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The Swedish Foundation for Strategic Research: An analysis of its impact and systemic role

Tomas Åström, Erik Arnold, Peter Stern, Malin Jondell Assbring, Miriam Terrell, Anders Håkansson, Karolina Henningsson and Maria Grudin

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Executive Summary

The Swedish Foundation for Strategic Research (SSF) was established in 1994 and was tasked with funding research to promote Sweden's long-term competitiveness. The Foundation was given an initial capital of SEK6bn and had awarded SEK10.9bn in grants by the end of 2013, but still had SEK10.1bn left in assets at that time. Funding has been around SEK500m per annum during the last decade, with universities as the main beneficiaries.

This study, commissioned by SSF, has assessed the impact of a selection of its funding programmes (corresponding to 10 per cent of its total funding), and has analysed the Foundation's systemic role.

The evidence indicates that SSF in most respects has fulfilled its statutes. The programmes provided large research grants that either strengthened existing university-based research groups or established new ones. The size of the grants meant that their impact on developing the critical mass of research groups was quite significant. The programmes facilitated interdisciplinarity and some degree of inter-sectoral mobility. However, the study finds that academic–industry links have not been sufficiently strong or functioned adequately. There is thus a major risk that research results remain of potential rather than actual significance for Swedish industry's long-term competitiveness. However, the Foundation has contributed significantly to human capital development. Many PhDs co-funded by SSF have been employed by companies following graduation, thus contributing to their competitiveness.

The type of "strategic" research that SSF funds is different from, and needs different governance compared with, either traditional basic research or application-/commercialisation-driven R&D. The logic of such research does not follow the "linear model" of basic research leading to application, but rather operates the other way round: from problems to more fundamental research. The historical development of the organisations funding fundamental engineering research in Sweden testifies to the difficulty of trying to combine the funding of strategic and other forms of research, but also to the potential vulnerability of a funding organisation taking on such a role in the Swedish system. SSF's own description of itself as in between the Swedish Research Council (VR) and the Swedish Governmental Agency for Innovation Systems (VINNOVA) underlines the vulnerability of the role. It is also unduly negative, as if the role were of lesser importance; in fact, it is not only vital, but increasingly so as the nature of technology becomes more and more scientific.

The evolution of the Swedish funding system since 1994 has effectively involved the state handing over the strategic funding function to SSF and adapting its own agencies around SSF. This creates a void in the system if and when the state wants to implement a policy for strategic research. If the state is to evolve a coherent and holistic research policy, then it needs to re-establish a role in strategic research funding, not least since this is one of the most dynamic sources of innovation and industrial development over the longer term.

SSF is needed because existing government agencies are not structured to take on the job. Since the Foundation's funds are finite and the need to fund strategic research is permanent, there has to be some sort of transition whereby the state assumes its responsibility again. If SSF were to disappear – quickly or slowly – without arrangements being made to replace its function within the research funding system, the consequences for Swedish industry and research would be significant.

Summary

Assignment

The Swedish Foundation for Strategic Research (*Stiftelsen för strategisk forskning, SSF*) commissioned a study with two main elements: an impact assessment of a selection of the Foundation's programmes, and an analysis of the Foundation's systemic role. The programmes and calls selected for the impact assessment part of the study were:

- Strategic research centres (SFC) in Life sciences. Six centres were granted a total of SEK397m in the years 2003–2008
- Framework grants in Materials science. Seven projects were granted a total of SEK98m in the years 2003–2007
- Framework grants in Information technology (IT). Fourteen projects were granted a total of SEK245m in the years 2002–2007
- Future research leaders (FFL). Twenty-one projects were granted a total of SEK210m in the years 2001–2007, and eighteen projects SEK162m in 2005–2010
- Strategic mobility. Seventeen projects were granted a total of SEK15m in the years 2008–2010, and fourteen projects SEK12m in 2009–2011

The study was conducted by Technopolis between February and October 2014. Data acquisition included desktop studies; 63 interviews; five web surveys; bibliometric analyses; analyses of spin-off companies; analyses of Swedish funding for research, development and innovation; a foresight focus group and an interpretation seminar, both involving relevant and knowledgeable stakeholders.

Background

The Foundation was established in 1994 and was tasked with funding "research within natural science, engineering and medicine" to promote "the development of strong research environments of the highest international standard and of significance for the development of Sweden's long-term competitiveness".

The Foundation had an initial capital of SEK6bn. However, its asset management has been very successful. Thus, despite SSF having awarded SEK10.9bn in research grants during the intervening period, by the end of 2013 it still had SEK10.1bn in assets. Funding peaked in 2000 at an annual level close to SEK1b, but has since declined. In the last decade, it has been around SEK500m per annum. Universities have been the main beneficiaries throughout the years. In 2013, they received 96 per cent of the funding, leaving 3 per cent for Research and Technology Organisations (RTOs) and 1 per cent for other types of beneficiaries.

Funding through the five programmes and calls primarily studied amounted to SEK1.1bn, corresponding to 10 per cent of SSF's total funding by the end of 2013.

Results and impact for grant beneficiaries

According to the projects' final reports, the five programmes co-produced 454 completed PhD degrees with another 231 PhDs planned, i.e. a total of 685 PhD degrees; 3,249 peer-reviewed journal papers; 900 conference papers; 105 awarded patents; and 201 patent applications.

Beneficiaries report that their grant was used to recruit graduate students and post-docs, as well as to co-fund personnel already employed. Beneficiaries judge that the research conducted was of the highest international level and that it was both interdisciplinary in character and relevant to industry. For all programmes but Mobility, beneficiaries agree that their research group had achieved critical mass through the SSF grant, with a particularly strong agreement from FFL beneficiaries.

Beneficiaries indicate that their research groups have become more likely to collaborate and establish durable relationships with other universities and RTOs, and many also agree that they have become more likely to collaborate with companies. The Mobility beneficiaries agree strongly that their grant contributed to collaboration and durable relationships with companies. Collaboration within the SSF projects primarily involved universities, both foreign and Swedish, and Swedish companies. Most beneficiaries found that new networks were created, that existing networks were extended and strengthened, and that new opportunities for collaboration emerged. In the SFC and FFL programmes, industry collaboration was mainly with large companies, and several beneficiaries explain that companies contacted them because they belonged to a successful research group.

Most beneficiaries have used research results from the SSF projects in subsequent projects. The most important sources for funding of subsequent projects are the Swedish Research Council (VR), the (private) Wallenberg Foundations, the EU Framework Programme (FP), the Swedish Governmental Agency for Innovation Systems (VINNOVA) and SSF.

SSF grants have improved beneficiaries' personal development and career prospects. The biggest impact has been for the FFL beneficiaries. Grants contributed to improvements in management skills and to promotions. Several beneficiaries, especially of the FFL programme, consider the SSF grant to have been a mark of esteem in itself. As expected, career advancement and personal development were most important among the less experienced and less established researchers. Many beneficiaries state that receiving an SSF grant clearly improves the likelihood of being awarded additional funding, and some state that the grant was crucial for them to remain in, or come back to, Sweden.

Bibliometric analyses of beneficiaries' publication patterns before and after the project paint a mixed picture. The FFL programme funded some already very productive researchers that became even more productive, whereas the median productivity of a control group of rejected FFL proposers (non-beneficiaries) declined very slightly. Almost all research groups funded by the IT programme increased their publication productivity, while most groups funded through the SFC and Materials programmes show a negative trend. The increase in internationally co-authored publications is quite substantial for beneficiaries of all programmes. However, it is important to note that Swedish authors generally co-publish strongly and that the overall level of co-publications is being driven upwards by a range of factors over and above SSF's funding. Moreover, SSF is one of a number of alternative funding sources for these beneficiaries, and publication outputs are only one of the intended results of the grants. (The Mobility beneficiaries' publication patterns were not subject to bibliometric analyses.)

Beneficiaries are convinced that their project contributed to a sustained strengthening of the international competitiveness of their own research group and of other research groups funded by the project. The grant represented quite a lot of money compared with others and permitted a long-term approach to the research. Such grants were quite rare at the time. Moreover, the grant was not entirely earmarked, but rather flexible in terms of the way in which it could be used. Beneficiaries find themselves in stronger bargaining positions when they have secured a major grant, and industry sees them as more reliable, long-term partners.

Results and impact in industry and society

Most company representatives involved in the projects as partners indicate that research ideas originated in their company and that they actively participated in the projects. They judge that projects were relevant to industry and realised mobility between sectors. Moreover, research was interdisciplinary and of the highest international standard. These assessments should, however, be interpreted in the light of these representatives probably having been "core partners", who may be expected to be more positive and more involved than the average partner. They were also few in numbers, given the volume of projects funded by the five programmes.

An analysis of all project final reports shows that in 51 per cent of projects, research was reportedly carried out in collaboration with industry; 19 per cent of projects led to development or implementation of a prototype, a process or a product; and in 2 per cent of projects, research results had already been introduced onto the market. The remaining 28 per cent merely stated that the project had included "research relevant to industry". This picture, which was painted in the project final reports between two and six years ago, is largely confirmed by interviews with project participants.

The companies said that their main benefits from participation were expanded research networks, access to new knowledge, and participation in subsequent Swedish-funded research projects. The companies have established durable relations with universities, and they have to some extent also recruited PhDs. Comparatively few patents have resulted, and company representatives agree that the commercial impact that has arisen thus far is limited. However, the projects have clearly dealt with topics of potential future importance to industry and society, and project activities have generated potentially useful results and follow-up projects. Nevertheless, company representatives agree that their company's international competitiveness has increased as a result of its participation in the SSF project.

It is necessarily more difficult to infer a great deal about the longer-term industrial relevance of SSF-funded research based on the short-term perceptions of participants and industrial stakeholders. "Strategic" research is more likely to produce knowledge of future use to industry than knowledge, which can be commercialised in the short term. As in the FP, such knowledge would be expected to be "pre-competitive" and to produce "intermediate knowledge outputs" of interest to technologically sophisticated companies, flowing into future rather than current research and innovation processes. The apparent absence of substantial and concrete impact in industry is probably in part a function of time; project results have not yet been implemented in industry. However, it is also due to a lack of, or limited, short-term industrial relevance, since research questions in many cases were formulated without being guided by the needs of industry or society.

Nonetheless, in a small number of cases, the implementation of research results is said already to have yielded sales of billions of SEK for participating companies. There are also examples of small-scale, short-term impact, such as cost reductions in an assembly line in a specific company that helps it maintain production in Sweden. An important impact is the supply of competence and skills to partners, which has added to their internal resources in the form of human capital, research capability, collaboration skills and networks. There are also examples of companies and hospital clinics recruiting PhDs co-funded by SSF, and of senior researchers from SSF projects now working part-time in industry.

Additional impact may be found in the form of 63 spin-off companies set up further to develop or patent and licence technology, products and processes resulting from SSF projects. In 2013, the 43 spin-off companies that are to be found in Swedish company databases had an aggregated net turnover of SEK177m, a combined loss before tax of SEK118m, and 212 full-time employees. Several of the companies have no business activities to speak of and only exist to own patents, while others rely on venture capital.

Do the programmes lead to the impact envisaged by SSF's statutes?

The evidence presented in this report indicates that SSF in most respects has fulfilled the tasks set out in its statutes. The programmes funded large research efforts that either strengthened existing university-based research groups and networks of groups, or established new research groups. The size of the grants meant that their impact in terms of concentration of efforts and thus development of critical mass for research groups were quite significant. The programmes facilitated interdisciplinarity and some degree of inter-sectoral mobility. However, the study finds that academic–industry links have not been sufficiently strong or functioned sufficiently well. There is thus a risk that research results remain of potential rather than actual significance for Swedish industry's long-term competitiveness. This constitutes a lost opportunity. Nevertheless,

the Foundation's interpretation of contributions to Sweden's long-term competitiveness is broad and long-term, and additional impact in industry may emerge in the future. Moreover, many PhDs co-funded by SSF have been employed by companies following graduation, thus contributing to their competitiveness.

Does SSF have special or unique opportunities?

Beneficiary-governed organisations tend to be change-averse. SSF's governance is *de facto* dominated by academics, which has led it to stay true to the themes with which it began and to set funding conditions that do not enforce the close involvement of industry. The downside of SSF's independence from the state is that it is in effect not answerable to anyone, so there is not a strong system of checks and balances at the level of policy that creates tension between SSF and the world around it. Such checks and balances would reduce the opportunities for the kinds of lock-in that SSF displays.

How does SSF fit with other funders?

The type of "strategic" research that SSF funds is different from, and needs different governance compared with, either traditional basic research or application-/commercialisation-driven R&D. The logic of such research does not follow the "linear model" of basic research leading to application, but rather operates the other way round: from problems to more fundamental research.

The historical development of the organisations funding fundamental engineering research in Sweden testifies to the difficulty of trying to combine the funding of strategic and other forms of research, but also to the potential vulnerability of a funding organisation taking on such a role. SSF's own description of itself as "in between" VR and VINNOVA underlines the vulnerability of the role. It is also an unduly negative formulation, as if the role were of lesser importance. In fact, it is not only vital, but increasingly so as the nature of technology becomes more and more scientific.

The evolution of the Swedish funding system since 1994 has effectively involved the state handing over the strategic funding function to SSF and adapting its own agencies around SSF. This creates a void in the system if and when the state wants to implement a policy for strategic research. If the state is to evolve a coherent and holistic research policy, then it needs to re-establish a role in strategic research funding, not least since this is one of the most dynamic sources of innovation and industrial development over the longer term. This policy problem is exacerbated by the poor level of coordination in the Swedish research policy and funding system as a whole.

Is SSF needed?

If the strategic research funding role is important then SSF is needed, since existing government agencies are not structured to take on the job. Since the Foundation's funds are finite and the need to fund strategic research is permanent, there has to be some sort of transition whereby the state assumes its responsibility again. There are several possibilities:

- The state establishes its own strategic research funding agency, cooperating with SSF to ensure a sensible division of labour
- The state and SSF write a contract, whereby SSF acts as an agency for the state-funded part of its role, in addition to the tasks that it already performs with its own declining resources
- SSF provokes a crisis, by maintaining a high level of spending in the knowledge that when the money runs out the state will be saddled with a strategic funding problem
- SSF offers to match new and additional strategic research funding by the state krona for krona, thereby using its limited funds to encourage the state into action

The next research bill is due in 2016, meaning that its contents will be negotiated during the course of 2015. It would therefore be timely for SSF to begin discussions now with

the government about such possible futures. If SSF were to disappear – quickly or slowly – without arrangements being made to replace its function within the research funding system, the consequences for Swedish industry and research would be significant.

1. Introduction

1.1 Assignment

The Swedish Foundation for Strategic Research (*Stiftelsen för strategisk forskning, SSF*) was founded in 1994, with the objective to support research in natural science, engineering and medicine that would strengthen Sweden's competitiveness. Since the Foundation celebrates its 20th anniversary in 2014, it has commissioned this study, which has two main elements:

- An impact assessment of a selection of the Foundation's programmes
- An analysis of the Foundation's systemic role

The aims of this study are thus twofold, to document impact of the Foundation's past activities and to chart its possible options for the future, for future consideration by the Foundation's board and management.

The study team has been tasked with answering the following specific questions:

1. Do the programmes match the Foundation's statutes?
2. Do the programmes lead to the impact that the Foundation's statutes stipulate, i.e. to improve Sweden's competitiveness?
3. What has worked well, and what has worked less well?
4. Does the Foundation have special or unique opportunities? If yes, which?
5. How does the Foundation fit with other funders in the Swedish innovation system?
6. Is any of the areas that SSF has funded under- or over-funded in relation to Sweden's industrial base?
7. Is the Foundation needed in the Swedish innovation system? If not, who takes over when the Foundation has exhausted its limited funds?

Given the wide scope and massive volume of the Foundation's funding since 1994, a limited number of programmes, or instruments, were selected to make the assignment feasible. The programmes and calls were chosen based on the following principles:

- The should span a range of instrument designs and types
- Similarly, they should encompass a variety of scientific areas
- Both group grants and individual grants should be included
- No current or recently concluded programmes or calls should be included (since these are not likely to have had any impact yet)
- No "old" programmes so as to minimise the overlap with a major anthology on SSF's and its sister foundations' first decade[1]

The programmes and calls thus selected by the Foundation were:

- Strategic research centres (*Strategiska forskningscentra, SFC*) in Life sciences:
  - Six centres funded 2003–2008; total funding: SEK380m
  - Supplementary funding for the six centres 2006–2008; total funding: SEK17m
- Framework grants (*Ramanslag*) in Materials science:
  - Seven projects funded 2003–2007; total funding: SEK98m

[1] "'I den absoluta frontlinjen', En bok om forskningsstiftelserna, konkurrenskraften och politikens möjligheter", S. Sörlin, Ed., Bokförlaget Nya Doxa, 2005.

- Framework grants in Information technology (IT):
  - Fourteen projects funded 2002–2007; total funding: SEK245m
- Future research leaders (*Framtidens forskningsledare, FFL*):
  - Twenty-one projects funded 2001–2007; total funding: SEK210m
  - Eighteen projects funded 2005–2010; total funding: SEK162m
- Strategic mobility (*Strategisk mobilitet*):
  - Seventeen projects funded 2008-2010; total funding: SEK15m
  - Fourteen projects funded 2009-2011; total funding: SEK12m

Figure 1 shows the duration of these programmes and calls (in red) and subsequent calls in the same programmes (in pink), as well as the number of projects and the total funding awarded by SSF. It was agreed that the programmes and calls selected should have at least a couple of years between conclusion and the vertical red line, which indicates the (approximate) time when this study commenced. Subsequent calls were to be assessed solely in terms of evolution of the respective instrument.

	No. of projects	Million SEK	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
SFCs in Life sciences	6	380																		
SFCs in Life sciences, complementary funding	6	17																		
Framework grants in Materials science	7	98																		
Framework grants in Information technology	14	245																		
Framework grants in Electronics and photonics	13	240																		
Future research leaders (FFL1)	21	210																		
Future research leaders (FFL2)	18	162																		
Future research leaders (FFL3)	20	170																		
Future research leaders (FFL4)	18	180																		
Future research leaders (FFL5)	20	200																		
Strategic mobility 2007	17	15																		
Strategic mobility 2008	14	12																		
Strategic mobility 2009	17	13																		
Strategic mobility 2010	10	9																		
Strategic mobility 2011	16	14																		
Strategic mobility 2012	13	13																		
Strategic mobility 2013	15	15																		

Figure 1 Timelines, number of projects and funding awarded in the programmes and calls studied. Source: SSF data.

1.2 Approach and methodology

Data acquisition has included:

- Desktop studies of literature on the Foundation's creation, board meeting notes, annual reports, activity reports, strategic plans, previous evaluations and peer reviews, programme-specific documentation (call texts, proposal ranking lists, funding data etc.), project-specific documentation (proposals, funding agreements, final reports) etc., and of the Foundation's web site
- 63 interviews with grant beneficiaries, non-beneficiaries (rejected proposers)[2], partners and mobility hosts, as well as individuals with deep insights into the Swedish innovation system and its funding agencies, see appendix A.1 for interviewees
- Five web surveys of:

[2] For both interviews and web surveys, the non-beneficiaries were selected from the top of SSF's ranking lists, just below the funding threshold, so as to achieve as comparable as possible control group.

  - Grant beneficiaries (except Mobility beneficiaries): 103 responses to 247 invitations, resulting in a 42 per cent response rate[3]
  - Mobility grant beneficiaries: 21 responses to 31 invitations, resulting in a 68 per cent response rate
  - Non-beneficiaries: 74 responses to 189 invitations, resulting in a 39 per cent response rate
  - Partners of grant beneficiaries: 12 responses to 32 invitations, resulting in a 38 per cent response rate[4]
  - Mobility hosts: 11 responses to 20 invitations, resulting in a 55 per cent response rate[5]
- Bibliometric analyses of publications lists of project final reports using the Scopus database
- Analyses of development of spin-off companies
- Analyses of historic developments in available funding for research, development and innovation based on funders' input to the Swedish innovation system 1995–2013
- Foresight focus group on the Foundation's role in the innovation system with 11 participants on 2 September 2014, see appendix A.2 for participants
- Interpretation seminar with 17 participants on 16 September 2014, see appendix A.3 for participants

The assignment was carried out between February and October 2014 by a team consisting of Tomas Åström, Erik Arnold, Peter Stern, Malin Jondell Assbring, Miriam Terrell, Anders Håkansson, Karolina Henningsson and Maria Grudin. The team was supported by Michelle Andersson, Linnéa Järpestam and Sandra Karlström. The assignment was led by Tomas Åström and quality controlled by Peter Stern and Erik Arnold.

We would like to take the opportunity to acknowledge the fact that the team has received tremendous support from SSF staff and assistance of representatives of several other funding organisations, and we are particularly grateful for the time invested by interviewees, survey respondents, and participants in the focus group and the interpretation seminar.

1.3 Report structure

Following this introductory chapter, **Chapter 2** summarises the Foundation's creation and development, including its programmes, a funding analysis and a review of previous evaluations and peer reviews. **Chapter 3** presents results and impact on grant beneficiaries and **Chapter 4** results and impact in industry and society. **Chapter 5** discusses the Foundation's role in the Swedish innovation system. **Chapter 6** assesses the extent to which the Foundation has fulfilled its statutes based on the evidence presented in the preceding chapters. **Chapter 7** summarises some of the lessons learnt and assesses SSF's administrative processes. The concluding **Chapter 8** deliberates on the study's findings.

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3 Grant beneficiaries include co-proposers in SFCs and Framework grant projects.

4 Names and contact information of partners were determined by asking main beneficiaries, i.e. project leaders, who they were. Some beneficiaries responded that there had been no non-academic partners, others did not respond at all despite reminders, which explains the comparatively low number of invitations (given the number of projects). The comparatively low response rate may possibly be interpreted as many partner addressees not seeing themselves as having been sufficiently involved in the project.

5 Names and contact information of hosts were determined by asking Mobility beneficiaries who they were.

Appendix A lists interviewees and participants in the focus group and the interpretation seminar, while **Appendix B** collates the abbreviations used in the report.

2. The Foundation for Strategic Research

2.1 Creation and evolution

The Swedish Foundation for Strategic Research has its origins in political duelling between Swedish successive governments led by social democrats and liberal-conservative coalitions.

The story may be said to start when an economist at the Swedish Trade Union Confederation developed the concept of so-called "wage-earners' funds". This entailed levying a special tax on companies' profits and using the proceeds to buy shares in those companies. This would allow the employees (the wage earners) to gain a level of control of their employers and get to enjoy a share of the profits. A social democrat government somewhat reluctantly saw legislation to introduce wage-earners' funds through parliament in 1983. The wage-earners' fund system went into effect in 1984, but was eventually terminated in 1992 following a liberal-conservative coalition's election victory in 1991.

The question was then what to do with the money amassed by the wage-earners' funds. Several alternatives were broached in the years to come, but as the liberal-conservatives realised that they would probably lose the 1994 election to the social democrats, they sought a solution that could not be reversed by the next government. The solution chosen was to place the funds in independent foundations that could not easily be brought under government control. Funds were also used to strengthen the pension system and to capitalise the two new venture capital companies Atle and Bure (SEK2.2bn each), which were mainly owned by the large companies that had originally contributed substantially to the wage-earners' funds.

In total, ten research-funding foundations received SEK17bn through acts of parliament in 1993 and 1994. In the first decision, SSF, the Swedish Foundation for Strategic Environmental Research (*Stiftelsen för miljöstrategisk forskning, Mistra*) and the Swedish Foundation for Humanities and Social Sciences (*Riksbankens Jubileumsfond, RJ*) received SEK10bn. SSF and Mistra, which were to be newly established, received SEK6bn and SEK2.5bn, respectively, while the already existing RJ received another SEK1.5bn. The second act resulted in the establishment of the Knowledge Foundation (*Stiftelsen för kunskaps- och kompetensutveckling, KKS*) and the Swedish Foundation for International Cooperation in Research and Higher Education (*Stiftelsen för internationalisering av högre utbildning och forskning, STINT*), as well as a number of other smaller foundations.

To understand such massive public investment in research, one must realise that at the beginning of the 1990s, Sweden was in crisis. An overheated economy had slumped into recession, unemployment was increasing, the real estate market was crashing and the national debt was mounting rapidly. The liberal-conservative coalition that had won the 1991 election had, among other things, promised investment in higher education and research to revitalise Sweden and its industry, echoing industry demands for greater public investment in research and postgraduate education. The new foundations were a key element in this policy.[6]

Another, related element was the launch of sectoral automotive and aeronautics research programmes, which were established in 1993 following industry lobbying. Although pocket money by comparison with the Foundations, SEK30m per year for each programme, these programmes aimed to make academic research more focused on industry needs, raise the research-intensity in industry and increase the number of PhDs employed in industry. This was also among the objectives in the Swedish Competence centre programme, which ran from 1995 to 2007. Some 28 university-

6 S. Sörlin, "Konturer av kunskapssamhället – tidsläget i det tidiga 1990-talet" in "'I den absoluta frontlinjen', En bok om forskningsstiftelserna, konkurrenskraften och politikens möjligheter", S. Sörlin, Ed., Bokförlaget Nya Doxa, 2005.

based consortia were selected to receive ten years of funding from Nutek (later the Swedish Governmental Agency for Innovation Systems (VINNOVA) and the Swedish Energy Agency). In total, the programme cost SEK4.9bn, of which the government agencies paid around SEK1.5bn. This was to be matched by industry and universities, so that state, industry and universities each paid for about one third of the programme. By the final stage, around 200 companies were involved, and large companies accounted for about 80 per cent of the industrial contribution, most of which was in kind, thus ensuring that companies were actively involved in the research. The two initiatives, as we shall later see, complement and partly overlap with the intentions of the foundations, and in particular SSF.

Following the act passed by the parliament in the spring of 1993, an organising committee prepared for the establishment of SSF. Parliament's decision had been preceded by consultations where stakeholders had argued for long-term and targeted competence development in engineering and natural sciences, including increased capacity in postgraduate education targeting industry needs. SSF was established on 3 January 1994 with statutes stating that:

> *§ 1. The objective of the Foundation [...] shall be to support research within natural science, engineering and medicine. The Foundation shall promote the development of strong research environments of the highest international standard and of significance for the development of Sweden's long-term competitiveness.*
>
> *...*
>
> *§ 3. The activities of the Foundation shall be built up gradually based on the Foundation's own, independent policy and shall be distinguished by the special characteristics outlined below. The research funded may involve both basic and applied research, and, not least, intermediate areas.*
>
> *The Foundation's activities shall be distinguished by:*
>
> - *a concentration of efforts in order for internationally competitive research centres or research areas to be established*
> - *interdisciplinary projects and programmes*
> - *the establishment of cooperation networks or firmer forms of collaboration nationally and internationally, for example by the establishment of an international exchange programme for researchers*
> - *promotion of postgraduate studies and recruitment of researchers*
> - *the establishment of research centres or research specialties in close affiliation with universities and colleges*
> - *collaboration between academia and industry in areas of particular interest to industry*
> - *the promotion of mobility of researchers internationally and between universities, institutes and companies.*
>
> *The Foundation's activities may in due course result in the depletion of its capital assets.*

The social democrat government elected in autumn of 1994 immediately sought to gain control of the newly established foundations, and attempted to coerce them to take over R&D funding responsibility in areas that hitherto had been the state's domain. The government did manage, through a change in legislation, to ensure that it could appoint the chairpersons to the foundations' boards, but it could not alter the objectives paragraph of the statutes (§ 1). Neither did the government manage to convince the

foundations voluntarily to take over funding responsibility in areas that were the state's domain.

The government then adopted a strategy resembling blackmail; it made draconian cuts in its appropriations to government agencies funding research and development (R&D). By 1997, the research councils had lost about SEK200m (8 per cent of previous appropriations), *Närings- och teknikutvecklingsverket (Nutek)*, responsible for funding of applied R&D, almost SEK300m (20 per cent), and the Swedish Environmental Protection Agency SEK150m (its entire R&D budget). Faced with such harsh realities, the foundations resorted to taking on part of what had previously been the responsibilities of these and some other government agencies. For SSF, this meant that it took over the funding responsibility for the ongoing interdisciplinary Materials consortia (competence centres for academia-industry collaborative R&D) from Nutek and *Naturvetenskapliga forskningsrådet (NFR)*, amounting to SEK50m per year (until 2000). SSF also took over the personnel that had administered the Materials consortia from Nutek. In addition, SSF took over various programmes in microelectronics, amounting to another SEK50m per annum, as well as the responsibility for ongoing projects initially decided on by the research councils, Nutek and the Swedish National Space Board (SNSB).[7] These legacies in part explain the Foundations' main funding areas; see next section.

2.2 Programmes

2.2.1 Main areas funded

The Foundation has employed a wide variety of funding instruments and programmes during its first two decades. Over time, the emphasis has shifted from Graduate schools and Strategic research centres to Individual and Framework grants.

Initially, SSF focused on funding research in biotechnology, "base technologies" (generic research, such as materials sciences and sectoral research) and IT. In subsequent years, further research areas were added. Manufacturing and production-related areas, and chemistry and process technology were added in 1996; materials sciences and engineering, and microelectronics in 1997; and life sciences in 1999. Most of these areas have survived over the years, although the names have varied.

As a result if its 2006 strategy[8], the Foundation's priority areas remained the same during the years 2007–2011:

- Life sciences
- Information technology and applied mathematics
- Electronics and photonics
- Product realisation and process engineering
- Materials science and engineering
- Bioengineering and life science technologies

Since the 2012 launch of SSF's current research strategy 2012–2017[9], the Foundation funds research in five main areas (also referred to as high-priority areas), which were defined through a comprehensive and iterative strategic dialogue between high-ranking scientists and representatives of academia and industry, namely:

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7 M. Benner, "En ny aktör söker sin roll – stiftelserna genom 1990-talet" in "'I den absoluta frontlinjen', En bok om forskningsstiftelserna, konkurrenskraften och politikens möjligheter", S. Sörlin, Ed., Bokförlaget Nya Doxa, 2005.

8 Strategic plan, SSF, 2006.

9 SSF Research Strategy 2012–2017.

- Life sciences (*Livsvetenskaperna*)
- Life science technology (*Bioteknik, medicinsk teknik och teknik för livsvetenskaperna*)
- Materials science and technology (*Materialvetenskap och materialteknologier*)
- Information, communication and systems technology (*Informations-, kommunikations- och systemteknik, IKST*)
- Data-X and computational sciences and applied mathematics (*Beräkningsvetenskap och tillämpad matematik*)

SSF now allocates its funds through open, competitive calls for proposals. In addition to call-specific criteria, all research proposals are to focus on at least one of SSF's main areas, entail scientific excellence and produce research results with potential for commercial exploitation in Sweden.

2.2.2 Graduate schools and Research programmes

In 1995, SSF started funding a number of Graduate schools (*Forskarskolor*), more or less connected to its Research programmes (*Forskningsprogram*), within most of the Foundation's present areas. The total amount of funding for the Graduate schools was SEK2.3bn in the period 1995–2007. During the years 1996–2007, SEK1.4bn were granted to Research programmes, which often included funding of specific centres or research groups.

In 1996, SSF started six Preparatory graduate schools in biomedicine (*Forskarförberedande biomedicinska skolor*) inspired by American universities. The purpose of these was to provide one year of preparatory research training, comprising both theoretical courses and practical laboratory work. The six Swedish universities organising Preparatory graduate schools were Umeå University (UmU), Uppsala University (UU), Stockholm University (SU), Linköping University (LiU), Chalmers University of Technology (CTH) and Lund University (LU). One intention of the Preparatory graduate schools was to provide candidates for the Graduate schools the Foundation funded, another was to provide the pharmaceutical industry with qualified potential employees.[10] In total, the six Preparatory graduate schools were granted SEK212m over the course of nine years (1997–2005), including additional funding (2002–2005).

2.2.3 Strategic research centres

A Strategic research centre (SFC) was characterised by the organisation of a number of independent, preferably co-located, research groups at a university or a research institute (hereinafter referred to as Research and Technology Organisation (RTO)) collaborating to solve an important research problem. The centre was led by a centre director, assisted by a steering group and a scientific advisory group. In addition to scientific excellence and strategic value, other important criteria for receiving such a grant were that the centre composition would yield added value in comparison with funding each group individually, and top-class scientific competence and leadership qualities of the main proposer.

Between 2003 and 2012, SSF funded 29 SFCs with a total amount of close to SEK1.5bn. The duration of an SFC was six to eight years (including a mid-term evaluation) and the annual grant amounted to SEK7–10m.

2.2.4 Framework grants

A Framework grant implies that a number of researchers from one large group, or a few independent research groups from one or more universities or RTOs, collaborate in

[10] SSF Activity Report 2006.

solving an important research question. The main proposer or one of the co-proposers must work at a university. The main proposer is responsible for coordinating the scientific activities funded by the grant. To help monitor and support the group and the research activities, SSF may appoint a programme committee consisting of experts from both academia and industry.

A proposal for a Framework grant is assessed on the basis of scientific excellence and strategic value of the research agenda, as well as the composition of the research group (or groups) in relation to the research question at hand. The main and co-proposers' scientific competence and complementarity are other important criteria.

Since 1998, SSF has awarded 165 Framework grants, of which 21 will end in 2014 and another 41 will continue for up to five more years. In Swedish, SSF referred to Framework grants as *Ramanslag* in 1998–2006 and as *Rambidrag* or *Synergibidrag* since 2007. The total amount of funding for the 165 grants is SEK2.2bn. The duration of a Framework grant is four to six years and projects may be evaluated at mid-term.

2.2.5 Individual and Mobility grants

The Foundation has launched several calls and programmes aimed at supporting individual researchers at a university or RTO, who apply for funding for an individual project or a research group. The funding period is three to six years with a grant level of SEK1–3m per annum. In total, 106 individuals have been granted SEK491m: 27 in Individual grants (1996–2008), 53 Junior individual grants (1997–2000) and 26 Senior individual grants (1995–2005).

In addition to the Individual grants described above, there is the Ingvar Carlsson award (homecoming or returning post-docs) and the Future research leaders (FFL) programme (formerly called "INGVAR" grants), both of which include leadership training.

The Ingvar Carlsson Award, named after (former Prime Minister) Ingvar Carlsson in acknowledgement of his contribution as the Foundation's chairman 1997–2002[11], aims to give homecoming post-docs the opportunity to establish their own research careers in Sweden. The Foundation has launched five calls and there are ongoing projects in the two most recent ones (2012–2015 and 2013–2016). Prior to this programme, the Foundation launched three similar calls for *Hemvändande postdoktorer* (homecoming post-docs) in 1997–1999. A total of 81 individuals have been granted SEK144m.

The purpose of the FFL programme is to support young and particularly promising researchers with leadership potential, by offering them grants to set up and establish their own internationally competitive research groups. SSF has launched five ordinary calls in the programme. In addition, in 2005 the Foundation's board decided to grant five female researchers who were almost awarded grants SEK2m each to encourage them to apply again. In 2010, another special call was launched further to support the careers of the most successful participants in the two first calls of the programme. The first group of beneficiaries received grants in 2001, while the projects of grantees in the fourth call are still continuing (2011–2015). In total, 84 individuals had received grants amounting to SEK694m (prior to the fifth call where beneficiaries have not received funding until 2014 and therefore are excluded from this narrative).

SSF awards grants to foster mobility between the private and public sectors, higher education institutions, countries and/or disciplines. Since 2007, the Strategic mobility programme (*Strategisk mobilitet* during the years 2007–2012) has enabled 93 individuals to spend four to twelve months full-time as a visiting researcher at the host organisation of their choice. The maximum grant is SEK2m and by the end of 2013 (thus excluding Strategic mobility 2013, wherein projects start in 2014) 85 individuals had been granted SEK70m.

[11] SSF Activity Report 2005.

Another mobility grant is Strategic international recruitment (*Strategisk internationell rekrytering*), where a researcher at a Swedish university may apply for funding for a very prominent foreign visiting researcher to work in the proposer's research group. The visiting researcher was obliged to spend at least half his/her time at the host organisation for a period of one to three years. Four grants of a total amount of SEK12.8m were allocated as a result of a single call in 2007.

2.2.6 Other funding instruments

In addition to the main funding instruments described above, the Foundation has tried several other instruments and programmes.

SSF has co-funded research programmes in collaboration with other national and international research funding organisations, on condition that the programmes match the Foundation's main areas and that SSF's funding brings added value over and above the money.

The initiatives to stimulate international cooperation have targeted Asian countries and SSF has chosen to focus on Japan and the Republic of Korea, with the purpose of increasing the number of collaborations with its foremost researchers. (An attempt to set up a cooperation with China was unsuccessful.) Between 2000 and 2010, SSF granted SEK26.8m to 27 projects through the *Japansamarbete* programme. The *Scientific collaboration with Korea 2014* programme, with a SEK30m budget, was launched in 2014.

In order to achieve more efficient utilisation of research infrastructure, SSF in 2014 also started providing support to key experts (Research Infrastructure Fellows) to make research infrastructure more accessible to users in academia and industry.

An instrument referred to as Brain drain (*Flyttfara*) targets universities that want to prevent leading researchers from leaving Sweden due to more attractive offers from abroad. In order to receive such a grant, the university must supply the majority of the funding and the researcher concerned must belong to the top ten per cent of excellent researchers within the scientific field, as assessed by international peers.

Outside its formal programmes, SSF may fund information activities, such as scientific conferences, although the activity proposed must have potential to improve Swedish research, competitiveness or society. Since 2008, SSF has granted SEK11m to 32 proposals for information activities.

2.3 Funding granted

The Foundation had an initial capital of SEK6bn, but its asset management has been very successful. Thus, despite SSF having awarded SEK10.9bn in grants by the end of 2013, it still had SEK10.1bn in remaining assets at the end of the same year.

Figure 2 and Figure 3 present the distribution of funds over the Foundation's main research areas. Funding peaked in the year 2000 at close to SEK1bn, but has since declined; in the last decade, funding has averaged around SEK500m per annum. As discussed in Section 2.2.1, the main areas were reasonably constant until 2011, see Figure 2, although the terminology varied somewhat between years. When considering the accumulated funding until 2011, Life sciences received the most, followed by Information technology and applied mathematics, Electronics and photonics and Product realisation and process engineering. Materials sciences and engineering and Bioengineering and life science technologies received the least funding.

Figure 3 shows the distribution of funds across the new main areas in 2004–2013. Information, communication and systems technology is now the largest area, closely followed by Life sciences. Materials science and technology, Life science technology and Data-X & computational sciences and applied mathematics have received the least funding.

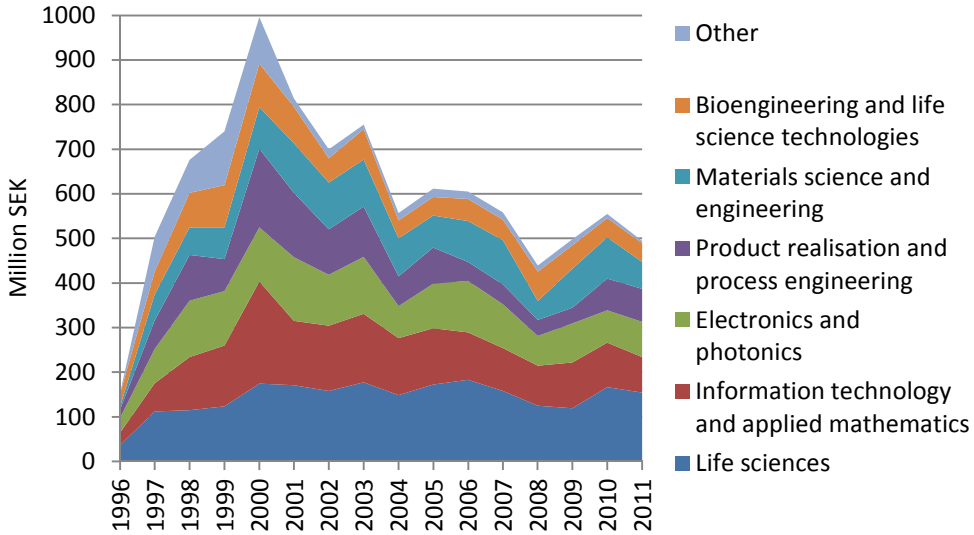

Figure 2 SSF funding awarded by research area, 1996–2011. Source: SSF data.

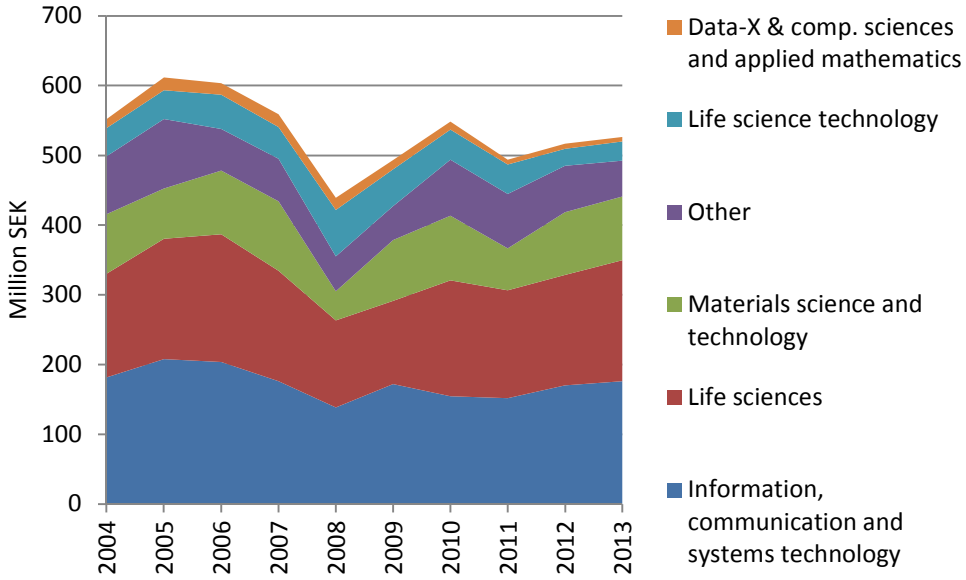

Figure 3 SSF funding awarded by research area, 2004–2013. Source: SSF data.

As explained in Section 2.2, the Foundation's main funding instruments have been Preparatory graduate schools, Graduate schools, Strategic centres, Individual grants and Framework grants. The steep increase in funding leading up to year 2000 is primarily explained by grants for Graduate schools and Framework grants, see Figure 4. Grants for Graduate schools started decreasing in the following years, whereas grants for Strategic centres grew rapidly in 2003 following the introduction of the SFC programme. Prior to 2003, Strategic centres included small-scale centres and start up grants for what would become large-scale centres. Strategic research centres were discontinued in 2012 and the last disbursements were made the following year. Individual grants and Framework grants are currently the largest funding instruments. Since 2008, SSF offers grants for Strategic mobility, which are included in the category Individual grants.

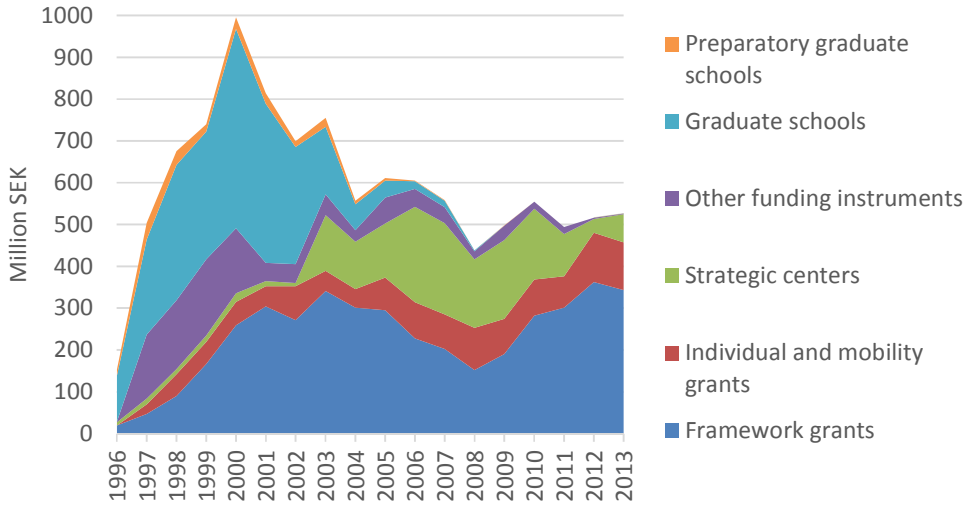

Figure 4 SSF funding distributed by programme/funding instrument, 1996–2013. Source: SSF data.

Universities have been the primary beneficiaries throughout the years. In 2013, they received 96 per cent of grant funding, leaving 3 per cent for RTOs and 1 per cent for other types of beneficiaries. Although the sectoral distribution of support has varied somewhat over the years, universities have consistently been the largest recipients by far.

Figure 5 shows that in 2013 CTH, LU and Karolinska Institutet (KI) were the primary HEI recipients, followed by UU, the Royal Institute of Technology (KTH), LiU and the University of Gothenburg (GU). The RTO and other categories, the latter including Junior individual grants and targeted grants distributed through research councils, only account for a very small fraction of recipients. Considering accumulated grants since 1996, CTH is the largest recipient (15 per cent), closely followed by KTH (14 per cent) and LU (13 per cent).

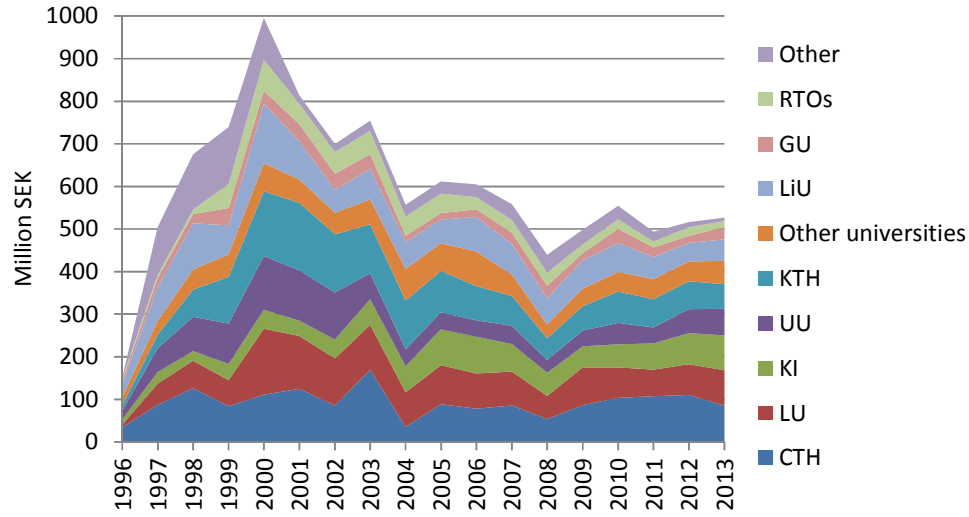

Figure 5 SSF grant recipients, 1996–2013. “Other universities” also includes university colleges. Source: SSF data.

2.4 Previous evaluations and peer reviews

As described in previous sections, the main focus of SSF's funding until about the year 2000 was on Graduate schools and Framework grants. The Foundation then altered its priorities towards thematic calls, and has since then focused on SFCs, Framework grants, Individual grants and Mobility grants. In this section we take a closer look at the evaluations and peer reviews commissioned by SSF, and highlight some findings and insights that may help us better understand the results and impact of the Foundation's investments in research and postgraduate education.

2.4.1 Mid-term and ex-post evaluations

During the first decade of the new millennium, SSF commissioned more than 20 ex-post programme evaluations. These were in some cases preceded by mid-term peer reviews, initiated either by SSF itself or a programme committee, to assess scientific quality. The ex-post evaluations, often carried out by independent consultancies or research institutes, typically raised issues concerning SSF's selection process, results and impact in academia and on postgraduate education, industrial relevance, interaction between industry and academia, as well as fulfilment of programme objectives and SSF's statutes. In recent years, the Foundation has taken a different approach to evaluation, and the number of external programme evaluations has decreased noticeably.

2.4.2 Thematic evaluations and studies

Since the Foundation's establishment, IT has been one of its main funding areas. In 2008, the Foundation commissioned an assessment of its funding in IT in the period 1994–2000.[12] The assessment concluded that the research funded had been in line with SSF's statutes. However, it was noted that some programmes had suffered from delays due to tardy programme set up, which in most cases caused decreased industrial relevance, since the programmes were outrun by industry developments. Further, the assessment found that the programmes had not devoted sufficient attention to several highly relevant and well-established IT subareas (e.g. the Internet, multimedia, search engines and IT in the public sector). The assessment argued that the most prominent impact of the IT programmes were doctoral education, especially within the centres of excellence funded. The assessment also noted SSF's freedom in programme design, which was seen as a comparative advantage for SSF and the assessment advised the Foundation to use this to explore novel funding schemes in the future.

Life sciences and Life science technologies have been two other important funding areas throughout SSF's existence. In 2008, SSF commissioned two impact assessments of some of its earliest programmes in biotechnology, bioinformatics, and genome research.[13] The assessments showed that the funding had contributed to a strengthening and diversification of the Swedish knowledge base in several important and strategic areas, and that this would hardly have been possible without the support from SSF. In most programmes studied, no obvious connection to industry or to innovation was found, and the number of patents and spin-off companies identified were therefore very low. The assessments concluded that SSF's funding had nonetheless been of notable strategic importance, since (at the time) the Swedish life science sector was losing its international competitiveness, and public research funding opportunities were decreasing.

SSF, together with the Swedish Research Council (VR), has initiated several peer reviews of specific research areas funded by both organisations. In 2004, they appointed

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12 "Värdering av SSF:s IT-insatser under perioden 1994-2000", SSF, 2008.

13 S. Faugert, I. Meijer, P. Mattsson, P. Salino, K. Eduards and H. Segerpalm, "Effekterna av SSFs stöd till tio nationella nätverksprogram inom biomedicin och bioteknik", SSF, 2008.
"Bioinformatik, gen-etik, genomik och utvecklingsbiologi", SSF, 2008.

a panel of international experts to carry out a review of Swedish research in biomedical engineering.[14] In 2008, microelectronics was reviewed, and in 2009, VR together with SSF initiated a peer review of research in mathematics. The peer reviews concluded that Swedish researchers in these fields conduct some first-rate research, but the Swedish research funding system was criticised for not providing sufficient funding opportunities.

SSF has also supported biomedical research through targeted investments in postgraduate education. The Foundation initiated the establishment of the Preparatory graduate schools in biomedicine in 1997, which aimed to strengthen Swedish research, to build networks between research groups and to increase the number of PhDs. An evaluation showed that postgraduate education in biomedicine had seen substantial improvements in quality and increased attractiveness, and that SSF's funding had contributed to lasting impact on postgraduate education and recruitment in several faculties of medicine in Sweden.[15]

In 2009, SSF analysed the patenting behaviour of Swedish researchers in life sciences.[16] SSF beneficiaries were compared with a control group of non-beneficiaries in the same research field and with similar scientific qualifications. The analysis showed that SSF beneficiaries more often applied for patents than the control group.

In SSF's early programmes, there was a strong focus on postgraduate education, with the aim of increasing the number of PhDs in industry and academia. In 2009, the Foundation conducted a study of SSF-funded PhD students in programmes started in the period 1996–2000.[17] The career development of the former PhD students was compared with a control group, and one of the most important findings of the study was that 46 per cent of the former PhD students were employed in industry, compared with 37 per cent of the control group.

2.4.3 Future research leaders (FFL)

The first FFL programme (2001–2006) was evaluated in 2005.[18] The programme was at the time unique in the Swedish research funding system and awarded 20 of Sweden's most promising researchers (out of over 400 proposers) funding for a period of six years. A comparison of the grant beneficiaries with those who were just below the funding threshold, with regard to research group size and spin-off effects (new research groups or companies) four years after being awarded the grant, yielded no significant differences. The main difference was that the FFL beneficiaries on average had more funding at their disposal. It was also concluded that the publishing behaviour was similar, but the FFL beneficiaries tended to publish in higher ranking journals and were slightly more active in terms of international co-authorships. An evaluation in 2005 highlighted the programme's leadership and mentorship initiatives as innovative elements. The leadership initiative seems to have been particularly successful in promoting collegial networks across disciplines. The programme was also evaluated in 2010, and the evaluation confirmed that participants in general believe the programme had made them better equipped as research leaders.[19]

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14 "International evaluation of Swedish research in biomedical engineering", VR, 2006.

15 "Var blev ni av, ljuva drömmar – En utvärdering av SSF:s satsning på den biomedicinska forskarskolan", SSF, 2008.

16 "SSF-stödda forskare söker patent i större utsträckning än icke SSF-stödda", SSF, 2009.

17 "Hur gick det sedan? – En uppföljning av forskarstuderande inom 55 SSF-finansierade forskningsprogram, startade åren 1996–2000", SSF, 2009.

18 "Utvärdering av Individual Grant for the Advancement of Research Leaders – INGVAR – med avseende på utformning, urvalsprocess och ledarskapsprogram", SSF, 2005.

19 "Utvärdering av Stiftelsen för Strategisk Forsknings ledarskapsprogram ICA och FFL", CMA Research, 2010.

2.4.4 Mobility grants

The Mobility grant programme was evaluated in 2011 by an external committee, based on final reports from 31 completed projects and interviews with grant beneficiaries.[20] The evaluation showed that the programme had yielded results that exceeded the funds invested, and that the programme had provided leverage for beneficiaries to achieve further development in industry and academia. The evaluators saw great potential in the instrument, since it stimulates mobility between academia and industry, and increases knowledge and understanding of the innovation system among both beneficiaries and hosts.

2.4.5 Strategic research centres

SSF has funded SFCs through three calls. In 2003 SSF launched two calls, one dedicated to Life sciences and one to Microelectronics (SEK400m and SEK270m, respectively), and in 2006 SSF awarded in excess of SEK800m to 17 centres covering all research areas prioritised by SSF.

The six SFCs in Life sciences funded from 2003 to 2008 were evaluated in 2005 by a panel of scientific experts and industry representatives.[21] The scientific performance was satisfactory and the evaluators concluded that SSF's funding had yielded internationally competitive environments for collaborative research and excellent postgraduate education. The industry representatives estimated that there was potential for future industry implementation of research results from all six centres.

SSF initiated a real-time evaluation to monitor the initiation and progress of the 17 centres funded during the years 2006–2012.[22] The first report from this assignment was a study of the centre selection process. The study concluded that the process in many ways followed a conventional peer-review procedure. However, the final stage allowed for the assessment committees to consider the strategic element by introducing non-traditional assessment criteria. The second report focused on the initial structure and organisation of eight of the centres. It was found that the centres studied resembled small knowledge-intensive enterprises in terms of organisation and structure. Furthermore, SSF's intention to introduce novel management processes for large-scale research environments seemed to have been embraced by all centres.[23] In 2009, a mid-term evaluation was conducted as a foundation for a decision on how to allocate SEK142m in funding reserved for the period 2009–2010. Nine of the centres were deemed to be performing particularly well and were thus well suited to receive the majority of the additional funding.[24]

2.4.6 Framework grants

The Framework grant instrument has not been the subject of any dedicated evaluation. However, many centres and research groups funded through this instrument have been included in evaluations and analyses referred to earlier in this section.

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20 "Rörlighet befrämjar utvecklingen – en utvärdering av programmet Strategisk mobilitet", SSF, 2011.

21 "Mid term teports from Strategic research centres in Life sciences", SSF, 2005.
"Mid-term evaluation of six strategic research centres in the Life sciences", SSF, 2005.

22 P. Schilling, "Att välja ut strategiska forskningscentra. En analys av Stiftelsens för strategisk forskning bedömningsprocess", SISTER, 2007.

23 E. Deiaco, M. Benner, L. Geschwind, K. A. Karlsson, "Att komma igång med strategiska forskningsmiljöer – En analys av SSF:s satsning på strategiska forskningscentra", SISTER, 2008.

24 "Halvtidsutvärdering av Strategiska Forskningscentra", SSF, 2009.

3. Results and impact for grant beneficiaries

This chapter presents the results and impact of the programmes for the grant beneficiaries. The programmes, or rather instruments, studied exhibit several important differences, including that they have different target groups, are directed towards either development of individual researchers or the establishment of groups or centres, provide very different size grants and have different objectives. Nonetheless, the programmes largely achieve the same kind of results and impact, which in this chapter are presented under six sub-headings: results; organisational impact; impact on networks; funding of subsequent research; personal development and improved career opportunities; productivity and international visibility; and competitiveness.

The main data sources of this chapter are interviews and web surveys with both grant beneficiaries and non-beneficiaries (with emphasis on the former), but we also draw on project final reports and bibliometric analyses based on the Elsevier Scopus database.

3.1 Results

3.1.1 Output

In the projects' final reports, a total of 454 awarded and 231 planned PhD degrees were reported, adding up to 685 PhD degrees, see columns (left axis) in Figure 6. As can be seen, the SFC and FFL programmes produced the greatest number of graduates, while the IT and Materials programmes produced considerably fewer. Only one PhD degree was reported from the Mobility programme, but this should come as no surprise as production of PhDs is not a priority of this programme.

Figure 6 also shows the apparent cost of a PhD degree for the different programmes (excluding Mobility), indicated by the green curve (right axis), calculated by dividing the total SSF funding for the programme calls by the number of PhD degrees awarded and planned. The average cost is similar for SFC and FFL, around SEK1.5m, and SEK1.2m for the Materials programme, but considerably higher in the IT programme, SEK2.9m. These "costs" should of course be taken with a grain of salt, but the green line aids in comparing the results of programmes with very different budgets.

In this respect, it is illustrative to consider that the full cost for an engineering PhD degree in Sweden is approximately SEK4m (assuming an average duration of 4.5 years). Thus, Figure 6 illustrates the well-known fact that it is highly unusual for a PhD student in Sweden to be funded through only one grant, but rather through a combination of grants, typically from different funding sources. The number of PhD degrees varies greatly between projects in the same programme, so it seems reasonable to assume that the authors of the final reports have applied somewhat different criteria for inclusion of a PhD degree in the list of graduates.

The columns in Figure 7 show the number of papers produced (left axis); a total of 3,249 peer-reviewed journal papers and at least 900 conference papers were reported (no conference papers were reported in any of the final reports of the SFCs). The green curve shows the apparent cost per peer-reviewed journal paper, and the purple curve the apparent cost per peer-reviewed journal or conference paper (right axis). The cost for a peer-reviewed journal paper from the SFC, FFL and Materials programmes is about the same, just below SEK300k, whereas it is considerably higher for the Mobility and IT programmes. On the other hand, looking at both journal and conference papers, the costs are more comparable, between SEK220k and SEK360k, per paper, indicating that the publication productivity is comparable between programmes. It is likely that the large share of conference papers in the IT programme can be explained by it being far more common in the IT field to publish research results at highly regarded conferences than in most other research fields. As for the Mobility programme, publication of scientific papers was not prioritised.

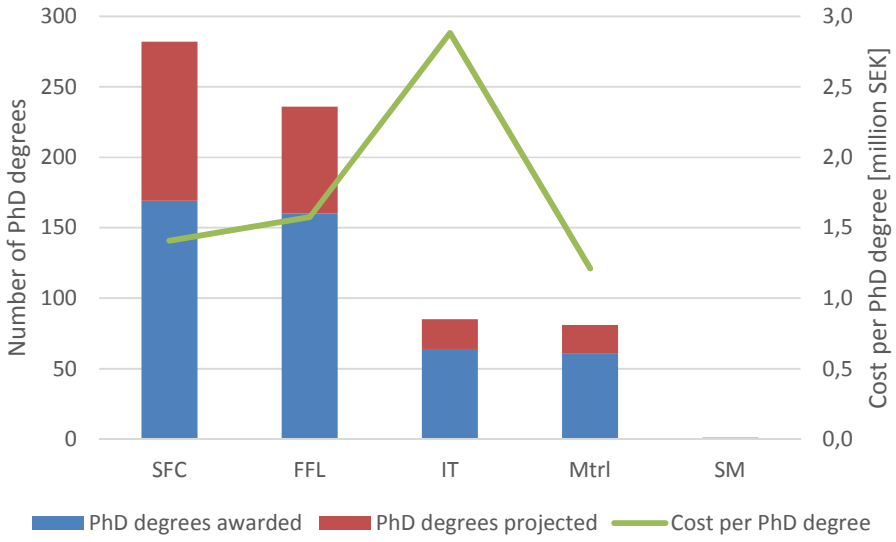

Figure 6 Number of PhD degrees produced (columns; left axis) and apparent cost per PhD degree (curve; right axis). Source: Project final reports.[25,26]

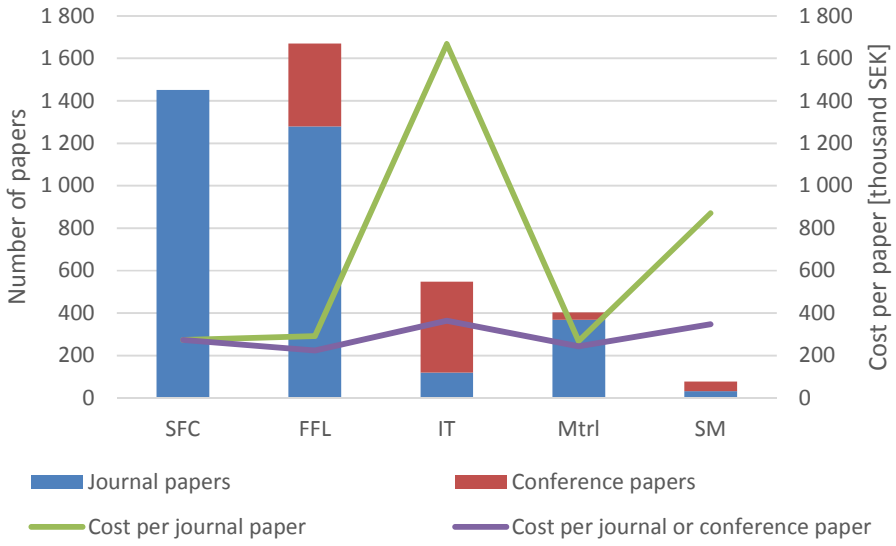

Figure 7 Number of papers produced (columns; left axis) and apparent cost per paper (curves; right axis). Source: Project final reports.

Figure 8 similarly shows the number of patents awarded and applied for (columns); a total of 105 awarded patents and 201 applications, see also Table 1. The apparent cost per awarded patent (green curve) varies greatly, from SEK5m for the FFL programme

[25] The programme notations used herein are:
SFC: Strategic research centres in Life sciences
FFL: Future research leaders; FFL1 and FFL2 only
IT: Framework grants in Information technology
Mtrl: Framework grants in Materials science
SM: Strategic mobility; Strategic mobility 2007 and Strategic mobility 2008 only

[26] For two of the IT projects, the final reports do not include any publications, meaning that the number of publications from this programme is likely an understatement. The funding for these two projects has been excluded from the division resulting in the cost per paper.

to more than SEK60m for the IT programme. The SFC and FFL programmes were dominated by research in life sciences, whereas the IT and Materials programmes targeted two other research areas. Whether the difference in patenting behaviour possibly may be explained by variations between disciplines or researcher productivity is difficult to assess, although it is common practice in parts of the IT sector not to patent inventions. Judging from programme call texts, patenting was not emphasised in any of the programmes studied, although SSF has highlighted patenting in project monitoring and reporting.

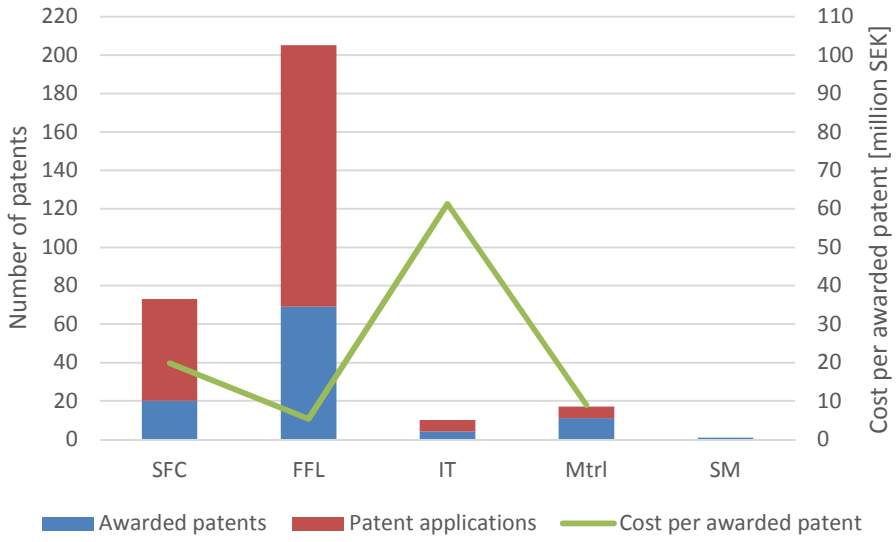

Figure 8 Number of patents awarded and applied for (columns; left axis) and apparent cost per awarded patent (curve; right axis). Source: Project final reports.

Table 1 Number of patents awarded and applied for. Source: Project final reports.[27]

	SFC	FFL	IT	Mtrl	SM	Total
Patent applications	53	136	6	6	0	201
Awarded patents	20	69	4	11	1	105

3.1.2 Nature of research

The view of the beneficiaries is that the projects in the SFC, IT and Materials programmes were highly industrially relevant. This may seem surprising, as SSF does not require industry co-funding, in contrast to the common practice of other important funding agencies, including VINNOVA, the Swedish Energy Agency and the EU's Framework Programme (FP). Many of the research groups funded already had established collaboration partners in industry, and these ties were further strengthened through the SSF projects. Our empirical evidence contains some examples of research results that have been commercially implemented, through both established companies and spin-off companies based on project results; this is discussed further in Chapter 1.

The programmes targeting individual researchers have also, to some extent, fostered industrially relevant research. The Mobility grants have stimulated researchers in academia temporarily to conduct research in industry (and a few vice versa), and our web survey shows that these researchers have developed a more positive attitude to collaborative research with industry compared with beneficiaries of the other

[27] That the number of awarded patents exceeds the number of applications for two programmes is explained by the fact that two Materials projects reporting seven awarded patents, as well as the one Mobility project that reported one awarded patent, did not report any applications at all.

programmes. Several of the FFL beneficiaries we interviewed said that their research has led to industrial applications currently in the process of being commercialised.

Many interviewees say that their project has encouraged collaboration between researchers from different disciplines, which has resulted in new research topics and new methods being explored by combining different experiences and know-how. Interviewees state that this has affected the overall orientation of their research and led to scientific development.

Beneficiaries are enthusiastic about the fact that SSF's grants are large and long-term (the Mobility programme being the exception), which provides a degree of freedom and peace of mind that makes it possible to develop a coherent research agenda. Without an SSF grant, they would have had to live with a shorter planning horizon constantly applying for smaller grants, thus taking time from research.

Interviewees, survey respondents and project final reports suggest that some of the projects have yielded very significant scientific results that belong at the international forefront. While much of this empirical testimony is not necessarily objective, the final reports of several SFCs refer to bibliometric studies that they have carried out themselves. For example, the Centre for Infectious Medicine (CIM) at KI reports that the average impact factor for the centre's publications published in 2003–2007 was 6.0, compared with 3.3 for all of KI's publications. Another example is Umeå Plant Science Centre at the Swedish University of Agricultural Science (SLU)/UmU (the Developmental Biology of Plants project), which states that the average impact factor of the centre's publications had increased from 4 to 6. Some of the projects in the SFC programme were led by consortia that already were world-leading, and the SSF grant enabled them further to reinforce their positions. The FFL programme has given promising young researchers the opportunity to establish their research careers and in the process build their own research groups. The Framework grants have funded some state-of-the-art research that has shown great potential for commercial implementation.

Large-scale prestigious grants from the SFC and FFL programmes are means to build capacity and to conduct internationally competitive research, and such grants are often levers in beneficiaries' careers. Several interviewees explained that they are either managing or part of well-funded research groups. They said that the SSF grant has made it easier to get additional research grants and that it has attracted industry co-funding.

3.2 Organisational impact

3.2.1 Beneficiaries

The vast majority of beneficiaries have experienced positive impact on their organisations as a result of the SSF grant. The organisational impact primarily concerns universities, as the majority of beneficiaries work in academia. Interviewees believe that their success adds prestige to the organisation they belong to, as universities benefit from having researchers that attract prestigious grants, are engaged in strategic issues and conduct innovative research. SSF grants in general and in the FFL programme in specific, are said to be larger, longer and more focused on strategic issues compared with grants from other funding agencies. In the long run, prestige and good reputation are believed to improve universities' abilities to further attract external funding. Some interviewees lament that the generous SSF grants also yield universities substantial overhead income.

Most survey respondents state that their SSF grant was used to conduct research of the highest international class that was both relevant to industry and interdisciplinary in character, see Figure 9. The grant was used to recruit graduate students and post-docs, and in the SFC and Framework grant programmes to co-fund personnel already employed. Beneficiaries of the SFC and, to a lesser extent, FFL programmes also state that the grant was used to recruit senior researchers. Unsurprisingly, respondents from

the Mobility programme stand out in most respects given the specific objective of the programme, notably in terms of mobility and industrial relevance.

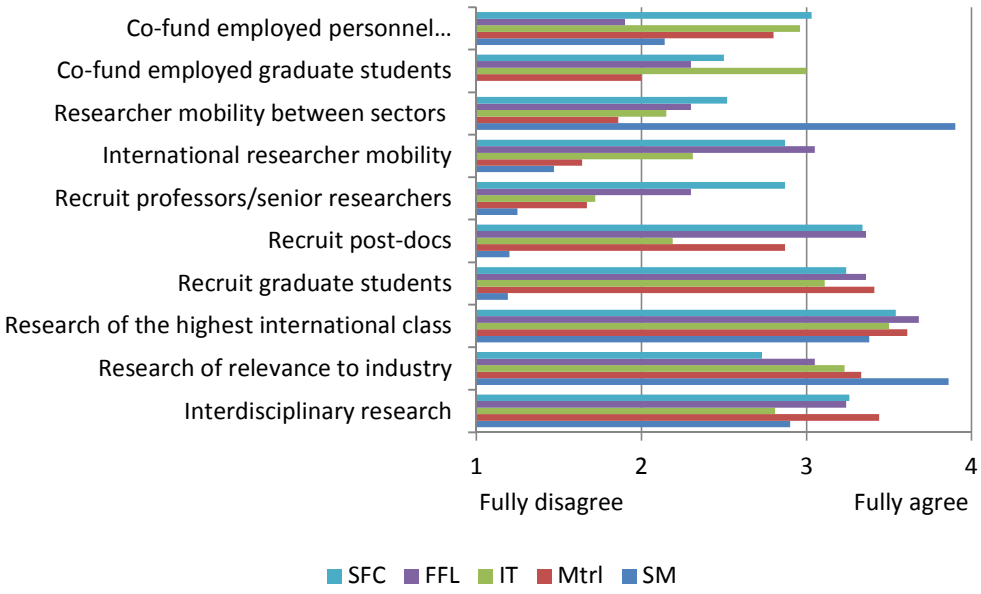

Figure 9 Use of SSF grant. Truncated statement ends "...other than graduate students". Source: Web survey.

For all programmes but Mobility, almost all beneficiaries agree or fully agree that their research group had achieved critical mass through the SSF grant, with a particularly strong agreement from FFL beneficiaries, see Figure 10. That the agreement is lower for beneficiaries of the Mobility programme seems reasonable, since grants are much smaller than in other programmes and focus on one individual's mobility. The somewhat lower ranking for the SFC programme concerning collaboration and durable relationships with companies follows from that fact that a large majority of the activities were collaboration between research groups in universities or RTOs.

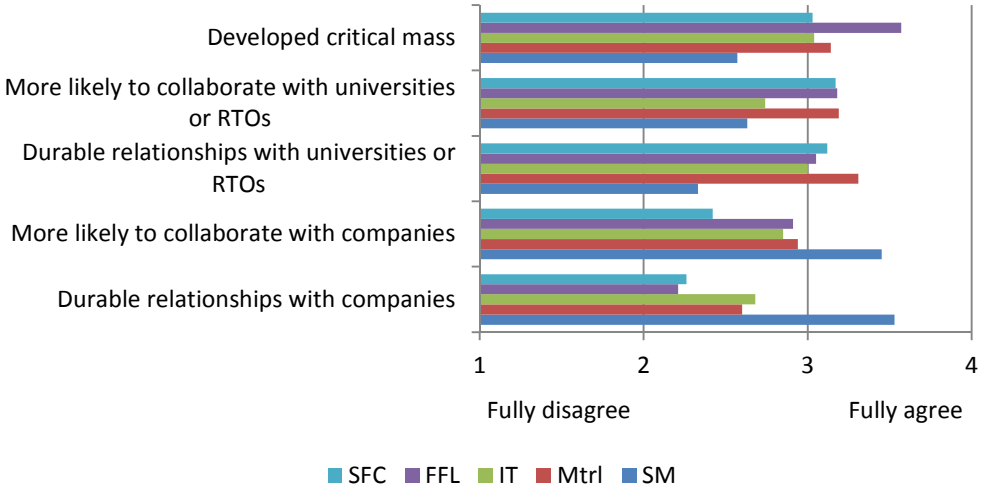

Figure 10 Impact of SSF grant. Source: Web survey.

Several beneficiaries explained that the grants provided the means to employ world-leading researchers and experts, as well as PhD students and post-doctoral researchers.

In some cases, the prestige that an SSF grant implies attracted new researchers to the organisations. This is especially evident for SFCs that received large grants and already were, or became, renowned for ground breaking research. Some interviewees believe that their group will maintain critical mass, since the collaboration networks established in their project continue to expand and reinforce their group. We return to the networking aspects of Figure 10 in Section 3.3.

Projects have generated a wide interest from researchers outside the immediate research group but still within the beneficiaries' own organisations. One example is from a Mobility project, where an industry researcher conducting research in a university noticed that more people within his own organisation had become interested in participating in the continuation of the project. This had led to further potential for building critical mass, as well as improved internal relations within his organisation.

Some projects have provided opportunities for improved working methods within the participating organisations. In some cases, new tools have been generated. One FFL project resulted in a collaboration agreement between a university and an RTO, which has led to the two organisations now working closely together and even sharing facilities.

Interviewees explain that the leadership course of the FFL programme not only benefits the beneficiary (which we will return to in Section 3.5), but the beneficiary's improved leadership skills also benefit the research group and organisation at large.

Many projects have given rise to new postgraduate courses. Research results have contributed to the constantly ongoing process of updating existing courses, and have resulted in new courses specifically targeting PhD students active in the SSF funded projects. There is also an example of an SSF grant having had a structural impact on education. The Centre for Autonomous Systems (CAS) at KTH was awarded its first grant from the Foundation in 1996. Later on, the centre received continued funding through the IT programme in 2001, and has for over a decade been the hub for research and education in robotics at KTH. The university's masters programme in robotics is now coordinated by CAS.

3.2.2 Non-beneficiaries

Figure 11 shows non-beneficiaries' survey responses regarding the impact of not receiving an SSF grant. They largely agree that it constituted a lost opportunity for the group to develop critical mass and to strengthen its international competitiveness. In fact, very few respondents believe that not receiving a grant did not constitute a significant loss in all these respects. The survey responses show no notable differences among the programmes studied.

Non-beneficiaries interviewed nevertheless claim that not receiving an SSF grant has not had any long-term detrimental impact on their research groups or organisations. It seems as if most non-beneficiaries have been able to fund their research by other means, but the SSF rejection delayed the research groups' development. Some interviewees did not see any impact at all on their organisation, as they had managed to obtain funding from other funding sources, and sometimes through other SSF calls. We return to sources of alternative funding in Section 3.4.

One interviewee who had great hopes of receiving funding had to lay off employees when the SSF proposal was rejected. This led to a "short-term crisis" for the research centre until alternative funding could be secured from another funding body. Another interviewee had plans to build a research group, but was not able to employ researchers until funding was secured, which somewhat delayed the group's development.

Some interviewees, who eventually received funding from sources other than SSF, argue that an SSF grant would have provided the research group with more freedom to pursue certain scientific topics. Others feel that they missed out on the possibility for long-term planning of their research and establishment of a research group, since this is more difficult with grants from other sources that typically have more short-term foci.

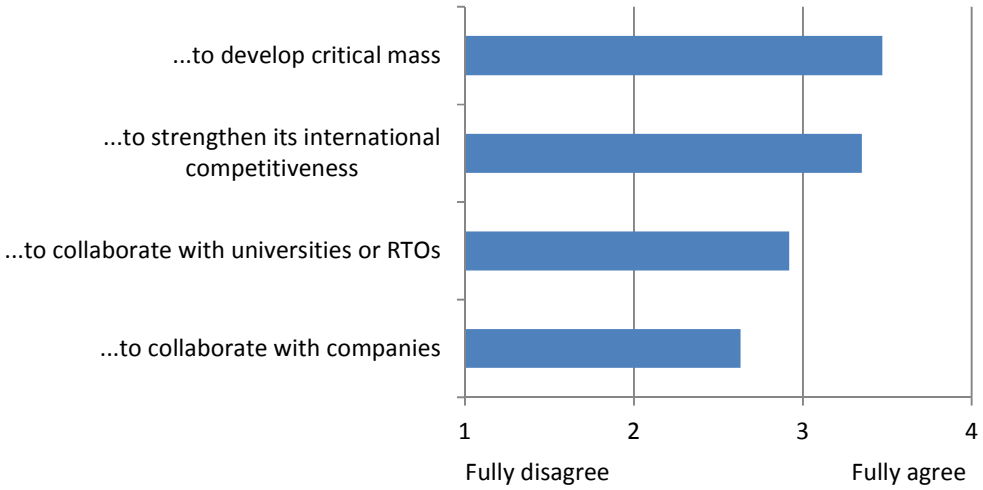

Figure 11 Impact on non-beneficiaries' research groups. Statements begin with "The fact that you did not receive a grant from SSF constituted a lost opportunity for your research group..." Source: Web survey.

3.3 Impact on networks

In the calls for proposals of the programmes studied, the proposers' existing networks and previous collaborations have, in some shape or form, been an assessment criterion. The one exception is the call for proposals for SFCs, where networks were not assessed.

If we now return to Figure 10, we see that beneficiaries judge that their groups have become more likely to collaborate and establish durable relationships with universities or RTOs. Many respondents also agree with the statement that the projects have contributed to the research groups having become more likely to collaborate with companies. The Mobility programme stands out from the others in that respondents strongly agree that the SSF grant has contributed to collaboration and durable relationships with companies, which seems like a reasonable impact of this inter-sectoral programme. Several beneficiaries point out that the grant has provided a valuable opportunity for close and long-term collaboration between academia and industry, which is hard to realise with other types of grants. In the survey, one recipient commented:

> *This project has provided a "success story", where we can show that close academia/industry collaboration is possible with an individual spending time in the other organisation.*

As can be seen from Figure 12, collaboration within the SSF projects has primarily involved universities, both foreign and Swedish, and Swedish companies. However, it is obvious that collaboration patterns vary between programmes. Beneficiaries of the SFC and FFL programmes indicate that foreign universities were their main collaborators, whereas beneficiaries of the other programmes state that Swedish companies were their main partners. Perhaps this may be explained by projects in the IT and Materials programmes being closer to implementation and therefore of greater interest to industry.

Most beneficiaries of all five programmes interviewed appear to have experienced that new networks have been created, that existing networks have been extended and strengthened, and that new opportunities for collaboration have emerged. However, the prerequisites for network building are, to some extent, linked to the size and composition of the beneficiary's research group, and the type of research conducted, and some beneficiaries have not experienced extended networks as a result of the project. Small research projects do not necessarily include opportunities for

collaboration, and research groups that conduct basic research typically do not involve industry actors in their work. Researchers who entered a new field when embarking on the project, found it difficult to locate partners interested in participating in the project. Other interviewed beneficiaries state that the project did not have a direct impact on their own network, but enabled them to bring their existing network into the research work, which in turn enriched other group members' networks.

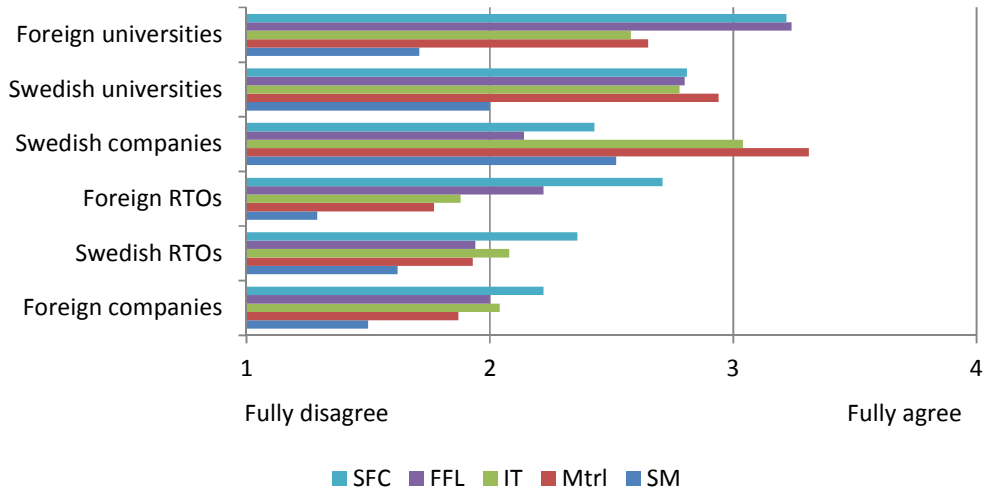

Figure 12 The extent to which the SSF project involved research in collaboration with different types of actors. Source: Web survey.

Several interviewees said that expanded networks and increased collaboration were among the expected outcomes. Moreover, they consider this a result of a deliberate strategy, rather than an unexpected bonus. Sometimes, networking activities imply staying in touch with former PhD students who have moved on to other organisations, and thus may be future collaboration partners. In some projects, beneficiaries have been affiliated with research groups at different universities, which has encouraged collaboration and networking between these groups. Other interviewees relate that they have actively reached out to companies with whom collaboration might be beneficial.

Interviewees explain that collaboration between universities generally comprises co-publication with colleagues at other institutions, exchange of PhD students and post-docs that conduct research at other institutions, accommodating visiting PhD students and inviting foreign guest lecturers. Some beneficiaries have come to collaborate with other SSF beneficiaries as part of their projects.

Industry collaboration takes place in different forms. In the SFC and FFL programmes, collaboration is mainly with large companies, and several interviewees relate that collaboration was initiated by companies contacting them since they belonged to an established and successful research group. Hence, some beneficiaries see a direct link between funding and network building; you are more attractive as a collaboration partner when you have funding. In the Mobility programme, industry collaboration is inherent through inter-sectoral mobility of a researcher.

In many cases, collaboration networks have survived project completion. As new projects are often established based on previous projects, networks can be maintained and cultivated, and some research groups claim to be stronger today than during the SSF project. Others have established collaboration with new partners during the SSF project, with whom they have since initiated new projects. Taking SFCs as an example, one research group initiated collaboration with a university hospital as part of the SSF project, and this relationship has since developed into collaboration with the Stockholm County Council, as well as with Swedish and foreign pharmaceutical companies.

3.4 Funding of subsequent research

3.4.1 Beneficiaries

More than 80 per cent of survey respondents from all programmes agree that research results from the SSF projects have already been used in subsequent research projects. The dominant funding organisations for such subsequent projects are presented in Figure 13.

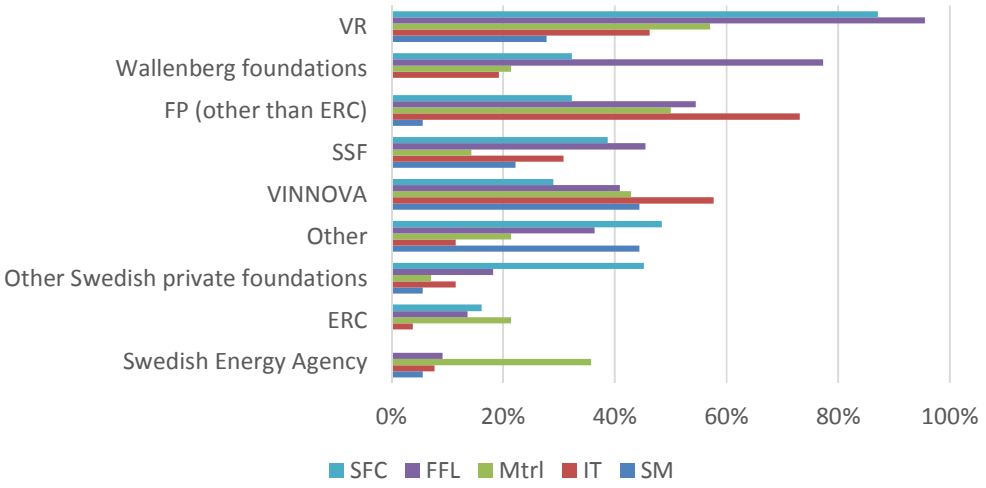

Figure 13 Most common funding organisations for subsequent research projects. "Other" refers to other sources than Swedish private foundations. Source: Web survey.

VR is obviously the most important source of funding for past beneficiaries of the FFL, SFC and Materials programmes, and 77 per cent of the past FFL beneficiaries have also received funding from the (private) Wallenberg Foundations. The FP (excluding the European Research Council, ERC) has proved an important source of funding for all but past Mobility beneficiaries, and VINNOVA and SSF are also recurring sources of funding. For past IT beneficiaries, the FP and VINNOVA have proved more important than other sources. The "other Swedish private foundations" that are so important to past SFC beneficiaries are dominated by the Swedish Cancer Society (a charity).

Interviewees explain that the SFC projects have resulted in a large number of FP projects, where the past SSF beneficiaries participate as both partners and coordinators. Some of the SFCs have lived on thanks to prestigious ten-year Linnaeus grants from VR. FFL beneficiaries clarify that the SSF funding provided them with the means to identify new research areas and to develop their own research agendas, which has facilitated establishment of new research centres. According to one FFL beneficiary, the grant fuelled other parallel projects rather than leading to subsequent ones; since the grant gave latitude, it was used to co-fund projects with more restricted funding, such as FP projects.

3.4.2 Non-beneficiaries

Seventy per cent of the non-beneficiaries have managed to secure funding for the proposed project (or parts of it) from another funding source, and some have also been successful in subsequent SSF calls. Their main funding sources have been VR, VINNOVA, the FP and Swedish private foundations. Nevertheless, the SSF rejection did affect the size and scope of the project and it notably delayed research progress; more than 60 per cent of non-beneficiaries state that the rejection did indeed constitute a lost opportunity to develop the research group's critical mass, to build networks or to increase the group's international competitiveness (cf. Figure 11). Thus, most non-beneficiaries appear to have fared well even without SSF funding, and we have

encountered several examples of individuals who have obtained both nationally and internationally prestigious grants, e.g. Linnaeus grants from VR, Advanced Grants from the ERC and private funding from for example Google.

3.5 Personal development and career prospects

3.5.1 Beneficiaries

Receiving a grant from SSF has had positive impact on beneficiaries' personal development and career prospects. Grants have had similar impact on the beneficiaries' colleagues in the same research group. This is not only the case for group grants, but also for individual grants, such as the FFL programme.

Survey respondents were asked to describe the impact of the SSF grant on their personal development, see Figure 14. Obviously, respondents have a very positive view of the influence of the SSF grant, but the beneficiaries of the FFL programme are consistently the most positive. Mobility beneficiaries are the second most positive when it comes to strengthened CV, career boost and enhanced research abilities. Perhaps this is because a Mobility grant for many beneficiaries entailed an experience out of the ordinary (a temporary change of scenery that resulted in a career boost?), whereas SFC, Materials and IT grants meant "business as usual" for most beneficiaries – although some of them have also experienced noteworthy career boosts.

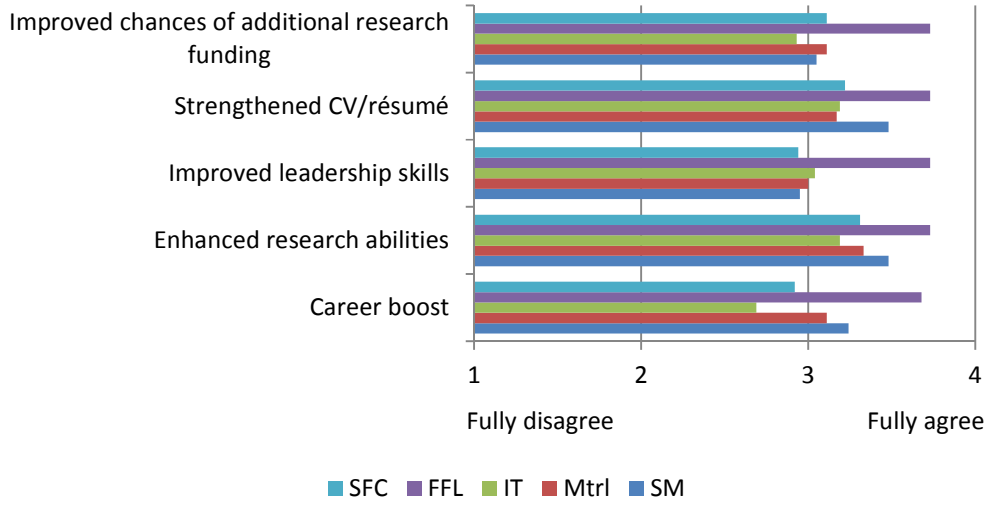

Figure 14 Personal significance of SSF grants according to the beneficiaries. Source: Web survey.

As already discussed in Section 3.4, receiving an SSF grant clearly improves the chances of being awarded additional funding. Many beneficiaries state that one good thing has led to another, and that they have received other large grants, partly as a result of the SSF grant. This, in turn, has boosted their research careers.

As expected, the career boost and personal development are greater for less experienced and less established researchers. Those who were already well-established senior researchers when they received the SSF grant express how the grant may not have affected their own careers, but certainly that of younger colleagues, including postgraduate students. One interviewee said:

> *I was already a senior researcher in the field with a strong track record. The project has been good, but not crucial for my career. It has, however, been important for the junior staff in the project and boosted their careers.*

Says another interviewee:

> *My career was unaffected, but the careers of the co-PIs have been affected in a very positive way.*

Indeed, both interviews and free-text comments in the survey indicate that the lower assessments shown in Figure 14 may be due to the fact that beneficiaries were already established researchers, rather than there being something wrong with the SSF grants.

Figure 14 also illustrates that the SSF grants have contributed to improved management skills for beneficiaries. Recipients describe how they were promoted to leading positions and higher academic titles as a direct and tangible impact of their SSF grants. Two different individuals comment:

> *I went from junior researcher to Professor and Head of research division.*

> *The supervision of seven PhD students in a short time span has been a major boost of my skills as manager and research leader.*

Several beneficiaries, especially of the FFL programme, consider the SSF grant to be an award in itself. They feel honoured to belong to the selected few, who were assessed to be the top eight per cent of all proposers.

There are numerous other examples of prominent awards and prizes received by beneficiaries, such as the Marcus Wallenberg Prize, Wallenberg Scholars, the Göran Gustafsson prize, the Distinguished Professor Award (KI), Anders Jahre's Award for young researchers in the Nordic countries, King Carl XVI Gustaf 50th Anniversary Fund for Science, Technology and the Environment, the Jan-Eric Sundgren Award, the Fernströms prize and the IEEE (Institute of Electrical and Electronics Engineers) Fellow of the Institute of Electrical and Electronics Engineers. One interviewee recounts:

> *The project helped me to establish myself as a leading researcher nationally in the area of information and communication technology. [...] In addition, my own contributions in a number of publications (over 400 journal and conference papers) and their quality (several best paper awards and IEEE Fellow) have reached the very top international level. I regularly give plenary talks and chair major events.*

There are also examples of impact in terms of geographical mobility. Some beneficiaries state that the SSF grant was more or less crucial for them to remain in, or come back to, Sweden and continue their research. One beneficiary says:

> *The FFL grant was the single most important factor in making me both return to Sweden and to academic research. It provided a solid foundation for receiving additional external funding. The leadership programme taught me a lot and enabled me to rapidly connect with the Swedish research community after a long stay abroad.*

Only a couple of interviewees and survey respondents state that the SSF grants did not affect their personal development or career opportunities. One survey respondent laments:

> *The host university does not recognise receiving the SSF grant as a reason for career promotion.*

3.5.2 Non-beneficiaries

We also asked non-beneficiaries to describe if, and how, the rejection affected their career and personal development. A significantly slower scientific development is mentioned as the main consequence. Some describe SSF's rejection as "devastating" and "a mental blow". The rejection was particularly hard for those who made it to a second assessment round and then were rejected. Some rejected proposers believe that a grant from SSF probably would have meant a greater scientific freedom, and others experienced being left behind in scientific development by colleagues within the same

area. One of the rejected proposers was about to evolve from a young researcher to a more senior position when applying for the SSF grant. In retrospect, he thinks the rejection was a significant disadvantage in his future career.

There are also examples of impact in terms of geographical mobility. Some non-beneficiaries decided to leave Sweden to take up an academic position abroad, where they successfully developed their research careers.

3.6 Productivity and international visibility

3.6.1 Background to bibliometric analyses

In the bibliographical data collection we have sought to reconstruct the publication histories of beneficiaries of FFL2, SFC, IT and Materials programmes. For the FFL programme, we have also included a group of 18 rejected proposers (non-beneficiaries) who were just below the funding threshold. This approach resembles that used in the evaluation of the first call of the FFL programme (INGVAR), FFL1.[28] The source of the bibliographical data is the Elsevier Scopus database, meaning that publications that are not listed in the database are not included in the analyses. A handful of individuals were not found in the database.

In order to retrieve each researcher's publications from the database, we applied a two-stage search strategy. First, we used a query containing the name of individuals in combination with their known affiliation. Next, all publications related to (i.e. authored or co-authored by) each individual were grouped using the Scopus Author Identifier.[29] We manually corrected for the obvious cases where individuals have multiple "identities" in Scopus.

Publication records were retrieved for the five years preceding the SSF grant, and the five years subsequent to the end of the project. For the FFL programme the time periods were four years at each end, since it ended so recently that five years has not yet passed. For the FFL programme, beneficiaries were compared, person by person, before and after they received the grant. For the other programmes, the main proposers and co-proposers of each project were grouped to form data sets consisting of between one and twelve researchers. These grouped data sets were then compared, before and after the project period, meaning that the before and after data sets comprise the same researchers.

Two aspects of the researchers' publication behaviour were analysed using bibliometric indicators, namely productivity and share of publications with foreign co-authors, as a proxy indicator of international visibility. For the productivity indicator, fractional counts were calculated to eliminate the risk of counting co-authored publications several times. When calculating fractional counts an author is attributed a fraction of a publication, and the size of the fraction depends on the number of authors of the publication; for instance, if a publication has three authors, then each author is credited one third of the publication's authorship.

3.6.2 Publication productivity

Both the beneficiaries and non-beneficiaries of the FFL programme were all active during the four years following the project period (and, of course, during the four years before the grant). Figure 15 shows a box plot of the median value of the number of publications (in fractions) for both beneficiaries and non-beneficiaries (indicated by the

[28] G. Melin and R. Danell, "The top eight percent: development of approved and rejected applicants for a prestigious grant in Sweden", *Science and Public Policy*, vol. 33(10), 702–712, 2006.

[29] The Scopus Author Identifier distinguishes between authors that have similar names by assigning each author in Scopus a unique number and grouping together all of the documents (co-)authored by that individual.

horizontal line inside the box), and the interquartile range (IQR)[30] representing the "middle fifty" per cent, i.e. the spread of the upper and the lower quartiles (indicated by the height of the box). The "error bars" indicate the least and most productive researcher, respectively. (These are not necessarily the same individuals before and after.) The figure illustrates that the median value for the beneficiaries, i.e. the publication productivity, increased from 5.7 to 7.5 between the two periods. The figure also shows that the increase in productivity is very unevenly distributed; some researchers' productivity increased much more than that of others.

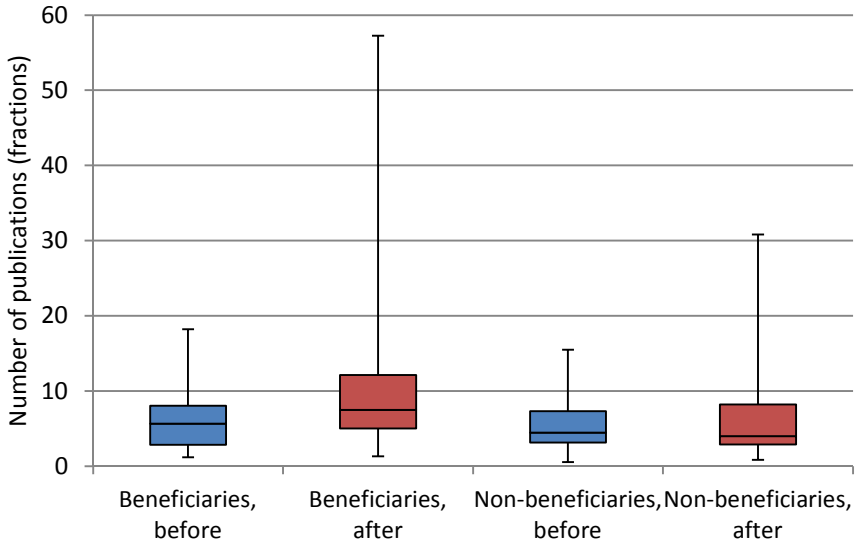

Figure 15 Publication productivity for beneficiaries and non-beneficiaries of FFL2. Source: Scopus database.

To put this increase in perspective, the figure indicates that the median productivity of the non-beneficiaries actually decreased slightly. Also for this group the individual variation increased, but to a lesser extent.

The variation between the least and most productive researchers is obviously quite substantial, and the variation in both groups increases with time. The productivity of beneficiaries during the four years following the grant is obviously highly skewed, and only two individuals have a count exceeding 15 (37 and 57 fractional publications respectively).

Figure 16 shows the publication productivity of the research groups that received Framework grants in IT and Materials science. Given the difference in research areas, no comparisons between programmes should be made. Instead, what is interesting is the relative development of the research groups funded by the programmes. In order to take variations in group size into account, we have divided the number of publications by the number of individuals of each group to get an average number of publications per individual. The figure illustrates that the researchers in the IT programme increased their productivity over time; the median increased from 4.5 to 7.4, and the IQR moved upwards. The most productive group increased the productivity per individual from 8.3 to 31. For the researchers in the Materials programme, the median decreased and the IQR narrowed.

In both programmes the IQR narrowed, indicating that the middle fifty per cent have become more similar. At the same time, the variation between the least and most

[30] Interquartile range is an indicator of statistical dispersion that represents the range between the upper 75 and the lower 25 per cent.

productive groups increased considerably in the IT programme. However, this is mostly the result of one single group outperforming the others by a wide margin.

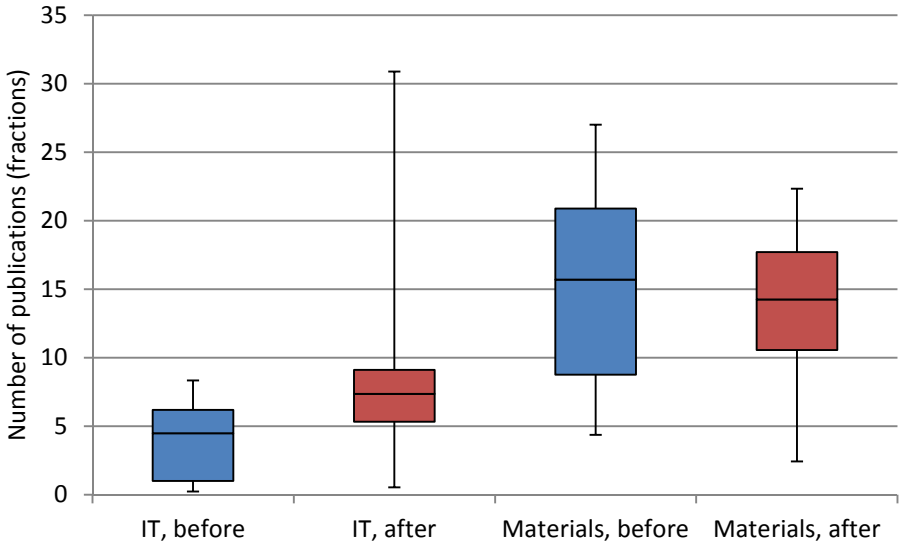

Figure 16 Publication productivity for individual researchers funded by the Framework grant programmes. Source: Scopus database.

The SFC programme funded larger and fewer groups compared with the Framework grant programmes, and the data sets consist of groups of between four and twelve individuals. As for the Framework grant programmes, the number of publications for each group has been divided by the number of researchers, creating an average number of publications per individual.

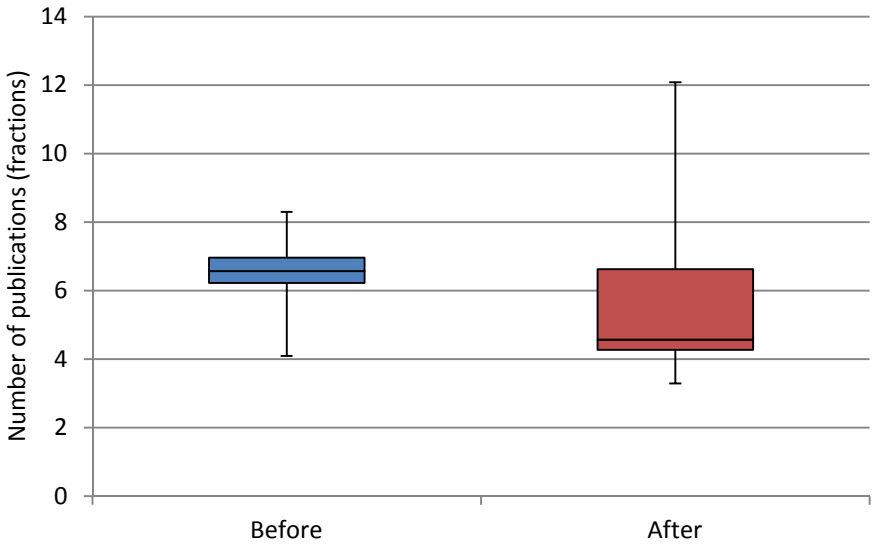

Figure 17 Publication productivity for individual researchers funded by the SFC programme. Source: Scopus database.

Figure 17 illustrates that the publication productivity of the groups funded by the SFC programme decreased from 6.6 before the SSF grant to 4.6 after, while the IQR increased and moved downwards. However, the difference between the least and most

productive groups increases, meaning that they have become more disparate in terms of publication productivity.

3.6.3 International visibility

The share of internationally co-authored publications has been analysed for individual beneficiaries and non-beneficiaries of the FFL programme, as well as for research groups funded through the Framework grants and SFC programmes.[31]

Table 2 shows that the average share of internationally co-authored publications varies notably between programmes. The FFL beneficiaries had the highest share, followed by SFC and FFL non-beneficiaries, before the grant. Interestingly, beneficiaries and non-beneficiaries have almost the same share of internationally co-authored publications during the period following the grant, meaning that the non-beneficiaries increased even more in this regard (although there are considerable variations between individuals). The table also reveals that international co-authoring of the groups funded by the other programmes on average has increased, particularly for SFC beneficiaries.

Table 2 Average share of internationally co-authored publications per programme. Source: Scopus database.

	Before	Standard deviation	After	Standard deviation
FFL beneficiaries	48%	22pp	56%	18pp
FFL non-beneficiaries	39%	21pp	53%	26pp
IT beneficiaries	24%	14pp	39%	13pp
Materials science beneficiaries	30%	16pp	39%	22pp
SFC beneficiaries	44%	10pp	61%	6pp

These developments should be seen in the light of a general increase in international co-authoring, particularly for researchers based in small countries. One study found that the share of Sweden-based researchers' scientific publications in medicine, natural sciences and engineering that had foreign co-authors increased to 51 per cent for the period 2004–2008 from 37 per cent ten years earlier.[32]

3.6.4 Concluding assessments

The second call of the FFL programme, FFL2, seems to have funded some already very productive researchers. The change we see in the four years subsequent to the grant testifies that these individuals have become more productive and visible in an international context. Of course, the increase in productivity for the beneficiaries cannot entirely be attributed to the SSF grant; to some extent it is the result of these researchers in general becoming more established and productive with time. The group of FFL non-beneficiaries is somewhat more scattered; some have increased their productivity while others have not. However, the non-beneficiaries' share of internationally co-authored articles has increased considerably, even more than for the FFL beneficiaries. In short, both beneficiaries and non-beneficiaries of the FFL programme have fared quite well. This result concurs with the findings of a study of FFL1.[33] The result implies that the two groups were just as capable, and that the main difference between them is that one

[31] The definition of an internationally co-authored publication is where at least two authors have affiliations in different countries.

[32] J. Fröberg, P. Hyenstrand, U. Kaby, S. Karlsson, U. Kronman and J. Lundberg, "Nationella analyser, underlag för strategiprojektet Svensk forskning 2010-2030", VR, 2010.

[33] G. Melin and R. Danell, "The top eight percent: development of approved and rejected applicants for a prestigious grant in Sweden", *Science and Public Policy*, vol. 33(10), 702–712, 2006.

group was funded through the FFL programme, and the other was funded through other grants.

For the Framework grants the results are mixed. Almost all groups funded through the IT programme increased their publication productivity, whereas most groups funded through the Materials programme show a negative trend (that on the whole is weak). While both IT and Materials groups remain less internationally visible than other SSF beneficiaries, the increase in international co-publications is quite substantial for IT beneficiaries. One reason for the difference in trends is likely to be that the groups were active in fundamentally different subject areas. At the beginning of the 2000s, when the projects started, Materials science was a more a mature research area than IT, in which many new technologies and applications emerged. Several beneficiaries of the IT programme have also stated that they were quite junior when receiving the grant or that they addressed new research areas in their projects, whereas some beneficiaries of the Materials programme point out that they already were quite established. Thus, the IT researchers' increased productivity should be seen as taking place at a time when IT research in both academia and industry was evolving rapidly. In contrast, in the more mature Materials science area, developments may have been more incremental in nature.

The development for the SFC beneficiaries seems to suggest that the groups' publication productivity stagnated, at least for some groups. However, the increase in internationally co-authored publications is quite substantial and is at the highest level of all programmes. We know from interviews with SFC project leaders that the centres evolved differently. Some of the centres utilised the SFC grant to develop new research topics or to continue research in clinical environments, which enabled them to continue to flourish. For other centres, the research did not materialise into industrial or clinical applications, but the research work continues and it is highly visible in an international context.

3.7 Competitiveness

By and large, SSF beneficiaries are convinced that the project has contributed to a lasting strengthening of the international competitiveness of their own research group and of other research groups funded by the project (co-proposers), see Figure 18. The figure also shows that beneficiaries are less confident that this is also the case for other organisations that participated in the project.

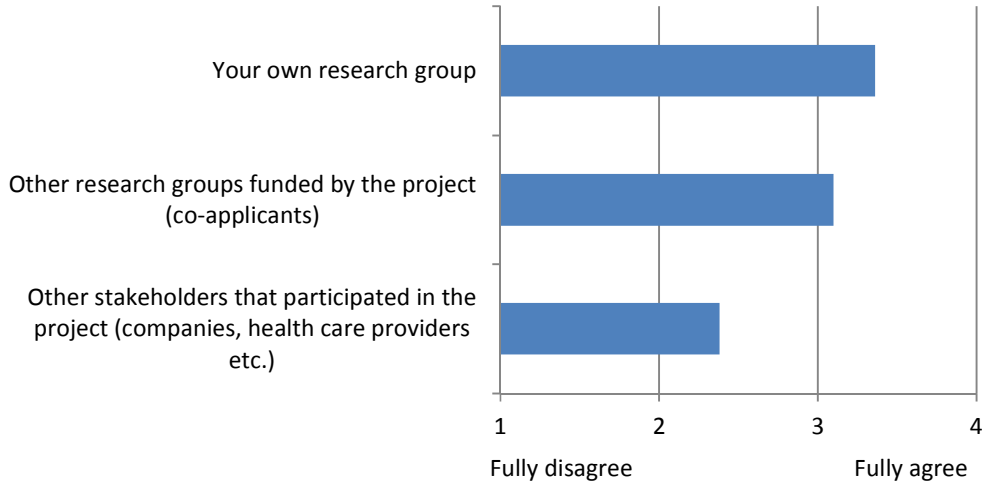

Figure 18 The extent to which the SSF project has contributed to a lasting strengthening of the international competitiveness. Source: web survey.

As discussed above, there are some, albeit sometimes subtle, differences between the five programmes studied in terms of results and impact. However, when it comes to international competitiveness and achievements connected with that, there are significant similarities between instruments, as becomes evident from our interviews.

Almost without exception, interviewees refer to how expertise and knowledge is created within their research field. Knowledge gained differs between programmes and shows great variation, from scientific results and improved methods to completely new perspectives in research. For Mobility beneficiaries, new knowledge is primarily related to their inter-sectoral experiences, e.g. improved understanding of how research questions are approached and how scientific results are implemented in industry and academia, respectively. In the other programmes studied, the significant achievements made and research results obtained are often realised through the experience of setting up a research group, expanded networks of other researchers and organisations, and acquiring leadership skills. In addition to impact on both the organisations and their networks, the production of scientifically useful knowledge laid the foundation for international co-operation, and if all else goes well eventually to the establishment of a strong research group.[34] The university's competitiveness is generally strengthened in terms of human capital, and capability to receive grants and to co-operate internationally.

Researchers and universities find themselves in better bargaining positions when they have secured a major grant, as potential industry partners then see them as more reliable, long-term partners. Mutually relevant research agendas build on a shared understanding, which is a prerequisite for solid, sustainable collaboration and reciprocity, in the sense of a balance in terms and conditions. Furthermore, a major grant makes it possible to set up special facilities, such as a laboratory, database or other forms of research infrastructure, for conducting the research.

On an individual level, beneficiaries have experienced increased competitiveness and great personal satisfaction, as already discussed in Section 3.5.

All in all, there are reasonable grounds to describe a virtuous cycle that started with the initial recognition of the individual researcher and/or the research results previously produced, in the form an SSF grants won in fierce competition. Especially for a young, this facilitated an early establishment of a personal research agenda, including at least some time and resources for high-risk research. As mentioned in Section 3.2, the SSF grant made it possible to recruit additional researchers, including senior ones, which helped to build up critical mass and competitiveness.[35] The group then attracted even more funding, including grants from the FP, making it possible to recruit complementary skills, and the group's success rubbed off on research partners and in some instances neighbouring laboratories. In some cases, this even led to the development of a world-leading research centre, where the research stands up extremely well in an international perspective, and where the results have been published in the best scientific journals. The knowledge produced has been implemented, both clinically and through patents, companies have been started etc. The centre has been held up as a role model, also for other environments in other areas. Several of the individual researchers have had a lot of funding from EU framework programmes, some a little less, depending on the direction of research. They have also been part of other international efforts, not least through National Institutes of Health in the USA, in collaboration with US laboratories. There are also examples where technology and concepts developed in collaborative efforts in one sector, e.g. robotics, spread to other sectors, e.g. automotive.

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34 One of the few exceptions from this pattern is the example where research results were transformed into one single, very specific application to develop a process in a manufacturing company. When the problem was solved, no one was really interested in the subject anymore and there will be no more research on the subject, despite it being highly relevant.

35 Some groups have experienced an increase from a handful to tens of researchers in a couple of years.

3.7.1 How SSF has contributed to increased competitiveness

According to beneficiaries, the SSF grant has been important for several reasons. It represented quite a lot of money and permitted a long-term approach. Such grants were quite rare at the time. The grant was not entirely earmarked, but rather flexible in terms of what it could be used for.

Apart from establishing operations, grants were used to make groups collaborate, especially in the SFCs, and to build common technical platforms to facilitate further research. In programmes with a clear focus on collaboration, efforts were also made to recruit internationally, and to establish co-operation with both Swedish and foreign universities, government agencies and companies, in a functional division of labour. This led to substantial collaboration with universities in both Sweden and abroad, and to huge international mobility among the organisations involved. In the SFCs, there was also a deliberate drive to achieve a high post-doc/PhD student ratio, which was seen as an important success factor. This was of course also important for the growth of networks.

Participants describe the approach in the SSF projects as representing a good balance between teamwork and individualism. As noted above, the FFL programme especially, with its management training courses, has helped produce better research leaders and managers. The networks that follow from participation in both national and international projects have proved to be important also after project completion, even if it is possibly going a bit too far to assert that a good contact is "at least as important as good research results", as one interviewee probably somewhat hastily did.

Although industry co-funding has not been a precondition to receive SSF grants, some of the interviewed beneficiaries point to industry funding as good leverage when applying for public funding, both from a networking point of view and since some other public funding agencies have an industry co-funding requirement for awarding grants. Among the researchers for whom this is important, there is an ambition to balance basic and applied research to serve both science and society. Some of these researchers have also learnt not to start too many projects at the same time, since the projects then risk progressing too slowly, and slower than developments in the surrounding world.

Several interviewees make reference to what stands out as an ability to develop effective routines or to establish clear procedures for collaboration with partners as essential for the ability to form strategic alliances. This in turn leads to new constellations of experts, which include the new partners. New groups in the R&D system are thus formed, which have a strong potential to increase their own competitiveness. From the individual researcher's point of view, some of the driving forces at play in the emergence of strong research groups reported by our interviewees are that it is pleasant to be part of such an environment and to see a new generation of researchers develop.

As an illustration of how competitiveness increases, one interviewee somewhat playfully, but still with a degree of seriousness, stated that "when you are young and have no money, no one wants to collaborate". It is clear that having had high-impact publications accepted in high-impact scientific journals accelerates collaboration, and SSF grants helped to support such a development. Being involved in an active and vibrant network also leads to industry representatives becoming familiar with the important issues from just hanging around, which was also made possible by the SSF grants.

3.7.2 Competitiveness and growth as a function of collaboration

As has already been noted, getting an SSF grant is in itself a significant recognition; such are not awarded to just anyone. The award decision was preceded by an extensive review process, and in the case of the FFL programme some criticism was raised against beneficiaries being too well-established when getting the grant, thus being today's research leaders rather than those of the future. Their research activities can then to a fairly large degree be said to consist of already existing ideas and projects that continue in or as other, new projects.

Both growth of groups and development of competitiveness can largely be expected to follow from collaboration, both within and between research groups, rather than just through extensive exploration of promising research ideas. This is also what our interviewees report. The SSF grants have been used for post-docs, both incoming and outgoing, which in several cases have been the start of long-term collaboration with other universities and with companies. There has been a series of visiting scholars, guest teachers etc. and many contacts have been brought into collaboration networks and shared between groups. Grants have been used to bring together established research groups, fund already existing PhD students, and facilitate exchange between principal investigators to establish best practice in their research areas.

The research conducted in the SSF projects produced a platform to bring into subsequent collaborations. Later participation in large projects, including FP projects, can be derived from these SSF projects. Another, alternative path of positive development, is that the SSF grant led to a VINNOVA grant, in which industry collaboration was required. The additional benefits from industry participation in turn led to opportunities to participate in a Nordic network.

4. Results and impact in industry and society

SSF's statutes, cf. Section 2.1, focus on different aspects of quality and competitiveness in research, and are less explicit with respect to long-term impact in industry and society. In the statutes, it is rather the collaboration between academia and industry, and a more or less undefined industry interest, which are highlighted, together with a general reference to inter-sectoral mobility of researchers. In essence, SSF's objectives and activities are similar to those we are accustomed to associate with different forms of accomplishments in academic research.

Nonetheless, the practice developed by the Foundation places more emphasis on industrial relevance than what the statutes suggest. Already in 1993, when the organising committee for SSF's establishment requested proposals for priority areas for SSF, it turned to industry associations, universities and RTOs simultaneously.[36] It was made clear that their proposals were to be brief and not in the form of project proposals, which put the different stakeholder categories on a more equal footing. Moreover, in its monitoring of the programmes of this study, SSF has consistently asked for the beneficiaries' assessments of their projects' impact in industry and society.

4.1 Results and impact on partners and hosts

The web surveys directed to partners and hosts in the Mobility programme show a number of results from participation in SSF projects. In order to get a "clean" group of company respondents, we have filtered out the responses of respondents that do not represent companies (one university and two RTOs). The remaining partner and host respondents are strongly dominated by large companies with more than 250 employees (75 per cent).[37] To start with, Figure 19 depicts different levels of involvement in preparation and implementation of the activities and projects supported by SSF.

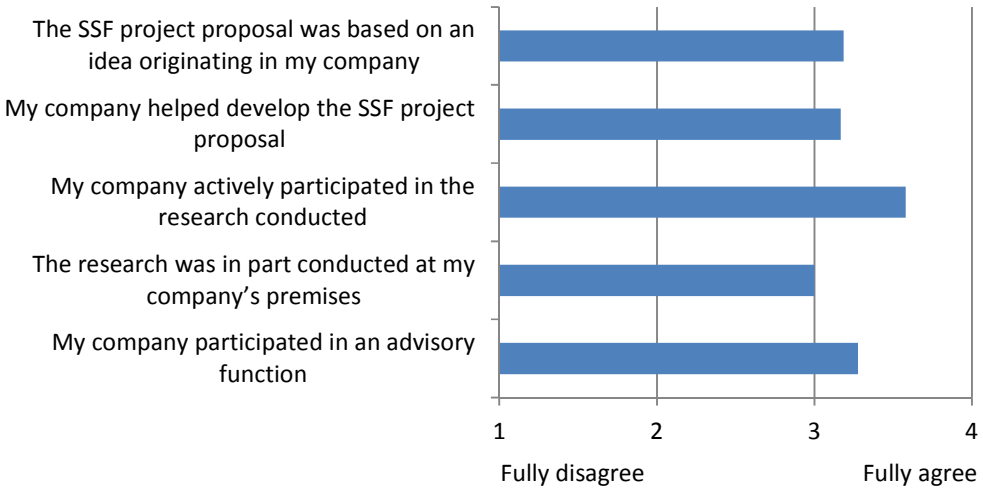

Figure 19 Involvement of partners and hosts in preparation and implementation of projects. Source: Web survey.

[36] T. Fagerström, B. Bentzer, A.-B. Edfast, J. Kangasjärvi and J. Nilsson, "I hur många korgar ska äggen läggas? En jämförelse mellan SSFs satsningar på ett centrum för skogsbioteknik och ett nätverk för växtbioteknik", SSF-rapport nr. 6, SSF, 2008.

[37] Respondent distribution on programme affiliation; Mobility: 45 per cent; SFC: 25 per cent; IT: 20 per cent; Materials: 10 per cent.

From Figure 19 we see that respondents agree quite strongly with all statements, but especially concerning their organisations' active participation in the research conducted and in a reference or advisory function. They also opened up their premises, and helped develop project proposals, which were often even based on an idea or problem originating within the partner or host organisation. These assessments should be interpreted in the light of the fact that we only had access to relatively few addresses to representatives of partners and hosts, meaning that they may have been "core partners", who may be suspected of being more positive and more involved than the average partner or host.

In their characterisation of the activities of the projects, the representatives of partners and hosts rank statements quite high, see Figure 20. The research was thus to a large extent regarded as relevant to industry, it realised mobility between sectors, the research was seen as being of the highest international class, and it was fairly interdisciplinary.

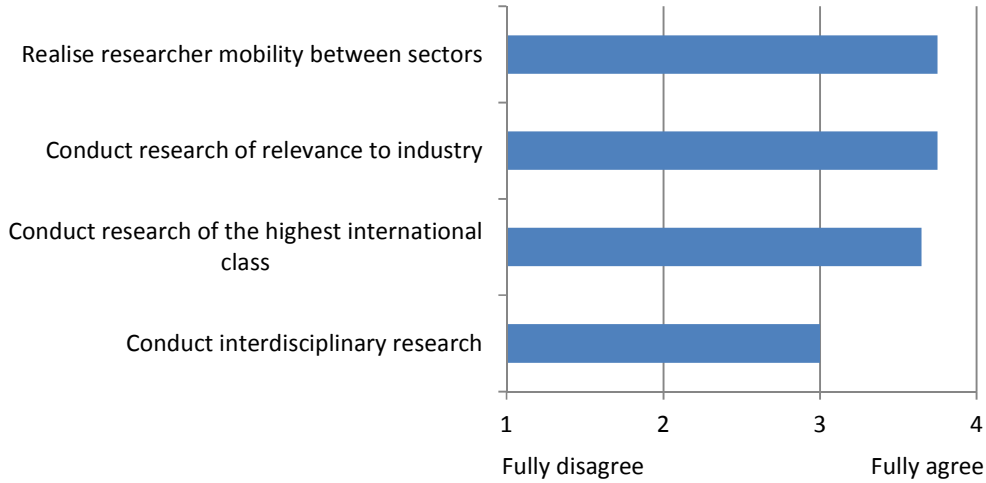

Figure 20 Partner's and host's characterisation of what the SSF grant was used for. Source: Web survey.

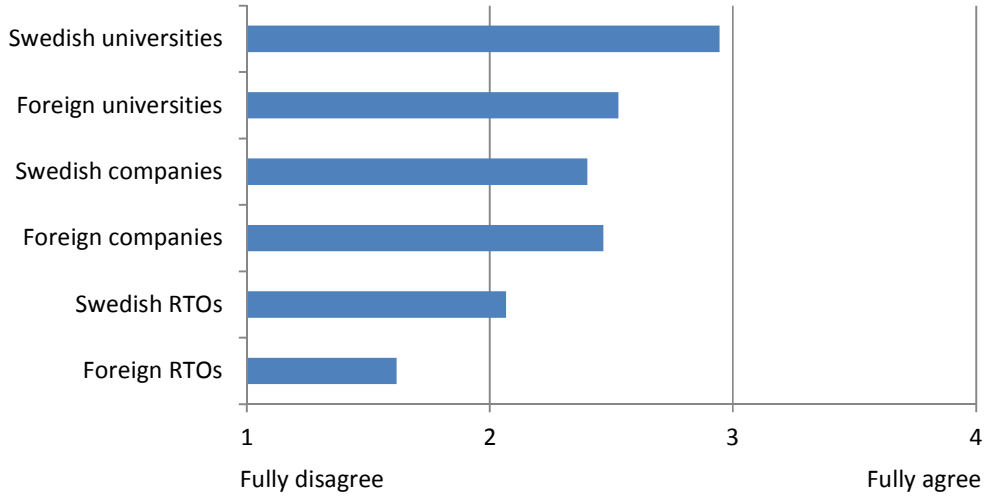

Figure 21 Partner's and host's assessment of collaboration with other organisations. Source: Web survey.

The extent to which projects involved other organisations (than the SSF beneficiary and the respondent's organisation) is shown in Figure 21. There seems to be a hierarchy of collaborating organisations; universities, companies and RTOs, and Swedish rather than foreign ones within each category.

Some of the most important things that partners and hosts get out of the project collaboration are shown in Figure 22. The figure shows that the two most significant benefits have been an expanded network of researchers and access to new knowledge, which is in agreement with what the beneficiaries themselves state. The least common benefits for partners and hosts are patent applications and granted patents, which is also in line with the perceptions of beneficiaries.

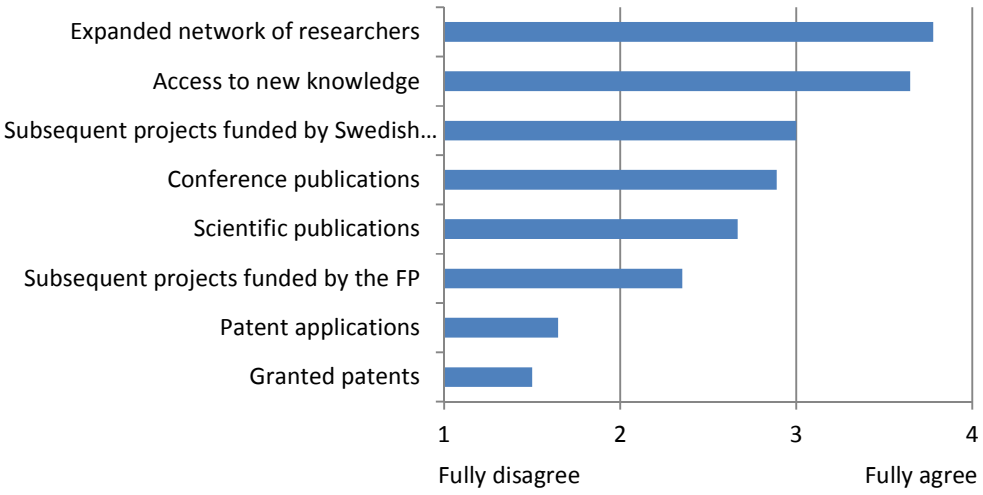

Figure 22 Partners and hosts benefits from project participation. Truncated statement ends "...organisations". Source: Web survey.

Partners and hosts were asked to assess how their relationships to the surrounding world had developed as a result of project participation. The main things that Figure 23 tells us are that partners and hosts have established durable relations with universities or RTOs (dominated by the former), and that participation in SSF projects has increased their international competitiveness. To some extent they have also recruited graduated researchers.

When asked to assess the extent to which research results either had already been used or were expected to be used, partners and hosts settled on a moderately positive assessment for both alternatives (around 3, meaning that they on average agree; not shown). All the same, it is evident from Figure 24 that not much commercial impact has arisen thus far. This is in line with SSF's expectation that impact in industry do take time to materialise. In 2007, the Foundation started mentioning a 5–15 year time span between project conclusion and exploitation in industry in its calls for Framework grants; the time span has recently been reduced to 5–10 years. It should also be noted that a large proportion of respondents (10–40 per cent) chose the "don't know" alternative when assessing these statements, which is a tendency we have seen before; representatives of large companies find it difficult to assess commercial impact of research results on their company.

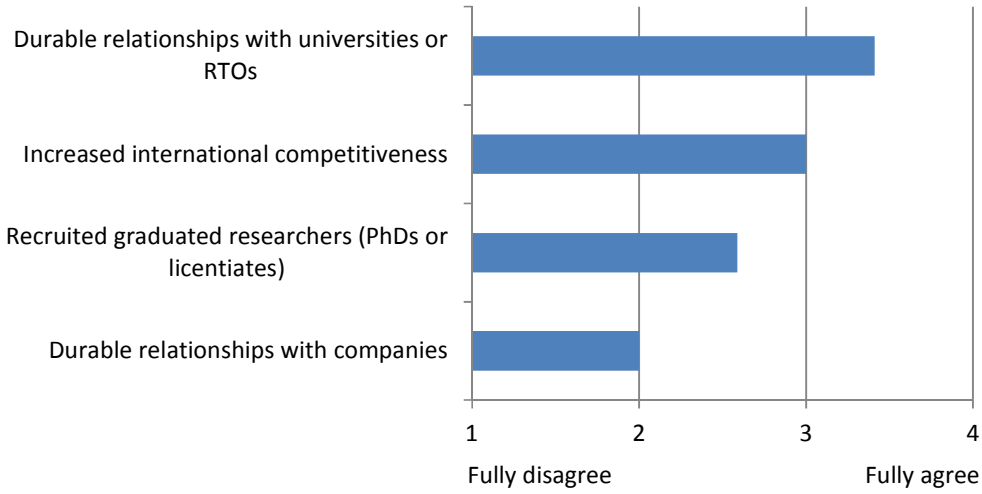

Figure 23 Partners' and hosts' development of relationships from project participation. Source: Web survey.

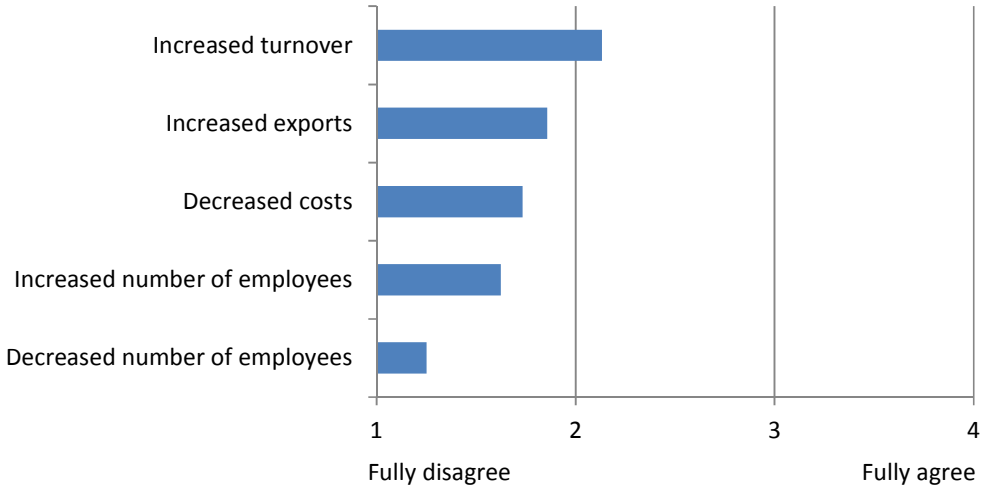

Figure 24 Commercial impact from partners' and hosts' participation in SSF projects. Web survey.

4.2 Research relevant to industry but not yet implemented

We learnt from Figure 23 that partners and hosts mainly have established durable relationships with universities and RTOs, and increased their competitiveness as a result of their participation in SSF projects. To a lesser extent, participation has led to partners and hosts recruiting graduated researchers, or to them establishing durable relationships with companies. At the same time, Figure 18 showed that grant beneficiaries (mostly universities) conclude that their own research group and other research groups funded by the project experienced a lasting strengthening of their international competitiveness, whereas beneficiaries are not so sure about the impact on other stakeholders, including companies.

This is partly a function of time; the results from the projects have not yet been transferred to development of products or processes in companies (recall SSF's 5–15/5–10 year expectation mentioned in the previous section). However, it is likely also due to a lack of, or limited, industrial relevance, where research questions may have been

formulated without being guided by the needs of industry or society. Results from such projects are clearly much less likely to be utilised in a subsequent development of successful products and processes, at least in the short term.

This picture appears also in the project final reports. There are 94 final reports from the five programmes studied. In 51 per cent of projects, research was reportedly carried out in collaboration with industry; 19 per cent of projects led to development or implementation of a prototype, a process or a product; and in 2 per cent of projects (i.e. two projects), research results had already been introduced on the market. The remaining 28 per cent of final reports merely reported that the project had included "research relevant to industry". Further development is often described in rather vague terms in the final reports; a representative example:

> *The research becomes increasingly important for the industry. I was invited to participate in several industrial networks, involving several leading companies.*

For research results that still have a long way to go to be developed into a product or process, impact may still be planned or even within sight:

> *Our work may have important implications for both industry and society. With respect to industry, all the technology we are producing is being patented by a company that I have recently founded. Our objective is to establish strategic alliances with companies for the co-development of our discoveries into products. The positive outcome of our activity may result in the generation of employment and novel therapeutics for diseases with poor outcome and high social costs.*

In one successful case of collaboration, which is not unique, a researcher describes the development as follows:

> *I have established numerous collaborations with industry, both in order to obtain additional funding for my research group, and to achieve better dissemination of my results to Swedish industry. I have also found that industry input gives valuable suggestions for my general research direction, and results in new "academic" solutions to specific problems.*

Development or implementation of a product or a process is illustrated by another quote:

> *Results with both immediate and long-term relevance to industry and the society have been obtained. The results have immediate clinical applicability with apparent gain for patients, and are of importance from healthcare and socioeconomic aspects.*

Finally, in one of the very few cases where the results were stated in the final report of the project as having led to introduction of a product on the market, it is clear that the development rather quickly can yield relatively large numbers:

> *This company now provides the invention to more than 30,000 children in over 20 countries, including around 10 per cent of Swedish schools.*

4.3 Interviews complete the picture

This overall picture, which was painted in the project final reports sometime between two and six years ago, is largely confirmed in the interviews with project participants. Our interviews provide a similarly complex narrative. On the one hand, commercialisation of research results from the projects has not been extensive; this part of the picture from both web surveys and final reports is supported by interviews. It is more a matter of the research activities having contributed to Sweden's good reputation, and to making it a leading research nation within certain research areas. On the other hand, the projects have clearly dealt with topics and themes of potential future importance to industry and society at large, and activities have generated many potentially useful results, as well as more activities in subsequent projects. Interviewed

beneficiaries regard the research as being increasingly important to industry, for example through the development of computer simulations, but in many of the projects studied there have been no efforts (yet) to reach out to industry.

At the same time, interviews show that there have been projects that included extensive collaboration with RTOs and industry, for instance in developing qualitative models and visualisation tools that help to increase transfer of knowledge from scientists to engineers. This is significant for both industry partners and for various educational purposes. One important part of the impact of the programmes is thus the way project activities and results support in shaping the education of future scientists.

The foundations for achieving other types of long-term impact have also been laid in projects that developed new technology, products and processes, which have subsequently been spun off into newly established companies (we return to spin-off companies in Section 4.4). This is different from situations where products have been developed and processes implemented in already established partner companies with significant own R&D resources and absorption capacity. In these latter cases, which indeed are few in the studied programmes, research results have proved most useful in improving already existing products or processes, and they have in turn yielded sales of billions of SEK for participating companies. This result is familiar also from other studies of the long-term industrial impact of R&D investments.[38]

Additional impact may be found in spin-off companies that have been able to sell licences. Project activities and promising results have also attracted multinational companies, and in at least one instance such a company has set up a Swedish office as a very specific response to development of novel instruments, software and methods.

Several interviewees point to the supply of competence and skills to participating companies, which should be regarded as a very important indirect impact. This can be understood as adding to companies' stock of internal resources in the form of human capital and research capability. Such internal resources involve not only R&D topics, but also personal and business networks. Interviewees from different SSF programmes testify that researchers from SSF projects now work part-time in industry. PhD graduates, who were funded by the SSF projects, have been recruited by companies, hospital clinics and other organisations. The competence, which also includes collaboration skills from years of project co-operation, is further used in FP projects in interaction with other companies.

On a tangible level, companies make more enlightened and strategic choices that sometimes include setting up their own R&D capabilities and resources, in which case they may also recruit from research groups funded by the programmes:

> *We started to build our own R&D capacity within the area, and have crafted our own internal R&D programme to which we have recruited skilled people. This follows mainly from the results coming out of research. The company must equip itself to be able to work and perform research on the area.*

There are cases where researchers from a specific field or centre are said to be "spread all over the system", contributing tangibly to applications elsewhere, sometimes in sectors other than those in which the research was originally performed. One specific example is illustrated by the following statement:

> *Robotics is now integrated in many companies. From the start it was mainly ABB. Now it is huge in the automotive industry.*

Small-scale, short-term impact, such as cost reductions in an assembly line in a specific company that helps it maintain production in Sweden, are intermingled with at least

[38] P. Stern, E. Arnold, M. Carlberg, T. Fridholm, C. Rosemberg and M. Terrell, "Long Term Industrial Impacts of the Swedish Competence Centres", VINNOVA, VA 2013:10.

parts of large-scale, long-term impact such as solutions to climate issues or for energy efficiency purposes. With regard to the former:

> *Production was rebuilt and improved. New measurements and working methods were introduced to work with the production processes. This was the result of a collective effort where research provided grounds for decisions. Such a large cost reduction and increased effectiveness will obviously also increase company competitiveness.*

And to the latter:

> *We have shown that it is possible to reduce power and hence consume less energy for the same performance. Reducing the energy consumption is crucial since it constitutes about 15–20 per cent of costs, and in some cases up to 40 per cent. Reducing the energy consumption is also vital from societal and environmental points of view considering climate changes.*

To some extent, the SSF programmes have dealt with and produced results relevant for the development of Key Enabling Technologies, such as for example developments in microelectronics, which are described as potentially very important for a broad range of applications.[39] Also in these cases, the activities have resulted in new collaboration with industry along promising avenues, at times with funding from other sources. This refers to single projects, as well as to the more comprehensive operations that found a continuation in a VINN Excellence Centre.

Projects have, according to both final reports and interviews, contributed to a certain degree to new ways of working and applied new approaches in collaboration, which have increased innovation capabilities. This can be seen as part of the general *de facto* ambitions to encourage the development of interdisciplinary critical mass within academia in areas of industrial relevance, and to basically change the research culture by encouraging companies to engage in "open innovation" (open both to academia and to interaction with other companies) and jointly exploring more fundamental questions than usual. An important part of the latter would be to promote greater interest in and acceptance of the value of industrial collaboration within academia.

In terms of the specific outreach and interaction with the outside world, project leaders have in both final reports and interviews reported that they generated popular-science articles aimed at the general public, and that researchers have participated in youth fairs and events, as well as giving lectures to clinicians or technicians. Researchers have engaged in the public debate on research policy, and in communication with the public and policy-makers, providing "scientifically correct information" in delicate matters. Their competence, which also includes lessons from their leadership training, has been used in different positions of trust, as well as serving in diverse corporate, programme and advisory boards.

As indicated above, interviews with researchers show that many of them have quite clear concepts and visions of the potential impact of their research in industry and on society. In these cases, their descriptions are fairly well developed and their stories seem to hold tight. The development and transformation of research results into products, processes, outcomes and impact go along the lines of a more or less explicit assumed programme theory, which involves collaboration between researchers and company representatives. It is described as mostly a matter of time before all of the good things will be discernible.

However, other interviews reveal cases where the project was clearly not conducted in accordance with these principles, and where researchers report that they just "will convene a meeting whenever we believe we have results of interest". It is approaches like these that make some researchers point towards a general need for a much broader

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39 In the EU context, a Key Enabling Technology (KET) is seen as a main driving force behind the development of future goods and services and the restructuring of industrial processes needed to modernise EU industry. The EU has very good research and development capacities in some key enabling technology areas, but has not been equally successful in transforming research results into commercially manufactured goods and services.

interface between universities or centres on the one hand and industry on the other. One of the possible solutions to this, which is quite frequently referred to in interviews, would be to implement an effective expansion of the RTO sector. RTOs' often both broader and more detailed knowledge of industry and its needs and problems, as well as an extensive experience from closer collaboration in specific R&D projects, would thus facilitate a process in which universities and industry can make themselves more relevant to each other by working jointly on problem formulation and design of projects, which are then also jointly implemented.

Although collaboration and networking in a broad sense are highlighted above as key success factors in achieving competitiveness of research groups and other participants in SSF programmes, we must point to the fact that it is not a panacea for all possible situations. Success and competitiveness can also be found in those cases where the result is one single patent, or nothing but one specific method applied in a company, and no further industrially applicable research in sight. The project in question led to no more collaboration, no more applications and no further research in the area, but the company gained a lot from implementing an improved process in its production:

> *The method is particular for this company and our closest competitors. The more knowledge and competence we have about the model, the better for our competitiveness. The project contributed that way. No new ways of working or new processes were implemented as a consequence of the project. Just the one model that was developed and introduced.*

Some of the projects are even quite far from any utilisation or application:

> *It was a new and exciting research field. The project was about basic research. It was not applied research, and thus not on the agenda to collaborate with any company. There were no companies to apply the results in their operations. It did not lead to any collaboration with anyone else either. Neither have I continued with this line of research.*

It is also important to keep in mind that it is often very hard or impossible to distinguish between the specific impact of SSF's grant, other grants and other confounding factors that lie behind the competitiveness or impact in industry or on society. Individuals and research groups are typically engaged in what is often called "the real project", which is usually more extensive in both time and scope than any single grant from one funding source. A researcher typically pools resources from different funding sources and uses them to pursue his/her overarching research question. Thus, it is rarely possible to directly attribute an observed impact to a specific research grant. Says one interviewee:

> *This is definitely multi-disciplinary research. We work with physicists, physicians, organic chemists and so on. My area looks like that, and that is also how it used to be before. Overall, it is very hard to distinguish which results follow specifically from the SSF funding, since I have had funding from other sources as well during the same period. At least I was able to hire three postgraduate students and one post-doc, but, again, SSF was not the only funding source. It made a difference, though, a 400 per cent increase.*

This pursuit of "the real project" is typically conducted by individuals or groups of researchers in networks of professional relations, where trust is fundamental. When involved in R&D and innovation, researchers often build on and maintain a knowledge community, or a Knowledge Value Collective (KVC).[40] KVCs consist of individuals who are united by the use of a common scientific and technological knowledge that they share and adapt to their own needs. This lays the groundwork for long and lasting relationships between individuals in companies and R&D performers and they also usually persist even when an individual changes employer. Thus, KVCs' extent and

[40] B. Bozeman and J. D. Rogers, "A churn model of scientific knowledge value: Internet researchers as a knowledge value collective", *Research Policy*, vol. 31, 769–794, 2002.

duration in time and space clearly exceed that of individual programmes, or even the companies and organisations involved in the programmes.

4.4 Spin-off companies

From project final reports, web surveys and interviews we have obtained the names of 63 spin-off companies established in association with the activities in the projects. Of these, 43 are to be found in Swedish company databases covering the last five years. Five of the companies are so newly started that no annual reports are registered yet, nine of them have gone bankrupt or been liquidated, and six of them belong to the "other/unknown" category.

Of the 43 companies, only 29 had a net turnover exceeding zero in the most recent financial statements, and the two largest companies accounted for 38 per cent of the combined net turnover. Thirteen companies showed a positive result before tax in the most recent financial statements; the most profitable company of the 13 accounted for 63 per cent of the combined profit. Figure 25 shows the aggregated net turnover, loss (i.e. profit before tax) and number of employees (full-time equivalents) of the 43 spin-off companies for the period 2009–2013.[41]

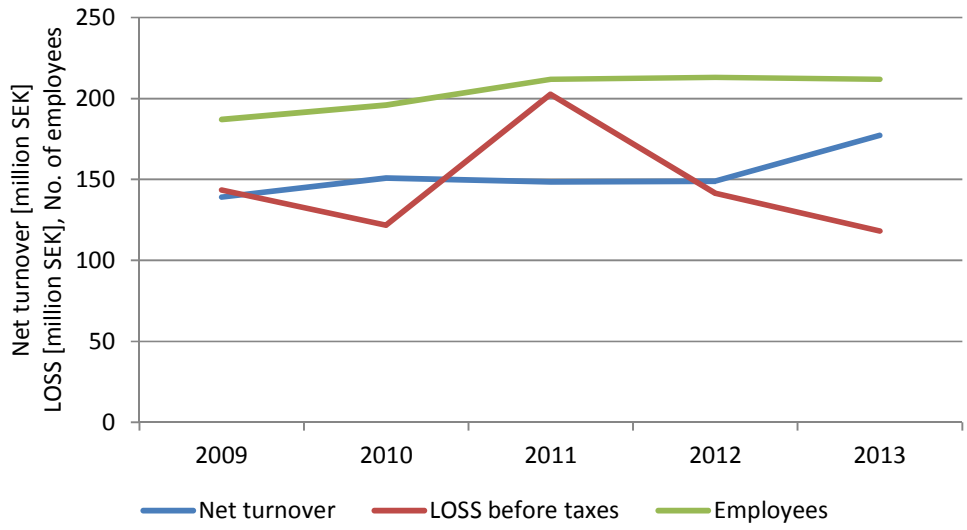

Figure 25 Aggregated net turnover, loss and number of full-time employees for 43 spin-off companies of the five SSF programmes studied. Source: Nordic Business Key provided by Soliditet AB.

The development of these spin-off companies should be interpreted with great caution. There is reason to believe that several of the companies with no or little turnover have no business activities to speak of, and that the company only exists to own patents. Other companies with no or little turnover have employees, thus costs, and consequently make substantial losses, meaning that they probably rely on venture capital. In some companies we would expect some testing, verification or proof-of-concept activities to be taking place, in which cases they have neither "taken off" nor been acquired by a larger company.

> *There were two spinoff companies. They have been successful so far, and have gone into phase-2 testing in drug development.*

Or, as in the less successful case:

[41] For six of the 43 companies the most recently available data were from 2012. Thus, in the figure "2013" should be interpreted as "2013 or most recently available data" etc.

This was no success for the company and it has ceased its production. It was not competitive.

Nevertheless, Figure 25 exhibits a very modest positive trend for the combined net turnover and number of employees, and the aggregated loss is in decline after a peak in 2011, possibly indicating a somewhat brighter future for some of the spin-off companies.

5. The systemic role of SSF

SSF plays a number of roles in the national innovation and funding system. First, it has effectively assumed some responsibility for funding research in certain themes, most of which were identified as being of importance before the Foundation was set up and during its operation. Second, through the use of new kinds of funding instruments, SSF has played a role in restructuring the research in the Swedish universities. Third, it has adopted a form of governance that tends to stabilise its role, perhaps more than is desirable. Fourth, it is active in funding "strategic" research, not only in the sense of research that may be important for Sweden, but also research that that drives fundamental enquiry from social and technological needs. Fifth, it occupies a funding role that is not only unique, but is neglected in the state funding system.

5.1 The thematic role

SSF's statutes empower it to fund basic and applied research as well as research lying between the two, with the overall objective of increasing Swedish competitiveness. Its scope is broad: natural sciences, engineering and medicine.

However, the social democrat government's efforts in 1995 to set the agenda at SSF through cutting funding at state agencies, especially Nutek, strongly influenced SSF's early activities, as indeed did the wider context of research policy from the 1980s. As Figure 2 and Figure 3 show, the Foundation has continued to focus on the trinity of technologies prioritised during the 1980s. First, it therefore built upon the national R&D funding effort in information and communication technologies (ICT) during the 1980s. This involved national programmes in microelectronics in the early-mid 1980s and industrial ICT towards the end of the decade. Second, it could build on the national strength in life sciences and medicine, built up significantly through research council funding. While Nutek did run some programmes in biotechnology, medical devices and so on, funding for applied research and development was limited. Third, it inherited early national efforts in materials technologies, via the Nutek-NFR materials consortia. These were academic-industrial networks aiming to increase the research intensity and the role of more fundamental research in materials.

Taking on these overall priorities meant that SSF could add value in each. In ICT, this was by continuing significant funding, but also by slowly shifting the focus away from the hardware orientation of the 1980s and towards ICT systems. This reflected changing industrial priorities as it became clear that Sweden was too small to compete in high-volume electronics, but could build strength in complex systems (for example in telecommunications systems, where Ericsson is still a global player). Life sciences have become a significant part of SSF's funding. Here the Foundation has increased the number of funding opportunities available to the research community, especially in areas with potential clinical or industrial application. Materials research was not generously funded in Sweden before SSF was set up, so the Foundation has increased the opportunities.

While not part of the technology trinity, production engineering has been a long-lasting theme within SSF, taken over from Nutek. Production engineering research has been hard to fund in Sweden. The research councils (including *Teknikvetenskapliga forskningsrådet, TFR*) did not fund it because it was seen as being too applied. While Nutek and VINNOVA have funded production engineering sporadically from the early 1990s, in pursuit of specific industry-driven problems, SSF has been able to maintain a more constant flow of activity through much of its history.

In effect, therefore, SSF has focused its efforts on enabling technologies likely to underpin the high-technology industries most governments have sought to promote since the 1980s. It has also devoted effort to production engineering, but its efforts in relation to technologies supporting more traditional Swedish industries have been more limited.

5.2 The structural change-agent role

SSF was set up at a time of important change in science policy funding instruments internationally. The fact that it was a new and relatively unconstrained organisation meant that it could depart quite radically from existing models.

Together with Mistra and KKS, SSF funded the spread of US-style graduate schools in Sweden. TFR had already launched some interdisciplinary graduate schools within the engineering sciences and the government allocated SEK10m for experiments in 1993–1996, but the Foundations were able to launch large numbers of graduate schools. Figure 26 shows when those Swedish graduate schools that existed in 2000 were set up, with dramatic growth following the emergence of the wage-earner fund foundations. SSF wholly or partly funded 41 per cent of the graduate schools indicated in the figure before de-emphasising graduate-school funding from 2000. While not all the graduate schools have survived, the impetus appears to have modernised practice in much of Swedish academia.

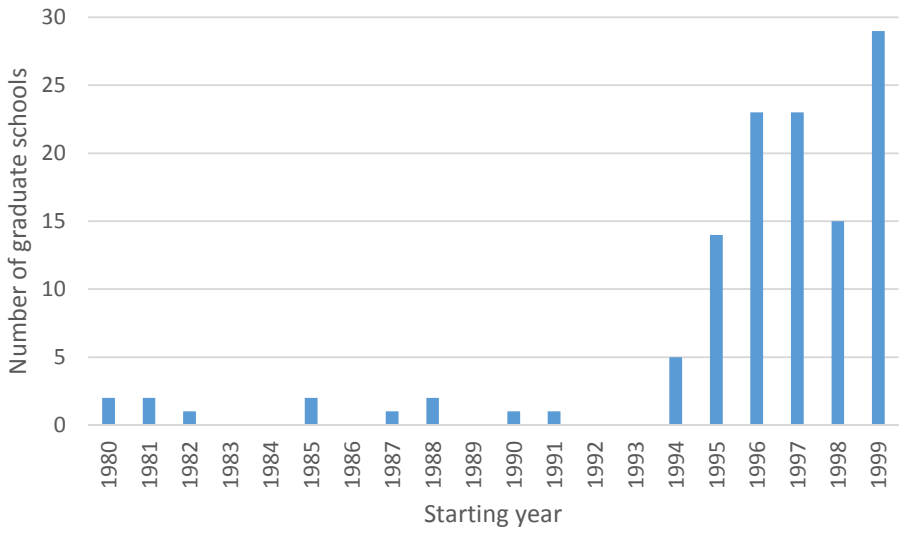

Figure 26 Start-up years for Swedish graduate schools existing in 2000. Source: "Forskarskolor, ett regeringsuppdrag", National Agency for Higher Education, 2000:2 R, 2000.

At the same time, there were two other important initiatives in Sweden that responded to demands for increased public investment in research and postgraduate education. One was the sectoral programmes in automotive and aeronautic technologies set up in 1993. These aimed to make academic research more focused on industry needs, raise the research intensity of industry and increase the number of PhDs employed in industry. They tackled comparatively short-term technological problems, typically associated with the next product generation. The other was Nutek's Competence centre programme, launched in 1995 and comprising 29 academy-industry consortia committed to doing research and postgraduate education together over ten-year periods.

SSF also used three other instruments that are structural in character, not least because they tended to de-fragment the research community and build the larger groups needed for international competitiveness. The fact that these invested money in groups of people, rather than just individuals, over sustained periods is key to their ability to induce structural change. The "golden rule" (she who has the money makes the rules) applies as much in academia as anywhere else. People who attract big grants over long periods tend also to accumulate other resources, so the universities gradually adapt their structures to the external financial incentives.

- First, individual FFL grants allowed younger (and, initially, also some older) researchers to build positions and in some cases to set new research directions. Even these individual grants provided beneficiaries with opportunities to recruit additional researchers and therefore the core of a research team
- Second, the framework grants provided from the Foundation's earliest days were big enough to fund several people, enabling research groups to build capacity. Their mid-term character and the flexibility with which SSF was prepared to see them used, meant that researchers could use them to build small empires within the universities
- Third, the SFCs provided the resources to build bigger structures that could eventually form the foundations of sustainable mass

Internationally, many funders have in recent years been building these kinds of instruments, moving grant sizes up so that they increasingly involve more than a single researcher and providing a "staircase" of funding opportunities that allow researchers to build empires that change the structure of the universities.

In Sweden, it has probably helped that SSF was not alone. Nutek/VINNOVA, KKS and Mistra all provided instruments that promote this kind of agglomeration. VR has also launched centre programmes. Entrepreneurial researchers have exploited multiple funders to build apparently sustainable entities of greater scale, such as the MC2 and SAFER centres at CTH – each of which is several times the size of the largest available centre-funding instrument.

SSF has also been able to play a flexible and useful role in the Swedish system, providing money at short notice to support research facilities in difficulty, providing incentives to key individual researchers to remain in Sweden and helping Swedish universities head-hunt talent from abroad. It would be much more difficult for a state organisation to do this.

Broadly, therefore, SSF has played a role as a change agent in the Swedish research system, encouraging agglomeration and the building of areas of research strength.

5.3 Governance, strategic intelligence and the direction of SSF's funding

For political reasons, the wage-earner fund foundations were set up to be outside the control of the state, with the late adjustment that the board chairs would be appointed by the government – a mechanism that in practice failed to let the state reassert authority over the foundations. SSF's board is in practice nominated by the Academies of Science and Engineering, the rectors' conference (Association of Swedish Higher Education, SUHF) and the coordination group of the government funding agencies.

Unlike in the Swedish research councils, therefore, members are not elected and academics do not formally have to be in the majority. However, board membership is and has been academically dominated, though there has been a constant presence of senior and influential figures from the R&D departments of large Swedish companies. As the selection process would suggest, board members are established, respected figures, most of whom are also visible in a range of other boards and committees connected to national research and innovation functions. These are members of Sweden's technocratic élite. They have strong network connections to the rest of the research system and hold positions that imply they are well informed about current scientific and technological developments, at least within their own fields. Our interviewees have nothing but positive things to say about the board and its members.

SSF has a small secretariat, with limited capacity for analysis, but whose personal capacities are also widely praised by our interviewees. It has been able to buy a fairly substantial body of evaluations and the Foundation has organised a number of consultation exercises with the research community to discuss SSF's thematic foci.

SSF's thematic directions were to a great degree dictated to it by circumstance at the outset. They were consistent with the previous pattern of national needs and picked up

a "direction of travel" towards the "technology trinity" and the pattern of funding that has persisted at SSF since the outset. As we observed earlier, that funding pattern has since been pretty stable in thematic terms. At the micro-level, quite a number of our interviewees argued that research topics tend to be rather mainstream. Several sources of evidence, from interviews through participant surveys to external reviews such as that of SSF's IT funding[42] suggest that the degree of industry participation in direction-setting and in the projects themselves has been less than desirable.

The emerging picture is one of SSF absolutely having done the right thing in terms of thematic priorities at the outset. However, the thematic mix has been surprisingly stable thereafter (cf. Figure 3). Such stability often occurs where beneficiary communities govern funding organisations (as is *de facto* the case at SSF).[43] It was strikingly a problem identified at both the Austrian innovation agency and the research council, which were governed respectively by the social partners and the research community .[44] It was apparent also in the recent evaluation of the Academy of Finland.[45] In Sweden, Madeleine Sandström's critique of VR pointed to the same problem.[46]

This static tendency is reinforced at SSF by the natural desire of a researcher-dominated organisation to view its own efforts in research terms. All the signals received by SSF are that the research funded is generally of good quality and that the beneficiaries are happy with the Foundation. In the absence of policy signals from the government or strategic intelligence from an analysis department to suggest change is needed, it is natural to carry on incrementally developing that which has gone before. However, it does also mean that while SSF was able to act as a significant change agent when it was set up, the governance structure tends to work against its ability to initiate further changes, even if the CEO and staff have the ability themselves to influence developments.

A further factor also undermines SSF's potential to act as a change agent, namely the lack of effective coordination in the Swedish research funding system. Unlike the original TFR (*Statens tekniska forskningsråd*)[47] – which had a specific task to coordinate technology research funding – neither SSF nor its sister funding organisations in the state has any such responsibility. Nor is there an effective research policy coordination function in the Swedish system overall.[48]

SSF would therefore be better served by a governance system that better balances the concerns of researchers and industry, while maintaining its focus on longer-term and more fundamental research than would normally be seen in an innovation agency.

5.4 What is "strategic" research anyway?

One can become over-fascinated by terminology, and the "strategic" part of the Foundation's name invites fascination. In practice, names are often chosen because they sound important or nice and will look good on the press release. So the intention of this section is not to try to ask what "strategic" means and test whether SSF conforms to this definition. But the work SSF funds is in important senses "strategic", so we explore what

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42 C. Andersson, O. Knutsson, U.-B. Fräjdin-Hellqvist, B. Hedfors, E. Lindencrona, H. Skoog, B. Thorngren and J. Wilander, "Värdering av SSF:s IT-insatser under perioden 1994-2000", SSF, 2008.

43 D. Braun, Who governs intermediary agencies? Principal-agent relations in research policymaking, *Journal of Public Policy*, 13(2), 135-162, 1993.

44 E. Arnold, "Evaluation of the Austrian Industrial Research Promotion Fund (FFF) and the Austrian Science Fund (FWF)", BMVIT, 2004.

45 E. Arnold, T. Luukkonen, P. Boekholt, A. Nooijen, Z. Jávorka and F. Zuijdam, "Evaluation of the Academy of Finland", Ministry of Education and Culture, 2013.

46 M. Sandström, Forskningsfinansiering – kvalitet och relevans, SOU 2008:30, 2008.

47 There have been two TFRs: *Statens tekniska forskningsråd* was in existence 1942–1968, *Teknikvetenskapliga forskningsrådet* 1990–2000.

48 "OECD Reviews of Innovation Policy: Sweden", OECD, 2013.

that means in historic and current contexts. This is an important ingredient needed in the next section, which talks about the division of labour in the funding system.

SSF represents an important stage in the development of the Swedish funding system for technological research. Over time, the nature of technological research has been changing. In the post-war period, it was about straightforward engineering, but in the subsequent period increasing amounts of science have been triggered by technological challenges, moving a lot of engineering design from reliance on rules of thumb or painfully constructed tables to science-based calculation. Improved understanding of materials properties results increasingly from work in physics, triggered by problems in materials science. For example, improving the performance of catalysts increasingly relies on research at the molecular level rather than experimenting with potential formulations. In the pre-war period, there was no scientific theory that could help engineers optimise propeller blade design, so blade shape optimisation was done by parameter variation: bit by bit changing the propeller shape, measuring its performance and recording the results in massive data tables.[49] Now, the science of fluid mechanics is well enough developed to allow designers to design the shape directly.

These changes in the nature of technological research imply a change in its economics. The more scientific and the further from practice technological research becomes, the more it suffers from the same "market failure"[50] as "basic" research, namely that it is costly and risky to do, results are uncertain and the opportunities decline for a private company to monopolise the knowledge sufficiently to make money. While traditional engineering research can be jointly funded with industry (if the state needs to be involved at all), industry struggles even to part-fund the fundamental end of modern technology research. The increasing role of science in technology therefore implies that fundamental technology research needs to funded in much the same way as other basic research, i.e. largely by the state or other patrons. This in turn raises questions about who does the funding.

The changing nature of technological research has also raised questions at a higher level about how to describe, fund and govern research. There were clear signs in the science policy discussion already in the 1980s that the old, simple distinction between basic and applied research was inadequate. As policymakers increasingly looked for national competitive advantage from the development of "key" or "enabling" technologies, the term "strategic" research emerged to cover work that, while fundamental (and therefore not "applied"), was nonetheless intended to underpin future industrial developments.[51] The OECD eventually invented the category "oriented basic" research to cover the same concept.[52] Ironically, given the origins of the term in a kind of competitive "techno-nationalism", the shift towards seeking more fundamental understanding implied not only greater involvement by the research and higher education sectors in addition to industry, but also internationalisation. The more fundamental the work, the more difficult it becomes to do or fund it alone and the more it becomes the business of the global scientific community. The "pre-competitive" focus of the FP (which originated in 1984–1985) testified to that need for internationalism.

The "strategic" sphere encompasses at least two kinds of science. One is "transfer science" or "translational research", which picks up results from fundamental research and moves them towards application – much as envisaged by the old "linear model" of

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49 W. G. Vincenti, *What Engineers Know and How they Know It: Analytical Studies from Aeronautical History*, John Hopkins University Press, 1990.

50 K. Arrow , "Economic Welfare and the Allocation of Resources for Invention,'" in Richard Nelson, ed., *The Rate and Direction of Inventive Activity*, Princeton University Press, 1962; see also Richard Nelson, "The simple economics of basic scientific research", *Journal of Political Economy*, vol. 67, 297-306, 1959.

51 J. Irvine and B. Martin, *Foresight in Science: Picking the Winners*, London, 1984.

52 *OECD Frascati Manual*, OECD, 2002.

innovation.[53] This is especially relevant in the life sciences. The other is fundamental engineering science, where problems are likely to be prompted by unresolved issues in applied science and may call on knowledge from other basic research, rather than being driven by it. This will include areas such as the "sciences of the artificial" such as complex systems, about which fundamental laws can be derived even though there are no pre-existing examples in nature to be "discovered".[54] In effect, these engineering sciences live lives of their own and have fundamental research issues of their own. Their development is not driven by basic research more generally.

Much of the life sciences work that SSF funds appears to be closer to the engineering paradigm than the translational research paradigm, in the sense that it involves a search for scientific and technological solutions to clinical problems, thereby driving research questions from the clinical level "upstream" towards research, rather than translating existing basic research findings into useful clinical technologies.

These shifts in the nature of technology research seems to have driven change in the way engineering research is funded. By the mid-1980s, the US National Academy of Engineering Sciences was concerned that education and research were not keeping up with the increasingly systemic nature of engineering, partly in terms of its dependence on science and partly its increased interdisciplinarity. This led the National Science Foundation to establish Engineering Research Centres to bring academic and industrial research together around these themes and in turn inspired Nutek's Competence centre programme.[55] The life sciences do not seem to have gone through this kind of organisational innovation, but the type of centres and projects funded by SSF appear to be increasingly common.

Table 3 The TRL scale, as deployed in Horizon 2020. Source: "The TRL Scale as a Research and Innovation Policy Tool", EARTO, 2014.

TRL Scale	Description
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technological validity in a lab
TRL 5	Technology validated in relevant environment
TRL 6	Technology demonstrated in relevant environment
TRL 7	System prototype demonstration in an operational environment
TRL 8	System completed and qualified
TRL 9	Actual system proven in operational environment

An alternative way to position at least one focus of SSF's funding is with reference to the technology readiness level (TRL) scale, see Table 3, which was initially developed to assess the readiness of technologies for use in space and defence, but which is now more broadly used (in a range of variants). The TRL scale is rather linear, because it was developed in connection with systems development. It describes milestones rather than processes. Nonetheless, TRL 2 marks the focus of a lot of "strategic" research. This way of viewing it makes it clear that it does not fit all that comfortably into either the normal

53 M. Gibbons, C. Limoges, H. Nowotny, S. Schwartzman, P. Scott and M. Trow, *The New Production of Knowledge*, Sage, 1994.

54 H. Simon, *The Sciences of the Artificial*, 3rd edn, MIT Press, 1996.

55 P. Stern, E. Arnold, M. Carlberg, T. Fridholm, C. Rosemberg and M. Terrell, "Long Term Industrial Impacts of the Swedish Competence Centres", VINNOVA, VA 2013:10, 2013.

funding business of a "basic" research council or than of an innovation agency, which is likely to engage more with the middle levels.

There is a case – especially in Sweden, where research council governance traditions strongly favour traditional "basic research" over other forms of research – to organise and govern "strategic" research funding differently from either traditional basic research or the closer-to-market work typically addressed by an innovation agency. History shows that strategic research sits uncomfortably with other kinds in the same organisation. And the needed governance involves a different balance of power between research and industry than is used in other organisations.

5.5 The division of labour in funding strategic research

How to fund technological research has been a contentious issue in Sweden for over half a century. SSF represents a distinct chapter in this story.

Following some years of lobbying by the Royal Swedish Academy of Engineering Sciences (IVA) and *Industriförbundet*, the manufacturing employers' association, commissions led by Gösta Malm were set up in the early 1940s to consider the organisation of research and technological development, in the context of the rapid advances being made in the UK, Germany and elsewhere, which threatened to leave Sweden behind. Malm produced a number of recommendations about structure and funding in 1942 that have shaped the structure of the research and higher education system ever since.

One key decision was that, because the Swedish system was small in absolute terms, research capacity should not be fragmented among a large number of organisations. Malm did encourage small, applied industrial research institutes to be set up, but he explicitly rejected the idea of a central state research institute. More broadly he argued that the universities should not only do "basic" research, but also the various kinds of applied and "sector" research needed by government and industry.

Malm's doctrine has persisted. His conclusion that the focus of technological and sector research policy should be on university research was reinforced by a parliamentary decision in 1979 that "the universities shall undertake a significant proportion of sector-related research, that is research that aims to support or develop state agencies' activities."[56] The universities were to function as "research institutes for the whole of society". Swedish experience suggests that one consequence of this is to encourage a running battle about the nature of "the university" and the relative roles of bottom-up and top-down funding. Other countries tend to avoid this because their research-performing organisations are more specialised.

Malm found that a key problem was a lack of researchers in technology and concluded that the universities' capacity to produce such people should be increased. Rejecting the idea of establishing a central institute of technology, Malm proposed that technology funding should be aimed at the universities and provided by a technology research council –the original TFR – which the government set up in 1942 at the same time as providing special grants to Sweden's two technical universities, KTH and CTH.

Research councils for the natural sciences, medicine and various sector missions were set up in the second half of the 1940s, increasing the supply and diversity of external funding to the university system. TFR lasted a long time, funding a mixture of academic research, academic-industry research cooperation, as well as some activity in the industrial research institutes. A mixture of academics and people from industry governed it, with elected researchers in the majority.

In 1967, it was folded into STU (*Styrelsen för teknisk utveckling*), the new agency intended to promote industrial innovation through research and capacity-building. But the money STU spent on the engineering research council function declined through the 1970s. In 1974, the right to make funding decisions was transferred from committees of

[56] SOU 1980:46

researchers to STU staff, who increasingly programmed the use of resources into technology programmes designed in cooperation with academia and industry. This proved crucial to STU's ability to fund successful technology programmes with both medium-term industrial relevance and a grounding in research.[57] Believing that this led technological research to be too short term, the government required STU to set up an internal research council (SULF) in 1984, once again governed by researchers, and when STU was merged with other agencies to form Nutek – a combined innovation and regional development agency – in 1990, SULF morphed into a new TFR: a free-standing, researcher-governed council, well supplied with industrial committee members and networks, but funding only academic research.

The new TFR's mission was to develop and implement a policy for Swedish fundamental engineering science. It was specifically responsible for:

- Engineering physics and materials technology
- Chemical engineering
- Biotechnology
- Engineering mechanics
- Medical technologies

It was initially an agency of the industry ministry, but was transferred to the education ministry in 1993, where it remained until it was merged into VR in the reforms of 2000. Since that time, there has been no distinct budget for technological research within the state funding system. The reorganisation of the funding system in 2000 that created VR, FAS (now Forte), Formas and VINNOVA provides an interesting example of co-evolution. In effect, the new organisation left a gap for the activities undertaken by SSF – though curiously SSF is not even mentioned in the legislation.[58] Indeed, this is only one extreme instance of the comparative absence of the Foundation from research policy discussions. This is clearly visible from the texts of the research bills published since their formation. The 1996 bill refers once only to SSF, and then to say that the fact that it is funding themes formerly handled by Nutek would justify a reduction in Nutek's budget. The 2000 bill (and subsequent ones) describe SSF's activities in the course of describing the wider landscape within which the government is making policy proposals. The 2004 and 2008 bills additionally discuss the need for policy coordination across research funders, but propose little that would alleviate the problem. SSF is not mentioned at all in the 2012 bill. Perhaps the independent status with which the wage-earner fund foundations have been endowed, has the drawback that they are difficult to engage in national policy or policy coordination.

Figure 27 shows the amounts of funding, in current prices, for research, development, innovation and demonstration available in the Swedish system since 1995. The figure shows that the overall available funding has increased quite rapidly, particularly the universities' institutional research funding and the funding made available by research councils. Figure 28 shows the shares of competitive funding available, i.e. excluding institutional research funding to universities and RTOs. Both figures show that SSF is a significant part of the funding mix, but that since a peak in 2000, it has been a much smaller funder than either the research councils or the innovation agency. Its relative importance has clearly declined as the importance of other funders has increased.

Since 2000, there are few signs that other funders have started to take up the "slack" caused by the gradual decline in SSF's annual funding. There have been no organisational changes at VR that would strengthen this function, while VINNOVA's agenda has reduced its focus on the technology programme tradition of STU and Nutek and increased its interventions in developing the structure of the innovation system and its actors, as well as development and the exploitation of technology. So as SSF's ability

[57] H. Weinberger, *Nätverksentreprenören*, KTH, 1997.

[58] Prop 1999/2000:81 Forskning för framtiden – en ny organisation för forskningsfinansiering

to fund declines, a hole begins to appear in the funding structure. This implies first that the state should no longer wash its hands of responsibility for "strategic" research in the sense of SSF, and second that SSF itself needs either to adopt a more niched strategy or to find other ways to fill the funding gap.

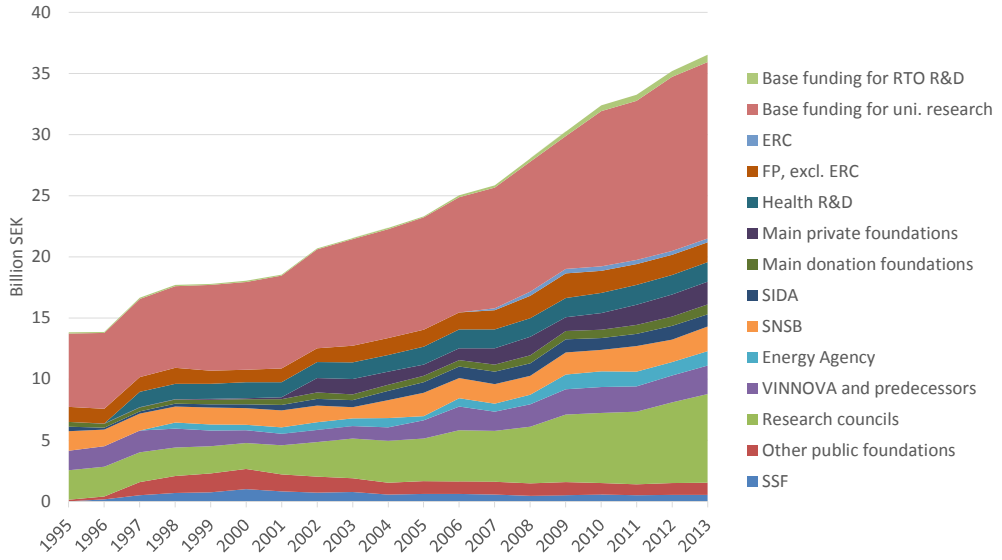

Figure 27 Main sources of funding for research, development, innovation and demonstration available to Swedish actors. Current prices. Sources: Annual reports, SCB national statistics, VINNOVA FP statistics and personal contacts.[59]

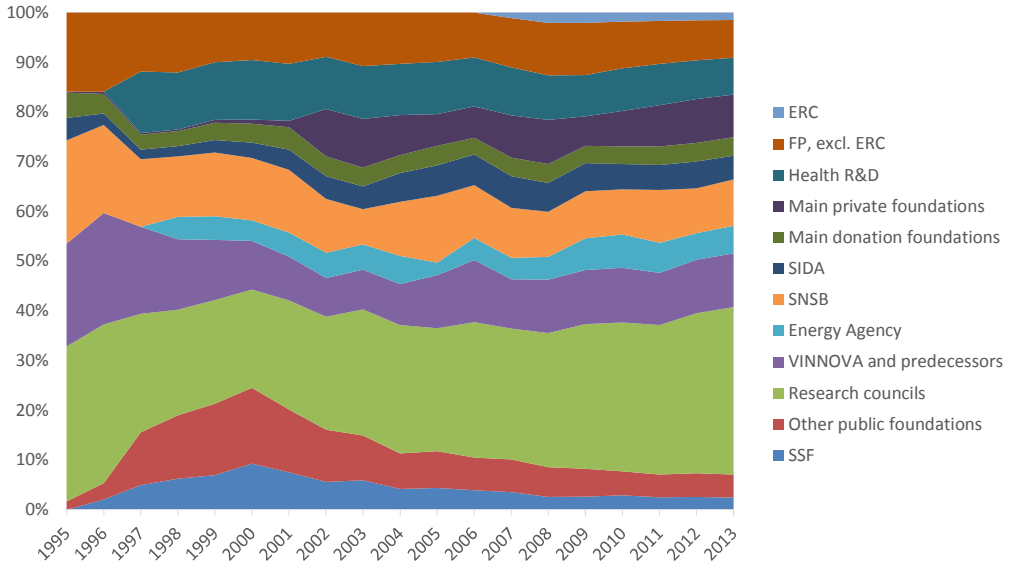

Figure 28 Shares of external, competitive funding for research, development, innovation and demonstration. Sources: Annual reports, SCB national statistics, VINNOVA FP statistics and personal contacts.[60].

59 Data for health R&D are not available prior to 1997; data for Wallenberg foundations (the dominating part of the Main private foundations category) are not available before 2002. Notable funding sources not included are a long tail of smaller foundations, as well as funding from companies, municipalities and other EU funding than the FP.

60 Ibid.

6. Fulfilment of statutes

In the following treatise the extent to which the Foundation has fulfilled its statutes, we focus on the Objective (§ 1) and Activities (§ 3) paragraphs, which were stated in Section 2.1. It should be noted that the following assessments are predominantly based on what this assignment has found by studying five specific programmes that represent a mere 10 per cent of SSF's total research funding by the end of 2013.

6.1 Objective

Given the Foundation's priority research areas through the years (cf. Section 2.2.1) and the funding analyses shown in Figure 2 and Figure 3, one might suspect that most of the funding has supported **research within natural science, engineering and medicine**. Indeed, an analysis of funding data reveal that the bulk of SSF's funding has funded research in these three fields of science and technology, see Table 4. With SSF's former classification system, used from 2000 to 2011, 93 per cent of SSF's funding went to research within natural science, engineering and medicine, and with the current classification system used since 2011 the percentage is 99 per cent for the years 2011–2013. Thus, it is clear that the first sentence of the objective paragraph of SSF's statutes largely has been fulfilled, although a non-negligible proportion of funding appears to have been granted to research in other fields, at least in the past.

Table 4 Relative classification of SSF's funding in fields of science and technology. Percentages do not add up to 100 per cent due to round-off errors. Source: SSF data.[61]

	2000–2011	2011–2013
Natural sciences	13%	35%
Engineering and technology	58%	39%
Medical and health sciences	21%	24%
Agricultural science	2%	0%
Social sciences and Humanities	3%	0%
Other	2%	0%

This assignment has found that **strong research environments** have been established in several areas. However, this is typically not entirely an outcome of SSF's funding, but rather the outcome of a series of grants from different funding sources over a longer period of time than the SSF grant. Some of the successful larger centres started to grow around the year 2000. There are some differences between programmes, where for example FFL grants early on in researchers' careers have proved much more significant for development of their research groups than grants to already well-established research groups and centres. Some FFL beneficiaries have thus built up their own successful research groups with the FFL grant as a foundation, using it as a lever to attract additional funding; without the FFL grant, they might not have been able to orchestrate such remarkable developments. For the already well-established groups that continuously exploit all available funding opportunities, the SSF grants were a welcome addition to the funding pot in that they added resources for research and for recruitment of additional postgraduate students and in some cases of key senior researchers. Nevertheless, SSF grants are reported to have contributed to quite dramatic changes and growth also for established research groups. On more than one occasion, SFC and FFL beneficiaries have been promoted to prestigious positions within

61 These classifications, made by the proposers themselves and then mapped onto the Frascati Manual's fields of science and technology by the authors, are not available before 2000. A new classification system was introduced in 2011, and since that year's funding was classified in both systems, the discontinuity is obvious; Natural sciences and Medical and health sciences gaining ground from other fields, particularly Engineering and technology.

their universities, including vice-chancellor and dean of research, which may be seen as acknowledgements of their success.

Whether research groups are **of the highest international standard** is more difficult to assess given the empirical evidence and analyses at hand. Our bibliometric analyses show that beneficiaries of the FFL and IT programmes in general have increased their publication productivity in the period after the SSF grant, while beneficiaries of the Materials and SFC programmes appear to have reduced theirs. All beneficiaries have become more likely to publish with foreign colleagues, but so has the entire Swedish research community. These analyses provide no guidance on the quality of the research conducted, but the final reports of several SFCs refer to bibliometric studies that they have carried out themselves, which show that the average impact factor for the groups' publications have increased substantially. Also, one of the most common sources of funding for subsequent research projects is the FP, which is highly competitive. A few researchers have also received grants from the ERC, which is even more competitive. Moreover, the self-assessment of beneficiaries is that the SSF grant has increased their international competitiveness. It is surely safe to say that many beneficiaries have used their SSF grants to conduct research of the highest international standard, but it seems reasonable to assume that this is not universally true; some have surely not been equally successful in qualitative terms.

The activities funded by the Foundation have in some respects clearly been of **significance for the development of Sweden's long-term competitiveness**. This is most evident for the individual beneficiaries and their research groups, whose activities have expanded, both quantitatively and thematically. Grants have allowed group leaders not only to recruit additional postgraduate students, but also senior researchers to take on managerial responsibilities and post-docs to work with participating companies, including researchers from other disciplines to facilitate interdisciplinarity and translational expansion. Individuals and research groups have also increased their competitiveness by evolving their national and international networks both in academia and with industry, not least through subsequent projects funded through the FP. The SSF grants have also facilitated securing additional funding, and the resulting development is a virtuous circle resulting in increased production of publications, PhDs and patents, and in many cases in publications in journals with higher impact factors. Altogether, it is thus evident that most beneficiaries and their research groups have increased their international competitiveness.

There are also some examples of significant contributions to companies' competitiveness, but they are few. Projects' industrial relevance is often unclear and in many projects the industry involvement has been weak or non-existent. It may well be that the research performed is of potential significance for the development of Sweden's long-term competitiveness, but given the generally weak academic–industry links in all programmes but Mobility, many of the research results may remain unexploited by industry, either because the results are not relevant to industry, or because industry is not aware of their existence. Nevertheless, the Foundation's interpretation of contributions to Sweden's long-term competitiveness is broad and long-term, and additional impact in industry may emerge in the future. Moreover, many PhDs co-funded by SSF have been employed by companies following graduation, thus contributing to their competitiveness.

6.2 Activities

This study has found that the research funded spanned the entire scale from **basic** to **applied research**. There are numerous accounts of **interdisciplinary** projects, and in the FFL and SFC projects interdisciplinarity was more systematically addressed; since grants were large, some research issues were explored from multiple vantage points and disciplines.

All of the programmes studied, with the exception of the Mobility programme, provided beneficiaries with resources that by Swedish standards were unusually large, thus constituting **a concentration of efforts** that facilitated the establishment of both

internationally competitive research centres and **research areas**. There are several examples of such research groups and research areas having been established.

It is obvious that projects have enabled **establishment of** new **cooperation networks** and cultivation of already existing ones. Cooperation has mainly been with other academic groups and non-academic partners in Sweden, and to a lesser extent with foreign ones. However, we have not come across many examples of what we would call **firmer forms of collaboration**: these are only occasionally referred to where very specific skills and competencies have been requested by some quite close collaborator in subsequent joint projects.

As is the norm in academic research, most of the research in programmes and projects has been carried out by PhD students supervised by senior researchers. It is thus safe to say that the programmes have significantly funded **postgraduate studies**. It is also clear that programmes have enabled **recruitment of researchers**, including both post-docs and already well-established senior researchers. (Although usually not part of any programme activity, a large number of PhDs co-funded by SSF have of course after graduation been recruited by universities, RTOs, companies and public-sector organisations.)

Almost all projects have been based around individual university researchers or university-based research groups, and in several cases competitive **research centres** and **research specialties** have emerged, but none (in the five programmes) associated with a university college.

There is little doubt that the programmes have led to **collaboration between academia and industry**, but the frequency and intensity of this collaboration has varied considerably, from no project-related collaboration at all to genuinely active academic–industry collaboration. On average, collaboration with industry has at best been modest. In terms of industrial relevance, it should be noted that most proposals were formulated by academic researchers on their own without industry involvement, and it was up to them to argue for the potential industrial relevance of the proposed research. In some projects, industrial interest arose during the project period, for others it is still a future prospect. Thus, the question of whether the research funded by the five programmes was of **particular interest to industry** results in a rather irresolute answer. Some projects were clearly of interest to industry, a few probably even of particular interest, others were of considerably less, possibly even no, interest to industry.

The programmes have all led to some degree of **mobility of researchers internationally** between Swedish and foreign universities, including post-docs and well-established senior researchers. The Mobility programme, which focuses on inter-sectoral mobility, has been quite successful in achieving mobility **between universities, institutes and companies**, with a notable emphasis on university researchers spending a period of time in industry; examples of other mobility directions are few, and when they occurred it was usually in the form of adjunct professors. There were very few examples of inter-sectoral mobility in the four other programmes. (As mentioned above, a large number of PhDs co-funded by SSF have after graduation moved to other universities, RTOs, companies and public-sector organisations, but rarely as part of a programme activity.)

7. Lessons learnt and administrative matters

7.1 Lessons learnt at the level of funding instruments

The unique circumstances that led to SSF being created had important implications for its funding portfolio, in terms both of the funding instruments it uses and in terms of thematic focus. By funding instruments we mean the form in which grants are offered, including the rules associated with them, their scale, duration and so on. Almost inevitably, most of the innovation in instruments and themes was done in the Foundation's early years, when it had to decide what to do. Subsequently there has been a slower process of learning and evolution.

Figure 4 shows how SSF spending has been split among different funding instruments since the start. By and large, SSF's instruments were similar to the new funding instruments being introduced at about the same time in other European countries. Graduate schools spread during the 1990s. The Netherlands was especially adventurous in setting up inter-university schools, an idea that was to a small extent also taken up in Sweden. During the late 1980s and the 1990s, there was growing international interest in research centres involving academia and industry working together, in the style of Nutek's Competence centre scheme, which was launched at about the same time as SSF itself. SSF's growing interest in providing individual research grants is mirrored internationally, too. The ERC, together with many other funders, has since established a Starting grants scheme for giving big grants to comparatively young researchers. More broadly, research funders have tended to increase average grant sizes, generally with the intention that one individual grant should feed more than one person and in the belief that that there are benefits from the promotion and training of research leaders, giving them responsibilities beyond what the faculties could manage in a collegial system. Many state-operated systems have therefore ended up with a similar offer to that of SSF: large, individual grants to build research groups; intermediate scale grant like SSF's Framework grants aimed at more established groups; and larger-scale centre grants.

The creation of the wage-earner's fund foundations coincided with a policy concern that Swedish companies employed a smaller proportion of PhDs than their equivalents in leading OECD countries, notably Germany. Graduate schools were therefore prominent in the early agendas not only of SSF, but also of Mistra and KKS. Creating such schools also provided an opportunity to tackle the fragmentation of the Swedish university research system, which in the early 1990s still tended to be organised on traditional continental lines, with individual professors and their students working in small and isolated groups. Graduate schools provided one way to reduce this fragmentation.

The Foundation funded a limited number of research centres during the 1990s, some of which subsequently grew in size. From the early 2000s, SSF stopped funding graduate schools in favour of the large SFC programme, contributing to reducing fragmentation and building areas of strength in the Swedish research and higher education system. Later, VR established Linnaeus centres for fundamental research (2006) and Berzelii centres for fundamental but potentially "relevant" research (2006) so that Sweden today has a comprehensive portfolio of centre-of-excellence schemes.

SSF has been providing individual grants since the outset, but launched its flagship FFL programme in 2000. This was universally praised in our interviews, not only by beneficiaries but also by others, who perceive the instrument as a valuable way to promote both thematic renewal and research careers within the Swedish research community. A key contribution was to include a compulsory leadership training course, intended to equip beneficiaries with key management and funding skills needed to establish and run a research group. This is an unusual requirement; the closest parallel is probably the inclusion of leadership training for centre managers in Nutek's Competence centre programme (and VINNOVA's subsequent similar schemes.) It recognises that the aim of the grant is not to help the beneficiary do "more of the same",

but rather to learn new behaviour. In our interviews, this training is consistently mentioned as an outstanding feature of the FFL programme.

In the first two rounds of FFL, a selection committee chose candidates wholly on scientific merit. Many of our interviewees feel that this resulted in the programme tending to fund somewhat established researchers. (Indeed, the domination of "young researcher schemes" by the oldest of the "young" is a problem that has been experienced elsewhere, for example in the Academy of Finland and China's National Natural Science Foundation.) In subsequent rounds, the assessment criteria broadened to take more explicit account of strategic opportunities, allowing funding decisions to become more nuanced. The eventual abolition of the selection committee and its replacement by thematic panels advising the SSF Board has also helped the Foundation to take more issues into account in "placing its bets" on individual researchers. Another improvement to the scheme has been the allocation of mentors to individual grantees. Beneficiaries interviewed feel that the training, the mentors and indeed the support of individual project officers at SSF have all been important to their career development.

The scope and focus of FFL has gradually been extended over time, to include an interdisciplinary tranche and the Ingvar Carlsson award for researchers returning to Sweden from abroad. At the same time, the success rate for FFL proposals has fallen in recent years, from 24 per cent (of 52 proposers) in FFL3 to 11 per cent (of 160) in FFL4 and 10 per cent (of 186 proposers) in the latest round, FFL5. At this level, its success rate is almost as low as that of the ERC or VR bottom-up grants, begging for a more restrictive eligibility criterion to be introduced so as to reduce the waste of proposal effort associated with such low rates.

The significant new instruments introduced in the Foundation's second decade were SFC (2003) and Strategic mobility (2008) grants.

The SFC programme was launched at large scale, with an intention to spend SEK 600m over a period of years. SSF's Board extended this sum to SEK800m[62] and called for more proposals and funding in areas relevant to the processing industry, whose needs it saw as being poorly covered in the original proposal round. However, the funding instrument itself seems not significantly to have been modified since its introduction.

Strategic mobility grants allow industrial researchers to spend a period in academic research, and vice versa. There is also a "repatriation" grant to Swedish researchers returning from abroad. Success rates have varied from 25 per cent (of 61 proposals) in 2009 up to 39 per cent (of 41) in 2011 and down again to 30 per cent (of 50) in 2013. The scheme has been positively evaluated and was widely acclaimed in our interviews.

Some rule changes have been made to the Mobility grants in recent years, mostly with the intent of making the interaction between the participating organisations more effective. The evaluation of the Mobility programme[63] proposed that the list of assessment criteria should be extended to include the ability of those involved to disseminate knowledge in the participating organisations beyond the people participating directly in the project. It also suggested that the assessment of proposals should look at the role of the project in the innovation process and the quality of the applicant's personal development plan. It also suggested that the best projects should be eligible for extension and that SSF create additional grants that would allow successful projects from its thematic programmes to add a mobility component. The evaluators suggested that SSF should encourage the host organisation to take employment responsibility for the grantee. (This would presumably overcome the lack of clarity academic grantees experienced about pensions – for which responsibilities were unclear.)

62 SSF board minutes 17 June 2005.

63 A. Aspgren, S. Brege, S. Josephson and B.-O. Elfström, "Rörlighet befrämjar utvecklingen – en utvärdering av programmet Strategisk mobilitet", SSF-rapport nr 14, SSF, 2011.

SSF has more widely started to discourage applications for a placement of less than 25% of the beneficiary's working time. From 2013, previous beneficiaries were allowed to re-apply to the scheme.

SSF' Framework grants attract positive comments from almost all of our interviewees and are rightly seen as integral to the operation of the Foundation, enabling it to make significant investments in research groups active in areas of strategic importance – both in the sense of those doing "strategic" research and in the sense of those working in areas of national importance. Surprisingly, given the importance of this funding instrument, it has not been evaluated in its own right. It is used in many of the SSF programmes that have been evaluated, but its characteristics do not appear to be addressed.

In some early programmes, framework proposals went through a two-stage application process. In recent years, however, assessment has been one-stage, as a result of which funding decisions take only six months to reach, which is quite rapid for an assessment process that needs to make use of international review of proposals, as well as a second stage of selecting projects based on strategic priorities.

Assessment criteria for framework proposals have remained rather consistent, certainly since 2005. Proposals need of course to be consistent with the specific (especially thematic) requirements of the call. They should be of high scientific quality and the proposer has to demonstrate an appropriate track record. They should demonstrate international cooperation among researchers and synergies with other relevant funding initiatives. Since 2007, active involvement by industry has become a requirement, responding to emerging concerns about the weak links between some SSF projects and industrial practice.

More widely, for a period in the mid-2000s, SSF reserved 3–5 per cent of project funding for commercialisation activities. In practice, this proved difficult for the researchers to implement and in 2009 SSF defined more closely what kinds of expenditure (chiefly patenting) that would be permissible under this heading.

This brief overview suggests that the design of SSF's instruments has been sound and that the Foundation has been flexible enough to make minor modifications where needed. One reason for this success from the outset will have been the transfer of people and responsibilities from Nutek that occurred early in the life of the Foundation (cf. Section 2.1). While this meant that in practice SSF found itself implementing thematic priorities that were already established at the national level, it also meant that the Foundation had a staff which had good network relationships in Swedish research and industry and which was used to consulting with relevant stakeholders and doing programme design. Taking over the Materials consortia meant that SSF acquired the latest Swedish thinking in designing centre programmes – thinking that Nutek developed into its Competence centre programme. Many new organisations have to invent their missions based on a blank piece of paper and little experience, so – despite the risk of lock-in that comes with taking an existing set of colleagues – SSF was well placed to make good design decisions from the outset.

Another aspect of the Nutek (and before it STU) funding tradition is the ability and flexibility to react to bottom-up opportunities. While this discussion goes beyond SSF's formal instruments, it is nonetheless worth noting that the Foundation has been able to flexibly act as a "troubleshooter" in the Swedish system, tackling, sometimes at short notice, needs in the funding system that state actors could not so easily address or for which it would have been difficult to release large sums of money. Such funding activities include:

- Acting as one of the "owner" foundations for the SISTER research institute for studies in research and higher education
- Co-funding the Brain Power research centre with other Swedish funders
- Co-funding a Swedish node for the European Molecular Biology Lab (EMBL)

- Co-funding a programme of competence centres to involve the Swedish research institutes, with VINNOVA and KKS
- Funding the Swedish end of research cooperation with China, Japan and the Republic of Korea
- Funding the MyFab network of Swedish clean rooms

7.2 Administrative processes

Beneficiaries, non-beneficiaries, partners and hosts have been asked to assess the Foundation's administrative processes in different dimensions. In general, interviewed beneficiaries have a positive view of the administrative processes, whereas criticism is mainly expressed by non-beneficiaries responding to the web survey. Beneficiaries describe the Foundation as professional and efficient in all processes, from calls for proposals to reporting. The proposal process is perceived as simple and straight-forward; proposals are submitted online and proposers only have to provide the most essential information, which according to beneficiaries is an appreciated difference from the requirements of many other funding bodies.

Figure 29 shows beneficiaries', non-beneficiaries', partners' and hosts' assessment of SSF's administrative processes. Overall, the assessments of SSF's processes are surprisingly positive, even those of non-beneficiaries. It seems reasonable that beneficiaries agree to the statements to a greater degree than non-beneficiaries, who probably feel slighted. It would of course be remarkable if non-beneficiaries thought highly of SSF's processes for assessment and selection of proposals, but that they also find them opaque may be more worrisome; it is also worth noting that beneficiaries are not overly impressed by the transparency of the Foundation's processes either.

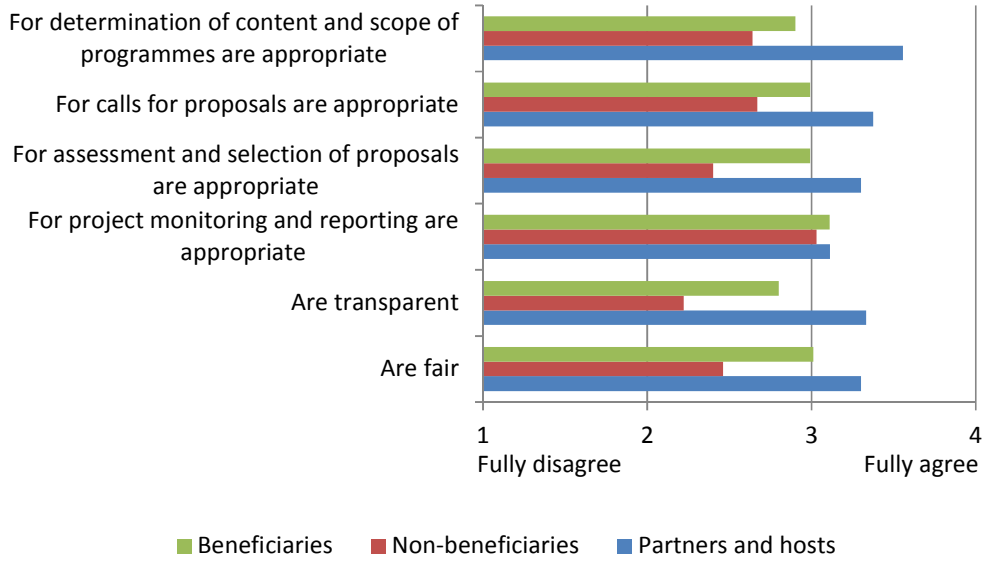

Figure 29 Beneficiaries' and non-beneficiaries' assessment of SSF's administrative processes. Statement begin with "SSF's processes…" Source: Web survey.

Most positive in all respects are partners and hosts. However, in both interviews and survey, the majority of partners and hosts point out that they are not very familiar with most of SSF's administrative processes, since these have generally been the realms of beneficiaries. Consequently, around half of survey respondents have answered "not applicable/don't know" when it comes to SSF's administrative processes, and the assessments by the remainder of partners and hosts should probably be taken with a grain of salt. The partners and hosts that nevertheless have an opinion perceive the processes as efficient, and they are particularly content with how content and scope of

SSF's programmes are determined. (Just as in Chapter 1, the group of partner and host respondents contains companies only, of which 75 per cent have more than 250 employees.)

7.2.1 Determination of programme and call contents

Although beneficiaries are rather satisfied with administrative processes, both interviewees and survey respondents point out that there is room for improvement. Several interviewees and survey respondents experience issues with the scope and content of calls for proposals. The most frequent comment is that areas in calls are too narrowly defined. While some interviewees suggest that narrow calls can be more effective as they discourage proposers who are not truly qualified, other interviewees and survey respondents believe that narrow calls inhibit competition. Many competent and distinguished researchers are disqualified from applying, say interviewees, which might prevent novel areas from evolving. As previously mentioned, the flexibility that SSF grants give, for example to address high-risk projects, are appreciated, and both interviewed beneficiaries and non-beneficiaries would like more focus on new research areas. However, some survey respondents express an understanding of narrow calls; an organisation as small as SSF probably cannot assess too many proposals.

Both interviewees and survey respondents articulate that it is unclear on what grounds a certain area was chosen. Some beneficiaries, including a partner, worry that that areas may have been influenced by researchers involved in planning a call, which may favour their own research field and ultimately themselves. As described in Section 2.2.1 the five main areas in SSF's current research strategy were defined through a dialogue with academia and industry. Despite this, some interviewees wish for a more comprehensive dialogue between researchers and SSF in selecting future programme areas, to prevent the process from being perceived as arbitrary.

Some researchers would like more time to prepare proposals, especially when it comes to large collaborative projects for which it takes time to assemble consortia. Many survey respondents ask for recurring opportunities to continue their research projects with SSF funding in order to maintain long-term research capacity within specific areas, while others would like to see a plan for upcoming calls, so researchers can plan ahead.

7.2.2 Proposal assessment

Similar to concerns regarding the processes for determination of programme and call content, interviewees of all categories express that the Foundation's processes for assessment of proposals lack transparency. In the web survey, non-beneficiaries state that it is difficult to comprehend on what ground proposals were rejected and wish for more comprehensive written feedback to proposers.

Moreover, survey respondents claim that assessment criteria put too much emphasis on proposers' CVs, rather than on the potential of the proposed projects. This opinion is particularly expressed by non-beneficiaries of the FFL programme, as well as by a project partner, who believe that grant recipients were not chosen based on their future potential, but on existing merits. This is not only considered unfair, but SSF is said to miss out on the chance to support promising young researchers. A beneficiary explains:

> *This just leads to bigger groups, but not necessarily better research or better outcomes. A big group will always outperform a significantly smaller one, but rarely per person or per invested krona.*

Both beneficiaries and non-beneficiaries worry about conflicts of interest in proposal assessment, and suggest that SSF should avoid using Swedish experts as external evaluators, and possibly also introduce blind reviews.

7.2.3 Support during projects

The Foundation is considered supportive to beneficiaries during projects. Particularly FFL beneficiaries praise the opportunities for interaction with programme managers,

who are described as very helpful. The Foundation has organised workshops for all FFL beneficiaries, and the leadership course is also mentioned as a great opportunity to interact with SSF staff and other beneficiaries. Interviewed beneficiaries of the other programmes are also happy with SSF's support, and believe that it is easy to get in touch with SSF staff when necessary.

The Foundation is described as having a pragmatic approach to project plans. One interviewee recalls how he was able to alter his initial project plan, which gave him the freedom to act on new opportunities that appeared in the course of the project. Others mention that SSF is very flexible in allowing beneficiaries to extend project periods (albeit without additional funding).

Routines for reporting are also described as pragmatic, and reporting requirements are considered adequate. Many interviewees and survey respondents describe SSF's reporting requirements as being more reasonable than those of other funding bodies. As one beneficiary explains:

> *As a researcher, I feel like I am trusted to perform this task without excessive control; there is no suspicious follow-up on SSF's part. Other funding bodies should follow SSF's example.*

The only criticism made regarding interaction with the Foundation during the conduct of a project concerns the Mobility programme. Academic researchers who conducted research in industry found it difficult to comply with the *perceived* requirement from SSF that researchers should be employed by the host organisation. While this in fact was not an SSF requirement, several interviewees clearly thought it was, thus constituting a problem. Some remained employed in academia and had to deal with large overhead costs. Others were employed by the company, but found that they missed out on pension payments, or had to remain part-time employed at the university, which ultimately led to unnecessary stress.

7.3 Administrative efficiency

Table 5 compares selected R&D funding bodies' administrative efficiency as a ratio of operational costs and disbursed funding. For SSF, Mistra and KKS, asset management costs have not been included in operational costs (in order to make the comparison with government agencies fairer). To even out fluctuations between years, the table provides an average over three years, 2011–2013.[64] While a comparison such as this may provide some valuable insights, conclusions nevertheless should be drawn with care since the comparison does not take differences in mission into account, and there may also be differences in accounting principles (at least between countries).

The table illustrates that SSF appears to be quite efficient compared with its wage-earner fund sisters Mistra and KKS. SSF itself frequently refers to its role between VR and VINNOVA, and we see that while VR has lower relative administrative costs, VINNOVA's are considerably higher. However, as government agencies, both VR and particularly VINNOVA have other missions than to award research funding, which SSF does not, which at least in part explains VINNOVAs considerably higher relative costs. As for other Nordic innovation agencies, Tekes has a similar mission to VINNOVA's, whereas the Research Council of Norway is both research council and innovation agency.

64 For Tekes, 2011–2012.

Table 5 Selected R&D funding bodies' average administrative efficiency 2011–2013. Sources: Annual reports.

Funding body	Administrative efficiency
Wage-earner fund foundations	
SSF	6.2%
Mistra	12.2%
KKS	17.1%
Swedish research councils	
Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas)	5.8%
VR	6.6%
Swedish Research Council for Health, Working Life and Welfare (Forte)	8.4%
Innovation agencies	
Finnish Funding Agency for Technology and Innovation (Tekes)	5.2%
Research Council of Norway (RCN)	7.1%
VINNOVA	11.5%

8. Discussion

8.1 Do the programmes lead to the impact envisaged by SSF's statutes?

The evidence presented in this report indicates that the Swedish Foundation for Strategic Research in most respects has fulfilled its statutes. The five programmes that have been the focus of this study have contributed in different ways. The SFC, IT, Materials and FFL programmes funded large research efforts that either strengthened existing university-based research groups and networks of groups, or established new research groups. Grants in these programmes were of a magnitude rarely seen in Sweden at the time, which meant that their impact in terms of concentration of efforts and thus development of critical mass for research groups, including recruitment of senior researchers and PhD students, were quite significant. The network character of SFC, IT and Materials projects facilitated interdisciplinarity, while the Mobility programme was particularly effective in achieving inter-sectoral mobility.

However, when it comes to collaboration between academia and industry and industrial relevance of the research performed, this study finds that (except for the Mobility programme) the academic–industry link has not been particularly strong or well-functioning. Clearly, the link was strong in some projects, but they were in a minority. In many projects, the "industrial relevance" comprised what university researchers believed ought to have been of interest to industry, with little or no endorsement from industry. Moreover, in many projects industrial involvement was weak or non-existent. There is thus a major risk that research results remain unexploited by (Swedish) industry, either because the results are not relevant (in the eyes of industry), or because industry is not aware of their existence (or realise their commercial value). It may indeed be that the research performed is of "significance for the development of Sweden's long-term competitiveness", as beneficiaries assert, at least in terms of academic competitiveness. However, given the weak academic–industry links in all programmes but Mobility, much of the research risks remaining, at best, of *potential* significance for Swedish industry's long-term competitiveness.

It is clear that SSF in practice has put quite some effort into establishing academic–industry links (e.g. by including industry representatives in programme and proposal-evaluation committees, and by (in project monitoring) asking for beneficiaries' assessment of impact in industry and society), but the evidence presented herein implies that this effort has not been sufficient. In the future, SSF may at project level want to consider introducing a requirement that beneficiaries have non-academic partners, if not active in the research, at least in some form of formalised advisory function. Such a requirement would make beneficiaries place some focus on nurturing industry relations, thus increasing the chances of the research truly being "of particular interest to industry".

8.2 Scientific productivity and collaboration

Bibliometric evidence about the publication performance of SSF beneficiaries provides a mixed picture and needs to be read with care. In many cases, SSF is one of a number of alternative sources of funding, so it is hard to construct a clean "non-treatment group". Further, publication outputs are only one of the intended results of the grants, so bibliometric evidence alone is insufficient to provide an overall judgement.

FFL beneficiaries experienced a significant increase in publication productivity, whereas a control group of non-beneficiaries saw a slight decrease. Differences were not very large, indicating that the group of non-beneficiaries were more or less equally capable and successful as the group of beneficiaries, and the non-beneficiaries obviously managed to fund their research through other grants.

On the other hand, except for the beneficiaries of the IT programme, neither framework nor SFC grants led to overall increases in publication productivity. Several of the IT grant beneficiaries were quite junior when receiving the grant and were working in new

areas, whereas beneficiaries of the Materials and SFC programmes were more established, indicating that significant increases in publication productivity are more likely in emerging areas and/or from up-and-coming researchers. If a significant increase in publication productivity is sought, then support should perhaps be targeted at young researchers working in promising new areas. If other impact is also of interest, such as potentially important innovations for implementation in established companies, centre-type grants have a role.

Beneficiaries of all programmes studied increased their international visibility in terms of internationally co-authored publications. Since many activities in all programmes to a certain extent focused on collaboration and mobility, this positive result should come as no big surprise. International networks have been extended, which has stimulated co-authored publications. However, it is important to note that Swedish authors generally co-publish strongly and that the overall level of co-publications is being driven upwards by a range of factors over and above SSF's funding.

Collaboration, whether international or not, is indeed important for the growth of groups and evolution of research topics, but also for the quality of the work conducted and the development of groups' and researchers' competitiveness. It is largely long-term collaboration and interaction within and between research groups that explain such progress. When grants are used for both incoming and outgoing post-docs, visiting scholars and guest teachers; funding of postgraduate students; and facilitating collaboration between senior researchers; interesting things happen. Such collaboration leads to an influx of ideas, as well as new ways to investigate and re-investigate hypotheses and theories, and established knowledge and working practices are thus critically assessed from new and diverse perspectives. In short, collaboration tends to lead to growth, quality enhancement and increased competitiveness. This is what we have seen in the SSF programmes, as well as in other evaluations of similar programmes.[65]

8.3 Value for money?

SSF granted a total of SEK1.1bn through the five programmes. Knowing what we now know, was this a good investment?

In academic productivity terms, the five programmes co-produced almost 700 PhD degrees and in excess of 4,000 papers, as well as more than 100 granted patents. Had it been possible to attribute all of this exclusively to SSF's funding, then it would have been a fantastic outcome, and the answer to the initial question would have been a resounding "yes".

However, by "co-produced" we of course mean that no research group or postgraduate student survives on one grant only. To illustrate this, consider that the full cost for an engineering PhD degree in Sweden is approximately SEK4m; SEK1.1bn would then get us up to 275 PhD degrees and possibly a bit more than 1,100 journal papers (generously assuming four papers per thesis).

In addition, the SSF grants contributed to the development of a number of successful university-based research groups and networks, with some degree of industry collaboration. The grants also meant a lot for many researchers' careers, particularly the ones that were not so experienced when receiving the grant. Altogether, the five programmes have no doubt significantly contributed to the beneficiaries' long-term competitiveness.

However, given that SSF's statutes specify that one of the seven things that the Foundation's activities shall be distinguished by is "collaboration between academia

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65 P. Stern, A. Håkansson, S. Stålfors, M. Terrell, E. Arnold, C. Enzing and G. Melin, "Evaluation of two Nordic Centres of Excellence Programmes. The Programme on Food, Nutrition and Health 2007-2011 and the Programme on Welfare Research 2006-2011", NordForsk Policy Paper 4,-2014.

P. Stern, E. Arnold, M. Carlberg, T. Fridholm, C. Rosemberg and M. Terrell, "Long Term Industrial Impacts of the Swedish Competence Centres", VINNOVA, VA 2013:10, 2013.

and industry in areas of particular interest to industry", we interpret "Sweden's long-term competitiveness" as also including industrial and societal impact.

The five programmes appear to have contributed to the establishment of more than 60 spin-off companies, but – just as for PhD degrees, papers and patents – these can only be attributed in part to SSF grants. In fact, the attribution to SSF funding is probably much less for the spin-off companies than for PhD degrees, papers and patents, particularly when it comes to the companies' survival; witness the combined annual losses of around SEK150m per year in Figure 25. In terms of societal impact, the spin-off companies now provide more than 200 jobs and thus taxes paid by both companies and employees. Hopefully, some of these spin-off companies will develop favourably in the longer term. The PhDs co-produced are of course another important societal impact in that they contribute to their employers' competitiveness.

In the beginning of this chapter, we concluded that the weak academic–industry links may mean that much of the research performed remains of *potential* significance for Swedish industry's long-term competitiveness. This is a lost opportunity. It seems unlikely that stronger academic–industry links would have had any notable negative impact on the aforementioned academic achievements, but strong links with established companies (as opposed to spin-off companies) would have significantly increased the overall societal payback on SSF's investment by also strengthening established Swedish companies' competitiveness.

8.4 Lessons learnt

SSF's administrative processes are almost universally praised, although most stakeholders would like to see more transparency in terms of how the scope of calls is determined and more detailed feedback on proposal rejections. In spite of significant efforts already made in these respects, there is a lingering uncertainty and a degree of discontent among stakeholders (that of course can never be completely eliminated).

There is some criticism that SSF has supported today's researchers rather than those of the future, and that too much emphasis is placed on past merits instead of on future potential. Part of this argument is that it creates undue concentration of funds to a few individuals, to the detriment of proposers who possibly could have made better use of the funding. As regards the FFL programme, SSF appears to have already learnt the lesson, but considering that success rates have become very low, the time may be ripe to introduce a more restrictive eligibility criterion so as to reduce the waste of proposal effort associated with such low rates.

In the Mobility programme there have been issues with temporary change of employers for beneficiaries, and universities charging undue overheads. If these matters have not yet been sorted out, they ought to be.

SSF's different instruments are designed to accomplish different things, and we can conclude from this study that indeed they do. Scientific results; impact on both organisational, network and systems levels; funding of subsequent research; personal development and career boosts; increased productivity and visibility; and increased competitiveness are all achievements that follow from SSF's funding. These results and impact do not appear in sequence, one after the other according to an unambiguous and simple causal relationship, but rather in a somewhat messy pattern, characterised by inter- and path dependencies, and where processes do not necessarily start with research.[66] SSF ought to maintain a carefully designed mix of instruments that correspond to a set of objectives that go beyond what is traditionally considered research-related. There is much to be gained by these types of objectives being explicitly stated, and crafted in collaboration with stakeholders.

A comparison with other research funding organisations reveals that SSF appears to be significantly more administratively efficient (administrative costs divided by funding

[66] R. Rothwell, "Towards the Fifth-generation Innovation Process", *International Marketing Review*, 11 (1), 7-31, 1994.

granted) than its sister foundations Mistra and KKS. SSF is also considerably more efficient than VINNOVA, although VINNOVA admittedly has other missions than to award research funding, which makes the comparison a bit unfair to VINNOVA. SSF's administrative efficiency is at the same level as that of the three Swedish research councils that, just like SSF, mainly award research grants. However, being more or less "best in class" in terms of administrative efficiency may have its drawbacks. As discussed in Section 5.3, the absence of an analysis department of its own may mean that signals suggesting that some form of important change is needed, such as a need to strengthen projects' industry links, are not received.

Apart from the adverse effects on achieving industrial impact, weak academic–industry links also constitute a methodological challenge. As mentioned in Section 1.2, we have had to ask SSF beneficiaries who their partners, or stakeholders, outside academia were, since SSF has not asked beneficiaries that question. Some beneficiaries responded that there had not been any non-academic partners, while others did not respond at all. Some of the partners thus disclosed did not consider themselves as having been sufficiently involved in the project to have an opinion on it and its potential value for their organisation, meaning that the quality of the information we received left something to be desired. This clearly means that we have not reached all the "right" partners, and there is a possibility that there are significant examples of impact that we have not come across. It could be a wise move if beneficiaries were to be obliged to supply SSF with contact information to non-academic partners, and that SSF systematically documented this information. Such a requirement would facilitate future tracing of impact, while at the same time helping beneficiaries to focus on industry relations, as discussed in the beginning of this chapter.

Another methodological issue is that the projects of the five programmes studied were concluded between two and six years ago, which is a comparatively short time span for significant impact in industry to have occurred. Previous major evaluations and impact assessments of long-term collaborative R&D programmes (where academic–industry links have been strong) indicate that the time spans from R&D results to commercial reality may range from 5 to 20 years depending on industry, product, application etc. At the far end, is the aerospace industry with up to 20 years[67], while time frames in the automotive industry[68] and in manufacturing industry in general[69] appears to be in the order of half as long, and in some applications in IT and electronic communications occasionally somewhat less[70] (cf. SSF's expectation that impact in industry should materialise within 5–15 years after project conclusion, recently reduced to 5–10 years). Had we looked at a selection of programmes or projects from SSF's first decade, the chances of being able to document significant impact would in principle have been better. However, getting in contact with beneficiaries' partners would probably have been an even greater challenge than it has now proved to be.

8.5 Does SSF have special or unique opportunities?

While the birth of the Foundation was a side-effect of political events external to the research and innovation system, like the other wage-earner fund foundations it was

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67 T. Åström, T. Jansson, P. Mattsson, H. Segerpalm and S. Faugert, "Evaluation of the Swedish National Aeronautics Research Programme – NFFP" ("Utvärdering av det Nationella flygtekniska forskningsprogrammet – NFFP"), VINNOVA, VR 2008:05, 2008.

68 S. Faugert, E. Arnold, M.-L. Eriksson, T. Jansson, P. Mattsson, L. Niklasson, P. Salino, H. Segerpalm and T. Åström, "Effekter av statligt stöd till fordonsforskning – Betydelsen av forskning och förnyelse för den svenska fordonsindustrins konkurrenskraft", VINNOVA, VA 2009:02, 2009.

69 T. Åström, T. Jansson, P. Mattsson, S. Faugert, J. Hellman and E. Arnold, "Effektanalys av stöd till strategiska utvecklingsområden för svensk tillverkningsindustri", VINNOVA, VA 2010:05, 2010.

T. Åström, J. Hellman, P. Mattsson, S. Faugert, M. Carlberg, M. Terrell, P. Salino, G. Melin, E. Arnold, T. Jansson, T. Winqvist and B. Asheim, "Impact assessment of strong research and innovation systems" ("Effektanalys av starka forsknings- och innovationssystem"), VINNOVA, VA 2011:07, 2011.

70 P. Stern, E. Arnold, M. Carlberg, T. Fridholm, C. Rosemberg and M. Terrell, "Long Term Industrial Impacts of the Swedish Competence Centres", VINNOVA, VA 2013:10, 2013.

endowed with a high degree of freedom, at least formally. Its thematic scope is broad, the range of types of research it can fund is wide and it has governance and financial assets that largely make it independent of the state.

SSF chose (under some duress) to take over some of the important funding themes in enabling technologies, about which there was quite widespread agreement – ICT, life sciences and materials – and also to handle a number of other smaller themes. As a new organisation, it was able to put new kinds of funding instruments in place that would have a structural effect on the research community, promoting agglomeration and building strength around excellent researchers in areas of likely importance to industrial development and competitiveness.

Beneficiary-governed organisations tend to be change-averse. SSF's governance is *de facto* dominated by academics. This has led it to stay true to the themes with which it began and to set funding conditions that do not enforce close involvement of industry. As mentioned earlier in this chapter, this has been to the detriment of the effectiveness of many of the projects. The extent to which there has been innovation in SSF's instruments during its second decade has been modest, though this trend may be in the process of being broken by the launch of the Industry graduate projects and Research industrial fellowships schemes in 2014.

The downside of SSF's independence from the state is that it is not in a strong sense answerable to anyone. The Royal Swedish Academy of Sciences (KVA) and IVA have the right to evaluate the Foundation, but there is no system of checks and balances at the level of policy that creates tension between SSF and the world around it. Such checks and balances would reduce the opportunities for the kinds of lock-in that SSF displays.

SSF's governance could benefit from reforms that:

- Increase the influence of industry (though that influence should still be less strong than that on research overall, otherwise the Foundation will start funding overly short-term work)
- Bring that influence to bear at the project level by ensuring that there is an industrial component
- Increase the amount of strategic intelligence the Foundation acquires and has to react to. Potentially, it could use this increase in strategic intelligence to become a more active contributor to national and international research policy debates
- Provide the Foundation more clearly with someone to answer to. This could be parliament (in the style of the Finnish Innovation Fund Sitra); an external supervisory board; or SSF could choose to engage in dialogue with the state itself, recognising that this is SSF's choice and not an obligation

8.6 How does SSF fit with other funders?

The type of "strategic" research that SSF funds is in principle different from, and needs different governance compared with, either traditional basic research or application-/commercialisation-driven R&D. The logic of such research does not follow the "linear model" of basic research leading to application, but rather operates the other way round: from problems to more fundamental research.

The historical development of the organisations funding fundamental engineering research in Sweden testifies to the difficulty of trying to combine the funding of strategic and other forms of research, but also to the potential vulnerability of a funding organisation taking on such a role. SSF's own description of itself as "in between" VR and VINNOVA underlines the vulnerability of the role. It is also unduly negative, as if the role were of lesser importance; in fact, it is not only vital, but increasingly so as the nature of technology becomes more and more scientific.

The evolution of the Swedish funding system since 1994 has effectively involved the state handing over the strategic funding function to SSF and adapting its own agencies to avoid the resulting "hole". As Figure 27 and Figure 28 imply, that creates another hole

for the state if and when it wants to implement a policy for strategic research: it does not have its own agency and it does not have a budget. If the state is to evolve a coherent and holistic research policy, then it needs to re-establish a role in strategic research funding, not least since this is one of the most dynamic sources of innovation and industrial development over the longer term. This policy problem is exacerbated by the poor level of coordination in the Swedish research policy and funding system as a whole. We return to SSF's options concerning the rate at which it runs down its funds later in this chapter. However, on the current declining trend:

- The state needs to bring strategic research back into the mainstream and develop a policy for its role – and the role of others – in funding it
- SSF seems unlikely to be able to afford to tackle as much of the strategic research funding need as was earlier possible, so it needs to develop a more niched strategy

8.7 Are areas under- or over-funded?

Given that different parts of industry exhibit differences in research needs and intensity, there is no simple metric that connects the "right" amount of funding with industry structure. Equally, the needs of national industries and individual companies vary within individual branches of industry, depending for example upon their strategies.

A recurring niggle in our interviews (and also in some of the documentary material) is a complaint the SSF has over-focused on emerging and enabling technologies, at the expense of those that serve more traditional industry. The latter is also "strategic" in the sense that Sweden's major industries need to have a sound technological base and strong innovation opportunities in order to remain competitive. Nonetheless, the choice was made to focus on new and enabling technologies in line with something of a national consensus on research policy priorities. That choice has produced many useful results. At this point, we cannot explore the counterfactual possibility of having focused on more traditional areas. However, it is a clear weakness that SSF fails to shift its thematic trajectories much, suggesting that there is a need to introduce more evidence and debate from time to time in the process of setting thematic priorities. As things stand, SSF itself is not in a position either to make a judgement about the validity of the thematic balance of its past investments.

Moreover, one might argue that it is not necessarily a question of more (or less) funding that is the answer, but rather more of a governance issue. SSF's role is arguably somewhere between those of VR and VINNOVA, and SSF has set out to do things that these two government agencies cannot. However, in practice SSF may have come too close to VR's territory, and the weak academic–industry links have made the SSF-funded research insufficiently relevant to industry, and to a certain degree also unknown to it. In such a situation, more funding cannot compensate for the fact that SSF's funding has not been sufficiently focused on providing scientific solutions corresponding to authentic industry needs.

8.8 Is SSF needed?

A key line of argument in this report is that SSF has inherited the "strategic funding" role in the Swedish system, and that as a result the state funding apparatus has adjusted to its presence. If, as we argue, the role is important then under the current arrangements the Foundation is needed, as existing government agencies are not structured to take on the job. Since the Foundation's funds are finite and the need to fund strategic research is permanent, there has to be some sort of transition whereby the state assumes its responsibility again. A number of transitions might be possible:

- One where the state establishes its own strategic research funding agency, cooperating with SSF over time to ensure a sensible division of labour
- One where the state and SSF enter into a contract, whereby SSF acts as an agency for the state-funded part of its role, in addition to the tasks that it already performs with its declining resources

- One where SSF chooses to provoke a crisis, by maintaining a high level of spending in the knowledge that when the money runs out the state will be saddled with a problem
- One where – taking an idea from the Wellcome Trust in the UK – SSF offers to match new and additional strategic research funding by the state krona for krona, thereby using its limited funds to prompt the state into action

The next research bill should be presented to parliament in 2016, which means that its contents will be negotiated during the course of 2015. It would therefore be timely for SSF to begin discussions now with the government about such possible future arrangements. Ultimately, if SSF does not like the answer it gets, it can wait for the following government when the situation is even more pressing. However, since there needs to be a transition, it would seem sensible to establish that fact and begin thinking about how to organise it as soon as possible. If SSF were to disappear – quickly or slowly – without arrangements being made to replace its function within the research funding system, the consequences for Swedish industry and research would be significant.

Appendix A Interviewees and participants in focus group and interpretation seminar

A.1 Interviewees

Bengt Ahlgren	SICS Swedish ICT
Joakim Amorim	SSF
Carin Andersson	LTU
Per Andersson	Formerly Switchcore
Ewert Bengtsson	UU
Mats Benner	LU
Magnus Berggren	LiU
Martin Bergö	GU
Dan Brändström	KVA
Björn Dahlbäck	LU
Enrico Deiaco	Swedish Agency for Growth Policy Analysis
Lennart Elg	Formerly VINNOVA
Per Eriksson	LU
Katarina Flemmer	Tetra Pak
Anders Flodström	EIT ICT Labs
Magnus Frodigh	Ericsson
Mikael Gröning	Ministry of Enterprise, Energy and Communications
Leif Hammarström	LU
Per Hammarström	LiU
Christer Heinegård	Formerly Nutek
Anna Herr	CTH
Olof Hugander	Ministry of Enterprise, Energy and Communications
Sture Hägglund	LiU
Anders Höök	Saab AB
Kristina Höök	KTH
Alexander Kaplan	LTU
Bengt Kasemo	CTH
Sten Eirik Jacobsen	University of Oxford
Karl H. Johansson	KTH
Alwyn Jones	UU
Mats Johnsson	Ministry of Education and Research
Stefan Jonsson	KTH
Magnus Jändell	FOI
Gunilla Jönson	LU

Christer Larsson	Saab Dynamics
Carola Lemne	Praktikertjänst
Urban Lendahl	KI
Hans-Gustaf Ljunggren	KI
Lennart Lübeck	Stockholms Affärsänglar
Leif Karlson	AkzoNobel
Göran Klang	Ericsson
Klas Kärre	KI
Jörgen Larsson	LU
Johan Lindman	Stora Enso
Lennart Ljung	LiU
Göran Marklund	VINNOVA
Jan-Olof Nilsson	Sandvik
Ove Nilsson	SLU
Staffan Normark	KVA
Knut Petterson	Athera Biotechnologies
Magnus Rilbe	AB Volvo
Ulf Sandström	KTH
Lena-Kajsa Sidén	SSF
Lennart Stenberg	VINNOVA
Åsa Strand	UmU
Jan-Eric Sundgren	AB Volvo
Samuel Svensson	AstraZeneca
Balganesh Tanjore	AstraZeneca
Louise de Verdier	AB Volvo
Bo Wahlberg	KTH
Juleen Zierath	KI
Mikael Åkerholm	Maximatecc
Karl-Erik Årzén	LU

A.2 Participants in foresight focus group on 2 September 2014

Joakim Amorim	SSF
Per Andersson	Formerly Switchcore
Sofie Björling	Formas
Åke Iverfeldt	Mistra
Lars Hultman	SSF
Mattias Lundberg	SSF
Lennart Låftman	
Göran Marklund	VINNOVA

Birgitta Palmberger	Swedish Energy Agency
Madelene Sandström	KKS
Lars Wärngård	Forte
Erik Arnold	*Technopolis Ltd.*
Peter Stern	*Faugert & Co Utvärdering (Technopolis Sweden)*
Tomas Åström	*Faugert & Co Utvärdering (Technopolis Sweden)*

A.3 Participants in interpretation seminar on 16 September 2014

Joakim Amorim	SSF
Mattias Blomberg	SSF
Gunnar Brandt	Sandvik
Jan Fahleson	SSF
Inger Florin	SSF
Robert Forschheimer	LiU
Greta Fossum	Skogsindustrierna
Lars Hultman	SSF
Bengt Kasemo	CTH
Mirka Mikes Lindbäck	ABB
Olof Lindgren	SSF
Lennart Ljung	LiU
Bengt Nielsen	F.d. GE Healthcare
Lena-Kajsa Sidén	SSF
Lars Sjöström	Saab AB
Henryk Wos	SSF
Anna Wredenberg	KI
Peter Stern	*Faugert & Co Utvärdering (Technopolis Sweden)*
Miriam Terrell	*Faugert & Co Utvärdering (Technopolis Sweden)*
Tomas Åström	*Faugert & Co Utvärdering (Technopolis Sweden)*

Appendix B Abbreviations

CAS	Centre for Autonomous Systems at KTH
CIM	Centre for Infectious Medicine at KI
CTH	Chalmers University of Technology
ERC	European Research Council
FFL	Future research leaders (*Framtidens forskningsledare*)
FOI	Swedish Defence Research Agency (*Totalförsvarets Forskningsinstitut*)
Formas	Research Council for Environment, Agricultural Sciences and Spatial Planning
Forte	Swedish Research Council for Health, Working Life and Welfare
FP	EU Framework Programme
GU	University of Gothenburg (GU)
ICT	Information and communication technologies
IEEE	Institute of Electrical and Electronics Engineers
IKST	Information, communication and systems technology (*Informations-, kommunikations- och systemteknik*)
IT	Information technology
IT programme	Framework grants in Information technology (IT)
KI	Karolinska Institutet
KKS	Knowledge Foundation (*Stiftelsen för kunskaps- och kompetensutveckling*)
KTH	Royal Institute of Technology
KVA	Royal Swedish Academy of Sciences (*Kungl. Vetenskapsakademien*)
LiU	Linköping University
LTU	Luleå University of Technology
LU	Lund University
Materials programme	Framework grants in Materials science
Mistra	Swedish Foundation for Strategic Environmental Research (*Stiftelsen för miljöstrategisk forskning*)
Mobility programme	Strategic mobility
NFR	Naturvetenskapliga forskningsrådet
Nutek	Närings- och teknikutvecklingsverket 1991–2000, Verket för näringslivsutveckling 2001–2009
PI	Principal investigator (meaning project leader)
RCN	Research Council of Norway
RJ	Swedish Foundation for Humanities and Social Sciences (*Riksbankens Jubileumsfond*)

RTO	Research and Technology Organisation
R&D	Research and development
SCB	Statistics Sweden (*Statistiska centralbyrån*)
SFC	Strategic research centres (*Strategiska forskningscentra*)
SIDA	Swedish International Development Agency
SLU	Swedish University of Agricultural Sciences
SNSB	Nutek and the Swedish National Space Board
SSF	Swedish Foundation for Strategic Research (*Stiftelsen för strategisk forskning*)
STINT	Swedish Foundation for International Cooperation in Research and Higher Education (*Stiftelsen för internationalisering av högre utbildning och forskning*)
STU	Styrelsen för teknisk utveckling
SU	Stockholm University
Tekes	Finnish Funding Agency for Technology and Innovation
TFR	*Statens tekniska forskningsråd* 1942–1968; *Teknikvetenskapliga forskningsrådet* 1990–2000
UmU	Umeå University
UU	Uppsala University
VINNOVA	Swedish Governmental Agency for Innovation Systems
VR	Swedish Research Council (*Vetenskapsrådet*)

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