of elderly citizens. The key areas identified by VINNOVA are: services within health and social care, the link between health, climate and environment and the healthcare sector as a production system.[31]
- ***Transportation and Environment Objectives***: meeting challenges in the fields of transport and environment and with the crossover to a resource-efficient and fossil fuel-free society. VINNOVA has identified a number of key areas showing major promise: solutions to air pollution, noise, congestion and traffic accidents; fossil fuels, waste and recycling; bio-based materials in new applications; a smart electricity grid; sustainable cities and sustainable urban development; transport efficiency and logistics; city growth and attractiveness.[32]
- ***Services and ICT Objectives***: meeting the changes and opportunities in society resulting from the new information technology. Despite the obvious positive impacts of information technology, personal integrity, security, accessibility and reliability are becoming increasingly important as IT permeates yet deeper into industry and society. In partnership with relevant actors, VINNOVA has identified three key areas of major potential: Integration and Monitoring, Information Management and Services and Business Opportunities.[33]
- ***Manufacturing and Working Life Objectives***: opportunities for Sweden to compete with goods and service production in an increasingly globalised market. The most important trends will be: demand for more individualised products, products with heightened customer benefit and resource-smart products. [34]

Funding is provided for research required for renewal within different industries and for tests and demonstration of applications of research-based knowledge. Projects can be managed by companies, universities/research institutes or the public sector, but it is necessary for at least one of the parties in the project to be a university, college or research institute.

Health and Healthcare Programs

i) *Innovations for Future Health*

An ageing population and problems of lifestyle diseases and drug-resistant infections are increasing the strain the health service. At the same time, new research is providing an increasingly profound medical understanding of disease processes and new innovations are able to offer better prospects of preventing and treating various diseases. Under this the program there are regular calls for proposals each year, and a target budget of SEK 600 million. The purpose of the program is to utilise high-quality Swedish research by funding innovative ideas. The starting point is those needs which may be envisaged in the health field, looking ahead to 2015-2025. What needs will there be for prevention, diagnosis, treatment and care of disease? What will mark out a future patient/user/customer? What new, innovative projects and services will be used? What will the global market for these products and services look like?

ii) Innovation in Foods

A greater desire on the part of consumers to be able to make personal choices is a strong driving force in the field of innovative foods. Interest in the important role that food plays for our health and well-being is clearly increasing which suggests good growth potential in this area in Sweden. VINNOVA intends to stimulate R&D that will lead to the better exploitation of medical, biological and biotechnological knowledge by the food industry and those who conduct food research as well as contributing to the establishment of competence-driven innovation environments that can act as hubs in the Swedish development of innovative foods.[35]

Transportation and Environment

This area deals with meeting challenges in the fields of transport and environment and with the crossover to a resource-efficient and fossil fuel-free society. Trade and travel in Sweden is increasing and keeping pace with ongoing urbanisation, deeper European integration and rapid advances in contact with the rest of the world. This increased mobility brings advantages, including greater freedom of movement for goods and millions of people. However the increase also brings problems such as carbon emissions, overcrowding, accidents and increased road and traffic system costs.

VINNOVA has identified a number of key areas showing major potential. These are:

- solutions to air pollution, noise, congestion and traffic accidents
- fossil fuels, waste and recycling
- bio-based materials in new applications
- a smart electricity grid
- sustainable cities and sustainable urban development
- transport efficiency and logistics
- city growth and attractiveness.[36]

Services and ICT Objectives

This area deals with meeting the changes and opportunities in society resulting from new information technology. Europe has over 250 million daily Internet users and almost everybody has a mobile phone. Reliance on information and communications technology has been accentuated by its enabling role in practically all sectors. Information technology has fundamentally changed the way we do business, develop products and services, run companies and act as consumers.

Despite the obvious positive impacts of information technology, there are major challenges. Personal integrity, security, accessibility and reliability are becoming increasingly important as information technology permeates yet deeper into industry and society. In partnership with relevant partners, VINNOVA has identified three key areas of major potential: Integration and Monitoring, Information Management and Services and Business Opportunities. [37]

Manufacturing and Working Life Programs

This program addresses opportunities for Sweden to compete with goods and service production in an increasingly globalised market. The most important trends are identified as demand for more individualised products, products with heightened customer benefit and resource-smart products. In

addition, innovative leadership will be highly significant to competitive production, within industry and in other important areas such as health and social care.

Four sub-programs have been established.

i) Production Strategies and Models for Product Realisation

This program builds upon Swedish strengths, such as environmental perspective, knowledge-based products and processes and collaborative capability to fund research which can strengthen the long-term competitiveness of Swedish manufacturing. It aims to fund research projects that can help strengthen the long-term competitiveness of Sweden's manufacturing industry. The program started in 2009 and is set to continue up to and including 2015. A call for proposals was held during 2009.[38]

ii) Manufacturing in Continuous Change

This program is focussed on those areas in manufacturing technology considered particularly important from a Swedish perspective The program comprises the following sub-areas:

- Manufacturing adapted for new materials
- Influence of the environmental focus on manufacturing
- Prospects for information technology
- Industrial processes in continuous change.

The programme commenced in 2009 and is set to continue up to and including 2015. During 2009, VINNOVA held the first call for proposals entitled Manufacturing in Continuous Change - Hypothesis Testing.[39]

iii) Dynamic Innovation Systems in Change

This program addresses the impact of globalisation and structural change including labour market dynamics. This includes mobility, skills supply, adaptability and job creation. The goals of this program are to improve organisations' capacity to manage structural changes through R&D. These initiatives increase access to practical and scientific knowledge and use this in new models and methods. Initiatives have included calls for proposals in 'Adaptability and Skills Supply', DYNAMO - dynamics of the local labour market and VINNVINN – to stimulate mobility for specialist expertise. [40]

iv) *Designed Materials*

The focus of this program relates to materials whose structure can be deliberately manipulated so as to affect properties in a controlled fashion and achieve a specific functionality in product manufacture. Two calls have been made. The first for 'Designed Materials – Capability Testing and Concept Verification' to provide supporting data in assessing whether research results can produce commercially viable material concepts and how commercialisation can best happen. The second, 'Designed Materials - Industrialisation', resulted in support for projects aiming to transfer verified material concepts to industrially viable solutions and build up value chains and networks for development and use of industrialised material concepts. This program was closed in 2009.[41]

v) *Management and Work Organisation Renewal*

This program focuses on the importance of strategic management and work organisation for well-functioning workplaces and thereby the efficiency and long-term development of operations. The goal is new or improved working methods and organisational solutions which safeguard and develop ideas generated within the organisation or elsewhere. It is anticipated that these will result in new or improved work processes, products or service offerings.

Calls have included:

- The Competent Workplace (2007-2011) which aimed to increase the chances of organisations reaching their goals by improving the conditions for strategically relevant competence.
- Managerial Task: Conditions, Ways of working and Results (2008-2012) aimed to understand and improve the leadership that is practised in Swedish workplaces.
- Winning Services (2009-2013) supported R&D projects about the organisation and management of service activities.
- Swedish Management is an initiative to raise Swedish leadership tradition's advantages and its need to adapt to working globally.[42]

Open calls for proposals targeting stakeholders important for Sweden's innovativeness such as research-focused companies, universities, research institutes and public sector organisations are public, time-limited application opportunities that are set up within a specific program. All applications to VINNOVA's programs must be made via the eServices Portal.[43] Decisions to award funding are made with the help of national and international experts.

Detailed, fairly standard terms and conditions for grants are made available.[44]

The VINNOVA website contains a lengthy list of evaluations and impact analyses of various programs and selected publications arising.[45] The great majority do not apply to the strategically important knowledge areas program(s). A comparative evaluation of the ICT support programs of VINNOVA and TEKES provides some interesting insights.[46] However, detailed levels of funding per year have not been able to be identified.

3.2. Innovativeness of specific target groups

http://www.vinnova.se/en/Our-acitivities/Innovativeness-of-specific-target-groups/

Strengthening the innovative capacity of key individuals and organisations requires awareness of the opportunities of innovation. Strategic projects for developing innovations are also required. VINNOVA manages programs for developing leadership, innovation strategies and development projects which are important for the innovative capacity of specific target groups.

The projects can be managed either by individuals or consortia. In 2014 the programs for strengthened innovative capacity mainly targeted small and medium-sized companies, the public sector as well as universities and colleges.

VINNOVA's programs within "Strengthened innovative capacity" are divided into four strategic areas:

i) *Innovation Capacity in the Public Sector* - Innovation Management is a collective term for leadership and organisational processes aimed at supporting and developing innovation capacity in systems, in organisations and for individuals. An Innovation Procurement program was launched in 2011, aiming to increase and extend the development of innovation procurement, chiefly in the public sector. The program is now discontinued.[47]

ii) *Innovative Small and Medium-sized Enterprises* which are characterised by an ability to accept, apply and develop new knowledge and techniques in new business opportunities. A major part of VINNOVA's support for small and medium-sized enterprises (SMEs) takes place through the programs Forska&Väx (Research&Grow) and VINN NU. The program is now discontinued.[48]

iii) *The Knowledge Triangle* which aims to create an interaction between education, research and innovation thereby creating the conditions for increased relevance and utilisation of universities' activities.[1] VINNOVA supports the development of universities' capacity to lead and prioritise in a way that assists research results to be used. One focus is increased mobility between universities and industry. Other programs are designed to increase the capacity for partnerships between universities and other organisations in the Swedish innovation system including through incubators associated with universities.[49]

Programs within the Knowledge Triangle are:

- Verification for Growth (VINN Verification, which) supports comprehensive commercial and technical verification and validation of a research result with commercial potential.[50] This reduces technical and commercial risks, leading to identification of the most appropriate commercialisation strategy and a technical and a business concept that is appropriately protected in the commercialisation process. This is designed to permit researchers, subsequent funders and industrial partners to more clearly assess the potential, risks and most appropriate means for the continued commercialisation of the research results. The programme has a call for proposals that is open on an ongoing basis with fixed application dates. [51]

- The Key Actors Program, which is designed to develop expertise, methods, processes and structures that will make key players in the Swedish innovation system more professional in their roles with regard to collaboration between researchers, companies and others, and in the utilisation of knowledge and the commercialisation of research results.[52]

  The program, which started in 2006, is focused on universities. The first call, "Higher Education Infrastructure for Collaboration for Growth", was preceded by an offer of funds to the universities for the implementation of a peer review-based self-evaluation of their collaboration work. This evaluation formed the basis for subsequent applications.

[1] The Knowledge Triangle has become a central concept in EU and OECD considerations of innovation strategy and policy.

- Mobility for Growth, which supports experienced researcher careers through mobility and international collaborations. The program has a funding mechanism for incoming and outgoing transnational mobility for experienced researchers (including a reintegration phase for outgoing mobility), and it promotes active international collaborations between involved organisations. The Mobility for Growth programme targets experienced researchers who have a doctorate or at least four years' full-time equivalent research experience and who are interested in mobility as a career development option.

  The program runs from 2012 to June 2018 and there is currently an overall budget of €35 million, of which €10 million is co-funding from Marie Sklodowska-Curie Actions (European Commission).[53]

iv) *Individuals and Innovation Milieus* has the objective of developing strong research and innovation milieus in which universities, research institutes and companies all play key roles, either in one particular sector or several different ones.

The major program within the Individuals and Innovation Milieus is the VINN Excellence Centres, which provide a forum for collaboration between the private and public sectors, universities and colleges, research institutes and other organisations that conduct research. The Centres deal with both basic and applied research and they work to ensure that new knowledge and new technological developments lead to new products, processes and services. The program and investment is a continuation and further development of the previously implemented Competence Centres Programme, which started in 1995 and consisted of 28 Competence Centres.

Initiated in 2005, VINNOVA now supports 18 VINN Excellence Centres. The Centres are funded for ten years, at a level of €2.2M per year. The funding for each Centre is provided one-third by VINNOVA, one-third by industrial and other partners (in kind and cash), and one-third by the host university. There are 10-15 partners per Centre, both large and small innovative firms. In total, each Centre's research activities will involve at least SEK 210 million over ten years through the involvement of the collaborating actors.

The highly competitive selection process for VINN Excellence Centres involves a call for proposals in two steps. Those passing the first step are provided with a planning grant to develop their major proposal. Scientific excellence is evaluated by international experts.

A standard template contract and agreement has been established.[54]

The current Centres are[55]:

- *AFC – Antidiabetic Food Centre* (Lund University) focused on developing innovative food concepts that reduce the risk and consequences of diabetes. Collaborators include Aventure AB, Dr PersFood AB, Lyckeby Culinar, Orkla Brands, Pågen AB, Region Skåne and Semper AB.
- *BiMaC Innovation* (Royal institute of Technology, KTH) concentrates on the development of new, unique bionanocomposites and on a number of central, unsolved technical problems which have impeded development of the forestry sector. Collaborating parties include

Holmen AB, Korsnäs AB, SCA R & D Centre AB, Stora EnsoAB, Tetra Pak Packaging Solutions AB, Innventia AB and Sveriges Stärkelseproducenter (Sweden's Starch Producers).

- *BIOMATCELL* - Biomaterials and Cell Therapy(University of Göteborg) which aims to develop new knowledge on biological components, including stem cells, in order to generate new scientific discoveries, product ideas and clinical therapies in the international forefront of regenerative medicine. Collaborating parties include Arcam AB, Bactiguard AB,Cellartis AB, Integrum AB, Keystone Dental, Inc., Sandvik AB and TATAA BIOCENTER AB.
- *Centre for ECO2 Vehicle Design* (Royal institute of Technology, KTH) develops design tools for producing lighter vehicles with less air resistance that are simultaneously quieter and have better handling capabilities than current models. Parties involved include Scania, Volvo, Saab Automobile, Bombardier Transportation, A2 Acoustics, Polytec Composites, VTI (Swedish National Road and Transport Research Institute) and Trafikverket (Swedish Transport Administration).
- *Centre for Sustainable Communication* (Royal institute of Technology, KTH) investigates and develops the conditions under which ICT (media & communication) contribute to sustainability. collaborating parties include Bonnier, Ericsson, Regionplanekontoret (Office of Regional Planning), City of Stockholm, SVT Sveriges Television (Swedish Television).
- *Chase-Chalmers Antenna Systems Excellence Centre* (Chalmers University) encompasses research in antennae, signal processing, mobile communications, scientific computing, biomedical engineering and the biological effects of electromagnetic radiation. Collaborators include Ascom Tateco, Ericsson Microwave Systems, Flextronics Components, Geveko Industry, Micropos Medical, Perlos, Qamcom, Saab Bofors, Saab Ericsson Aerospace, Sony Ericsson, St Jude Medical and Telia Sonera.
- *Faste Laboratory - Centre for Functional Product Innovation* (Luleå Technical University) engages in innovative research to assist companies in product development, computer simulation and distributed engineering to gain a greater understanding of the function and performance of products from a life-cycle perspective. Partners include BAE Systems, Hägglunds, Hägglunds Drives AB, LKAB, Sandvik Coromant, Volvo Aero, Volvo Cars and Volvo Construction Equipment.
- *FunMat - Functional Nanoscale Materials* (Linköping University) seeks broader applications for nanostructured multifunctional materials for the engineering, processing and manufacturing industries. Industrial partners include Alstom Power AB,CemeCon AG, Ford Motor Company and Volvo Cars, Impact Coatings AB, Ion Bond, Sweden AB, Sandvik Tooling Sverige AB, SECO Tools AB and SenSiC AB.
- *GigaHertz Centrum* (Chalmers University) conducts research on wireless communications and sensor systems based on high frequency technology. Industrial partners include Ericsson AB, Saab, SP Technical Research Institute of Sweden, NXP Semiconductors, Omnisys Instruments and Mitsubishi Electric.
- *HELIX - Managing Mobility for Learning, Health and Innovation* (Linköping University) aims to promote the development of "good mobility". A central task is to create an arena in which researchers from various disciplines collaborate with players from companies to develop new knowledge and methods relating to the importance of mobility to learning and health. Collaborators include Industrikompetens AB, IUC Östergötland AB, Rimaster AB, SAAB AB,

Siemens Industrial Turbomachinery AB, Toyota/BT Products AB, Försäkringskassan (Swedish Social Insurance Agency), IF Metall and TRR Trygghetsrådet.

- *HERO-M - Hierarchic Engineering of Industrial Materials* (Royal Institute of Technology, KTH) conducts research on industry-relevant materials designed as an integrated to obtain the desired properties at minimum cost and time by way of a multi-length scale engineering approach. The Centre involves important Swedish materials industries such as steel and hard metal producers, plus specialised software and development companies. Industrial partners include Erasteel AB, Höganäs AB, Outokumpu Stainless, Sandvik Tooling, Seco Tools, Swerea KIMAB, Thermo-Calc Software and Uddeholm Tooling.
    - *iPack Center - Ubiquitous Intelligence in Paper and Packaging*(Royal Institute of Technology, KTH) develops core technologies for heterogeneous integration of biomedical sensors, energy supply, computing and wireless communication in fibre-based packaging and paper card. These are used for innovative products such as smart biopaper, intelligent drug packaging and preservation and intelligent patient monitoring equipment. Collaborators include Billerud AB, Korsnäs AB, NOTE AB, Catena AB, XaarJet, Ambigua Medito, SkiBar and Polyscorp.
    - *Mobile Life Centre* (Stockholm University) conducts interdisciplinary research with researchers from computer science, interaction design, sociology and psychology, as well as with game designers, artists, dancers and fashion experts to develop mobile applications, sensor-based applications, smart games, mobile mash-up services, new mobile media, technology platforms and materials for supporting amateur creativity. Collaborating parties include Ericsson AB, TeliaSonera Sverige AB, Microsoft Research, Nokia, City of Stockholm, Kista Science City AB, and Bambuser.
    - *ProNova VINN Excellence Centre for Protein Technology* (Royal Institute of Technology, KTH) conducts R&D in close cooperation with life sciences-oriented Swedish companies within the field of protein technology based on proteome information such as that generated by the Swedish Human Proteome Resource (HPR) project. Partners include Affibody AB, AstraZeneca AB, Atlas Antibodies AB, BioInvent International AB, GE Healthcare Bio-Sciences AB, Genovis AB, Gyros AB and Mabtech AB.
    - *SAMOT - Service and Market Oriented Transport Research Group* (Karlstad University) conducts research to improve public transport through a specific focus on service development. Collaborators include Värmlandstrafik, Swedish Public Transport, Stockholm Transport, Veolia Transport Sweden, City of Gothenburg (Mobility Services) and Gothenburg Trams.
    - *SuMo Biomaterials* (Chalmers University) focuses on the structural design of supramolecular biomaterials with unique functional properties with an emphasis on the material structure from nano to micrometre for the diffusion and flow of liquid, as these relationships are of crucial importance to the future development of biomaterials. Collaborating parties include SIK AB, AstraZeneca, Bohus Biotech AB, Eka Chemicals, Lantmännen, Mölnlycke Health Care, Södra Cell AB and Tetrapak.
    - *Uppsala VINN Excellence Centre for Wireless Sensor Networks WISENET* (Uppsala University) is focused on how to integrate sensing, data processing and communication into one sensor unit, manage and generate energy in the sensor unit, make sensor networks self-configuring, robust and maintenance-free up to 10 years and attach

sensors to the internet in a secure way. Collaborating parties include Communication Research Labs Sweden AB, Totalförsvarets forskningsinstitut (Swedish Defense Research Agency), Imego AB, Pricer AB, SenseAir AB, SICS, Swedish Institute of Computer Science AB and TermoSense AB.

- *Wingquist Laboratory Excellence Centre for Efficient Product Realisation* (Chalmers University) conducts research within four strategic areas; Systematic Construction & Information Management, Industrial Design, Robust Design & Variation Simulation and Virtual Factories & Flexible Automation. The research is strongly linked to the automotive and engineering industries in Sweden. Partners include Volvo Car Corporation, VolvoTrucks, Volvo Aero, Saab Automobile, ABB Corporate Research, Frauenhofer-Chalmers Research Centre for Industrial Mathematics, Kongsberg Automotive and RD&T Technology.

The success criteria for VINN Excellence Centres have been established as:

• Promoting sustainable growth by ensuring that new knowledge and new technological developments generated lead to new products, processes and services.
• Leading international research in different fields in collaboration between the private and public sectors, universities and colleges, research institutes and other organisations which conduct research.
• Research programs are set up and carried out in collaboration between the various participants in order to solve key issues.
• The majority of work is conducted at a university or a college to achieve a critical size and interaction between research, post-graduate education and graduate education.
• Long-term implementation with comprehensive evaluations prior to new agreement periods to secure long-term effects and international excellence.
• Long-term collaborative finance from private and public sectors, the university/college and financing governmental agencies, to be able to recruit, develop and keep people with leading international competence.
• The activities are overseen by a board where the participants from the public and private sectors hold the majority in order to secure the direction of the Centres towards the requirements of the private and public sectors, i.e. needs-driven research.
• Set up in innovation environments with effective innovation operations so that strong research and innovation milieus can be created (Centres of Excellence in Research and Innovation).

The VINN Excellence Centres have been regularly reviewed and evaluated.[56] In the second Evaluation of VINN Excellence Centres published in 2013, the focus was on Stage Two, Years 3-5, focused on the long-term output and outcome to the industrial, public and academic partners. The evaluation is an opportunity to give advice and recommendations on how each Centre can become even more efficient and effective. Based on the evaluation results, VINNOVA has decided that 17 out of 19 Centres will be approved for a third period.[57]

This evaluation report provides a summary of the performance of all the Centres:

- The Centres have helped the partners to improve or complete 158 products, services or processes as well as initiate three licensing in 2012
- 4 Centres have contributed to the founding of 8 companies
- 32 patents are pending/have been granted and trademark protection has been granted within 9 Centres
- Research collaboration has resulted in:

  - over 748 publications, including 133 joint publications with the public sector/industry

  - 73 postgraduates of whom 52 have doctor's degrees and 21 have licentiate's degrees

- 75 individuals from the business sector, from both national and international companies, have participated in a leadership capacity
- 12 projects fall outside respective Centre's agreements and are fully or partially funded by businesses
- 33 Centre researchers have been employed in the business sector in 2012
- 56 overseas visiting research fellows have spent time at the Centres
- 24 EU projects are reported to be connected to Centres.[58]

3.3. Cross-Border Cooperation

VINNOVA's programs within the Cross-Border Cooperation theme are Challenge-Driven Innovation and Partnership Programs.

For the Challenge-Driven Innovation, as described earlier, in contrast to science and technology-led initiatives, VINNOVA's strategies have the following characteristics:

- Addressing essential or critical needs in society and industry. These needs require users or customers whose demand for solutions encourages them to engage in developing and testing new solutions. Co-creation is a critical success factor.

- Promoting new cross-sector collaborations as solutions to social and societal challenges are rarely found in one traditional sector or a single research field. New collaboration patterns are emerging between actors in different value chains; for example 'green urban transportation' is being developed at the interface between energy, automotive engineering and ICT.

- Fostering systemic approaches which address framework conditions and social, political, commercial and technological subsystems.[59]

These are directed to four societal challenges in which Sweden's prospects for internationally leading innovativeness are considered high: Information society 3.0, Sustainable Attractive Cities, Future Healthcare and Competitive Production.[2]

[2] No information has been identified about the implementation of the Challenge Driven Innovation Program

The major program under the Partnership theme is Strategic Innovation Areas, where VINNOVA collaborates with the Swedish Energy Agency and Formas. The purpose of the venture is to create conditions to achieve international competitiveness as well as to find sustainable solutions to global challenges for societies. Within the venture there are two types of efforts:

- Strategic research and innovation agendas that aim to stimulate a strategic dialogue to, identify needs and opportunities that can be pursued through a joint research and innovation agenda.
- SIO programs that aim to support the implementation of the research and innovation agendas that are most important for Sweden and have the greatest potential to create conditions for international competitiveness and to find sustainable solutions to global challenges for societies.[60]

3.4. Innovation Offices Program

In the 2008 Research and Innovation Bill the government identified seven universities (Uppsala University, Lund University, Umeå University, Linköping University, Karolinska Institute, KTH Royal Institute of Technology Stockholm, and Chalmers University of Technology Gothenburg) that would be given the opportunity to develop so called "innovation offices" with a total funding of €8m annually.[61] These offices are designed to provide support in issues related to commercialisation, patenting and licensing, knowledge exchange and principles for contract research. In addition they are supposed to inspire, inform, and stimulate researchers to innovate. The rationale behind the establishment of these innovation offices is to increase the utilisation of research results and thus create benefits for the society and industry.

A recent government review of innovation-stimulating activities at universities stresses the importance of innovation offices in increasing universities' ability to act innovatively. Accordingly, the new 2012 Research and Innovation Bill has increased the allocation of funding to innovation offices and announced the establishment of a further four offices to extend the scheme's reach to cover all universities. The 2012 Research and Innovation Bill, increased the investments in HEI innovation offices by €2m annually to allow for the creation of four new innovation offices at the University of Gothenburg, Stockholm University, Luleå University of Technology, and the Swedish University for Agricultural Sciences.[62]

The scope of these Innovation Offices generally appears to be the conventional array of business outreach, entrepreneurship education and incubator facilities. Thus Lund University reports:

> The business sector in Lund boasts an impressive breadth of knowledge - intensive companies at the forefront in their fields. Most of the companies operating at Ideon Science Park, the first of its kind in Sweden, have their origins in research from the University. The world's fastest growing technology – Bluetooth – came into being at the end of the 1990s at Ericsson, the first company to be based at Ideon. Ericsson, Gambro and Alfa Laval are among the large, well-known companies with which Lund University cooperates.
>
> Innovation activities are an increasingly important aspect of the University's work. Business developers offer support and resources to those researchers who want to convert their

> results into commercial products. With the help of the University's Innovation system Luis researchers set up around ten companies every year. Southern Sweden's regional innovation office, Innovationskontor Syd (IKS), is also based here, which means that Lund University also supports researchers at other higher education institutions in the region.[63] There is also VentureLab - a student incubator that supports students and recent graduates who are wondering about starting their own company, Ideon Innovation that offers an internationally recognised business incubator process, and Lund Life Science Incubator.

Uppsala University reports that its *UU Innovation* fosters collaboration between Uppsala University and industry, partly by supporting research collaborations between the university and industry, and partly by supporting the development and commercialisation of ideas from research at Uppsala University. Expertise is available in areas such as project management, commercial development, and patent and contract law. For researchers, they offer advice, support, funding and business contacts in commercialising research, or to start collaborative research with companies outside the university.[64]

But perhaps the standout university in research commercialisation and industry-university interaction is Chalmers University:

> Chalmers University of Technology views itself as an *entrepreneurial university*. It is of special interest in the Swedish university system, since it started as a private industrial school in 1829 with a strong scientific orientation. In 1937, Chalmers was absorbed into the Swedish state-owned system but then opted out in 1994 to become a private foundation university but still received public university funding. To help jump-start structural changes, the Swedish government provided Chalmers with a loan that was instrumental in starting various spinoff activities.
>
> Clark (2007) analyses the factors that led to this new autonomy for appointing and rewarding personnel, allocating resources, devising programmes and collaborating with business. Beginning in the late 1970s, the "academic heartland" and the central administration at Chalmers started activities to strengthen entrepreneurship and innovation with a Chair in Innovation Engineering and the Chalmers Innovation Centre around which an infrastructure for transfers from university to industry and *vice versa* evolved in the following decades. The "developmental periphery" ranges from incubators to spin-off companies, from commitment to innovative behaviour to special innovation courses, from industrial contact groups to a major science park adjacent to the campus. Chalmers was well prepared to receive NUTEK funding for 6 out of 30 Swedish competence centres with strong industry involvement at the beginning of the 1990s.
>
> Two features that developed early and show more commitment from Chalmers than other Swedish universities were its strong alumni relations and fundraising campaigns. The "Chalmers spirit" welcomed the 1991 Swedish government initiative to give state-controlled universities a "foundation" status. While all comprehensive universities opposed this idea, Chalmers succeeded in obtaining this status over the Royal Institute of Technology. Almost two decades later the change is still seen as a success (Jacob *et al*., 2003).

Lindholm Dahlstrand *et al*. (2010) reveal that 42% of the alumni of the Chalmers School of Entrepreneurship (started in 1997) start businesses. Åstebro *et al*. (2012) conclude that "transforming university goals and practices toward increasing start-ups led by faculty might not be the most effective way for universities to stimulate entrepreneurial economic development" but note that "the gross flow of start-ups by recently graduated students with an undergraduate degree in science or engineering is at least an order of magnitude larger than the spin-offs by their faculty, that a recent graduate is twice as likely as her Professor to start a business within three years of graduation, and that the graduates' spin-offs are not of low quality".

Since the start of the Chalmers School of Entrepreneurship in 1997 – the first of its kind in Sweden – about 50 new companies have been created in which former students work as CEOs or hold other key positions. Åstebro *et al*. (2012) consider that the Chalmers approach shows that "to create a two-sided market for entrepreneurial talent and inventions and let students and university inventors match up to commercialize university inventions" might be a good alternative to traditional governance, when "the modal number of spin-offs from the top-100 U.S. research universities is zero", especially since "in a jurisdiction with the *Professor's Privilege*, such as in Sweden, the Chalmers arrangement poses no administrative difficulties".[65]

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