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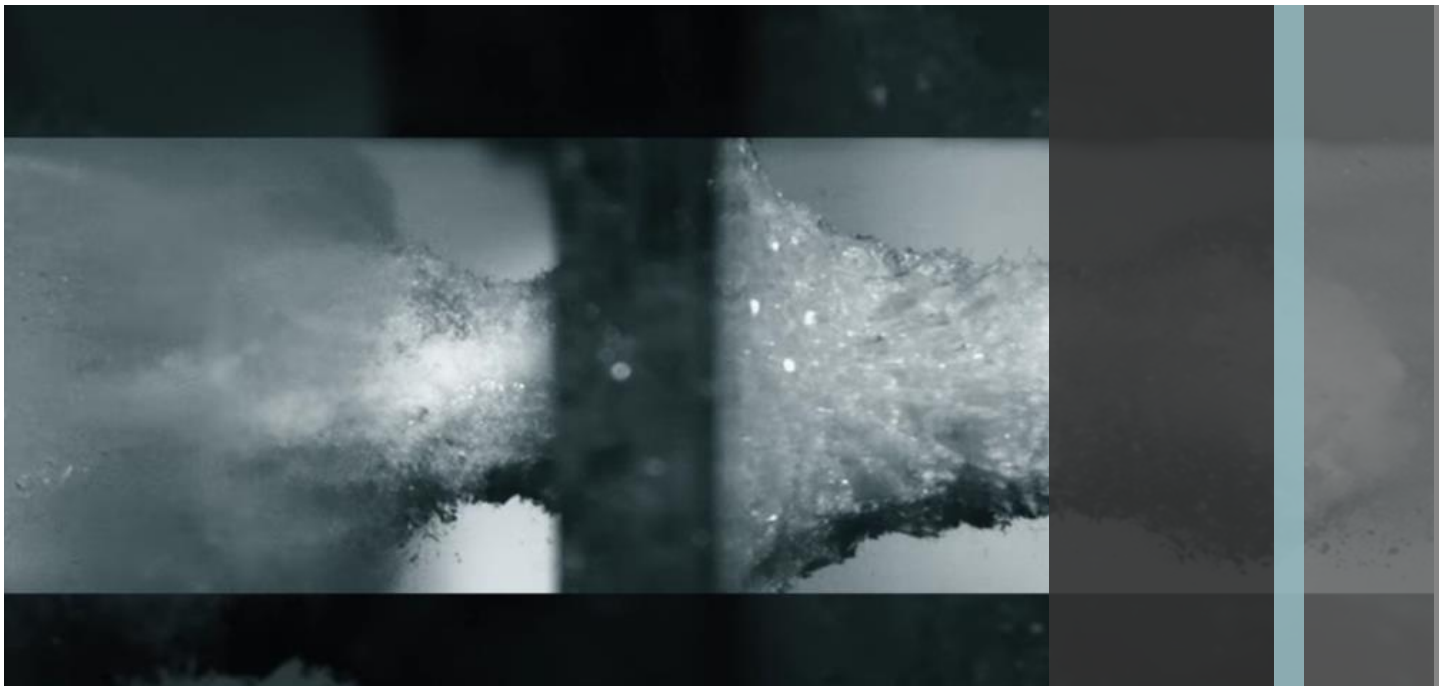

31 January 2018

Evaluation of the Scheme for Research-based Innovation (SFI)

Report for The Research Council of Norway

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Frontpage picture: SFI Casa presentation video.
http://sfi-casa.no/sfi-casa-video/

Content

Executive Summary

This report contains the results of the evaluation of the Norwegian Scheme for Research-based Innovation (SFI). The objective of the SFI scheme is to promote innovation by supporting long-term research through close cooperation between R&D intensive companies and prominent research institutions. A vital role of the SFI centres is furthermore to educate doctoral students who will pursue careers in industry. Since its inception in 2005, the SFI scheme has supported 38 centres in three generations, encompassing consortia of research institutions and commercial actors from all across Norway. The first generation of 14 SFI centres concluded their period of operation in 2015, which leaves 24 centres currently active.

A team of analysts and researchers from DAMVAD Analytics, Cambridge University and Rand Europe has evaluated the SFI scheme by a multitude of methods, including quantitative data analysis, interviews, questionnaire surveys, document studies, workshops and bibliometric analysis.

The purpose of the evaluation is twofold, according to the mandate:

- To provide insight into the goal fulfilment of the SFI scheme.
- To deliver proposals for the adaptation and amendment for further development of the SFI scheme.

Regarding goal fulfilment, the evaluation answers the following five questions:

1. To what extent has the SFI scheme contributed to stimulating innovation and internationalization?
2. To what extent has the SFI scheme contributed to creating active cooperation between an innovative business community and prominent research communities?
3. To what extent has the SFI scheme provided for greater long-term, continuity and risk reduction in given research areas?
4. Has the SFI scheme helped to strengthen and further develop the best Norwegian, business-oriented R&D environments – nationally and internationally?
5. What systematic differences in goal fulfilment and effectiveness can be identified between the SFI centres and what does it tell us about the factors that shape goal achievement?

Regarding proposals for further development of the SFI scheme we explore the following:

6. What is the significance of changes in framework conditions and in the research and innovation system nationally and internationally?
7. Are there limitations in the design of the SFI scheme that may hamper the establishment of future centres targeted at the public sector and the services sector?
8. What changes should be made in the SFI scheme in order to increase the goal fulfilment and value creation of the scheme?

Overall Impressions

The SFI scheme has within the period evaluated (2007-2016, both years included) brought more than 500 partners from industry, research and the public sector together in 38 centres each with distinct profiles and specialisations. The overall impression across all the evaluation results is that the SFI scheme performs well in facilitating close cooperation between R&D-performing companies and prominent research groups. The research is generally of a high quality, and the scheme makes an important contribution to enhancing researcher training in areas of importance for the Norwegian

business sector and society at large. The insights from evaluation suggest that while the SFI succeeds in educating and employing a great number of academic staff, there are some improvements which might increase the degree of knowledge transfer to the Norwegian private sector. Overall, however, both the research community and the private sector participants benefit from access to qualified personnel and knowledge upgrading.

There is a high overall satisfaction with the scheme among both participants and stakeholders. Nearly 90 pct. of all respondents report that the SFI centre they are part of, is a success. Furthermore, there is a high degree of satisfaction with the consortia agreements and with centre management as well as with the management of the scheme by the RCN. Also, the host institutions were for the vast majority of respondents considered helpful in providing good facilities and working conditions for research and innovation in the centres.

However, the evaluation also reveals a number of challenges suggesting areas of attention where the SFI scheme performs less well or not as well as could be expected given the objectives and measures of the scheme. The evaluation is not able to identify convincing results regarding the SFI schemes' contribution to innovation, commercialisation and internationalisation. It is also apparent that the industry partners are not as active in the research-based activities of the centres as one should expect. Also, the evaluation reveals challenges in regard to the research competences of the companies and the innovation competences of the researchers. Finally, the evaluation finds that the SFI scheme is not functioning well when it comes to supporting service innovation and public-sector innovation.

It should be noted however, that the above results cover a great variety of results for individual centres that we do not report on. According to the mandate, the evaluation concerns the SFI scheme as a whole and is not intended to be an evaluation of individual centres. Throughout the evaluation results are presented either in total or across the three SFI generations. It should be noted that as SFI-III has only been in operation for two years, the results are interpreted with caution.

The analysis of the results created under the scheme has led the evaluation to focus on changes in framework conditions and factors that support or challenge the schemes effectiveness and goal attainment. On this basis a number of new or higher ambitions have been formulated and specific changes are suggested for the SFI scheme. In the following we summarise all results linked to the key questions of the evaluation.

The SFI scheme's contribution to innovation and internationalisation

Measured by innovations, the SFI scheme has reportedly contributed to almost 300 innovations and 200 commercialisations. 14 pct. of the participating companies have introduced goods or services that are considered new to the industry or market during the past three years due to the SFI scheme. In total 13 new companies have been created as part of the SFI scheme.

Almost 80 pct. of all the partners (both industry and research) believe that their SFI centre has made innovations that will strengthen the sector or industry they are part of. We also find that the SFI centres produce more over time measured by both innovations, commercialisations, scientific publications and disseminations, which are all increasing, by centre per year.

Respondents predict that research and innovation results will continue well into the future – even those from the centres finalised in the first generation (SFI-I).

The SFI scheme contributes to internationalization primarily by increasing the partners' international network and reputation and improving access to and recruitment of research personnel. When it comes to research, 44 pct. of all articles are co-authored with international authors.

The evaluation has identified two challenges regarding the SFI scheme's contribution to innovation and internationalization. Firstly, centre leaders report a number of innovations and commercialisations, which the survey given to industry partners reveals are in fact new to industry or market. However, we also get the result in the survey that only a minority (14 pct.) of the companies can confirm that their innovations are due to their involvement in the SFI centres. It is complemented with the result that only few companies seem to use the SFI centre to get help with commercialisation. If this is the case, the actual number of innovations which can be directly tied to the scheme may be lower than reported by the centres. However, it should be noted that while we know a lot about types of academic publications, their authors, and their quality, we have little knowledge regarding the precise types of innovations and their origin. The way that innovations are registered and reported thus affects the metrics that can be used in assessing performance.

Another challenge to highlight concerns internationalisation, which several results indicate has rather low priority in the centres. The challenge was brought forward in the interviews and was again confirmed by the survey results and the workshop discussions. The survey results show that especially EU-projects and EU-funding has very low priority among partners. The publication analysis shows that the share of international co-publications is just about average compared to Norwegian universities in general. We believe the ambition should be higher considering that internationalisation is a clear objective of the SFI scheme.

One explanation given by the participants in the workshop and the interviews is that incentives for internationalisation are lacking, due to better funding possibilities in Norway. Participating in EU applications and projects is thus seen as a burden to the centres, merely adding complications and bureaucratic processes. This is seen as problematic as it is generally acknowledged that international cooperation increases scientific quality and researcher's ability to attract funding from national and private sources as well.

The SFI scheme's contribution to continuity and long-term cooperation

The evaluation finds that the SFI scheme contributes to continuity and long-term research and innovation cooperation to a great extent. The support for active long-term cooperation in large research and innovation projects is the biggest motivation factor for almost all participants joining a SFI centre. The one thing that stands out when getting the partners to answer why they believe that their centre has been a success, is the fact that the centres open up for collaboration between research and business partners, as well as facilitating collaboration within specific business areas.

Almost two thirds or 77 pct., 62 pct. and 71 pct. of the partners in SFI-I, SFI-II and SFI-III respectively come from industry, which tells us that the scheme contributes to collaboration between research and industry partners to a high extent.

When asked about their primary use of the SFI centre, the majority of industry and research partners respond to using it to cooperate with one another. 57 pct. of the industry partners use the centre to cooperate with research partners, while 50 pct. primarily use the centre to cooperate with other companies. 66 pct. of research partners primarily use the centre to cooperate with other researchers while 45

pct. argue that they use the centre to cooperate with companies in research projects.

The goals regarding participation differ among partners, however. 80 pct. of the industry partners use the centre primarily to learn about new research results, while only 13 pct. use it to publish articles with researchers. Only 34 pct. of the researchers states that they use it to publish articles with companies. The bibliometric analysis shows that that in total 11.9 pct. of the published publications has co-authorship with industry. There is no clear trend over time with 12.5 pct., 9,5 pct. and 12,7 pct. industry co-publication for SFI-I, SFI-II and SFI-III, respectively. A comparison with research and innovation schemes in Sweden and Denmark indicates that the share of industry co-authorship in the SFI scheme is below average. One could argue that ambitions should be higher given the objective of the scheme to support research-industry collaboration. In addition, it seems that the large bulk of publications with industry co-authorship are concentrated on a rather small number of companies.

There is some continuity in cooperation also in the sense that 17 partners from a SFI-I centre have continued cooperation in SFI-II while 23 partners participate in both SFI-II to SFI-III. In SFI-III, 69 partners (24 pct.) have experience from earlier generations with the majority coming from the first generation (46). The majority of these are private partners, with 30 pct. of all business partners in SFI-III coming from earlier generations.

Overall data on collaboration suggest that the scheme has worked well in including new firms into the Norwegian research and innovation agenda.

A challenge is that many of the participating companies are not research competent and many are not as active as expected in the activities of the SFI centres. This is important since the competence and active participation of companies in specific projects and in research collaboration is one of the strong driving forces for the SFI centres ability to generate commercially oriented outputs on the basis of excellent research. This observation goes both ways. Feedback from industry partners indicates that participating researchers do not have sufficient innovation and market understanding. It is argued that the researchers lack knowledge of market mechanisms and are generally not thinking or acting like innovators.

Cash contributions can be seen as an indicator of companies' motivation to actively participate in research and innovation activities. Survey results imply that in-cash contributions are the second most important criteria for goal attainment. Furthermore, 60 pct. the partners in SFI-I share the opinion, that the partners willingness to engage in long term partnerships increase when a share of the partners payment is in in-cash.

However, results in the cluster analysis do not clearly tie in-cash contributions to goal attainment, when looking at innovation outputs. Here the explanation seems to be that the substantial cash contributions registered, come from some of the large companies to centres in research dominated clusters, in which they are not very actively engaged on a day-to-day basis.

This could either explain or be a consequence of the fact that none of the centres in the research dominated cluster tend to have a strong business-oriented innovation performance profile. The answers from the research partners suggest that in the big research clusters, private funding is to a large extend provided as funding of research rather than contributions to innovation activities in which the companies take active part.

The SFI scheme's contribution to research performance

Measured by research results, the SFI scheme has contributed with almost 5.000 publications including 2.980 peer-reviewed articles. Scientific quality is generally high across almost all scientific subject areas. Looking, at all publications published under the SFI scheme, the publications have an impact, which exceeds both the Nordic and EU28 benchmark.

It is further interesting to note that the top-5 subject areas for publications published within the SFI scheme are medicine (31 pct.); engineering (20 pct.); biochemistry, genetics and molecular biology (17 pct.); chemistry (14 pct.) and computer science (14 pct.). Of the top 10 subject terms, 7 outperform both the EU and Nordic benchmarks in terms of impact.

1.839 doctoral students (PhDs) have so far been recruited through the SFI scheme. The scheme is seen as an essential support measure for the education of research personnel for industry by all participants. For a majority of business partners, the recruitment of research competent personnel at both PhD and master level is a primary motivation for engaging in the SFI centres. Over a third of PhDs in SFI-I went on to work in the private sector, indicating a degree of knowledge transfer and mobility from the research sector to the private sector. It also signals a relevance and quality of the PhDs completed. However, survey inputs and SFI-II evaluation reports suggest that there is room for improvement among market-oriented skills of PhD students.

When comparing the average output each centre created each year across the generations, SFI-II stands out, with nearly twice as many dissemination measures as SFI-I and SFI-III. Although SFI-II has not concluded its 8-year term, it is on level with SFI-I in terms of scientific publications per centre per year. Looking across the three generations we see a common trend when it comes to types of co-authorship:

- 45-55 pct. of publications are classified as collaborations with only national research environments.
- 35 pct.-45 pct. of publications have at least one collaboration with international research environments.
- 3-5 pct. of publications have at least one national industry co-authorship (but no international co-authors).
- 5-10 pct. of publications have at least one collaboration with international authors and at least one collaboration with industry.

The large bulk of publications are concentrated on few large universities and institutes that also host the centres, however with some variations. NTNU and the University of Oslo have each co-authored over 30 pct. of all peer-reviewed publications produced in the SFI scheme. The third largest co-author overall is SINTEF, contributing to over 15 pct. of publications. Considering that NTNU hosts 9 centres, SINTEF hosts 7 centres and University of Oslo only hosts 2 centres, it appears that University of Oslo is more productive in contributing to SFI publications than the other two host institutions are. It should be noted that this observation does not take into consideration the centres main subject areas, e.g. life science.

We also find that the share of industry co-authorships is below average compared to other schemes. This is lower than could be expected given the objective of the SFI scheme to contribute to active cooperation between the business community and the research community. There is a big potential for improvement here, since one can see that for all publications within the scheme, those with industry co-authorships have considerably higher impact relative to both the Nordic and EU28 benchmark, than publications without industry co-authorship. The

same potential exists for international co-publications. Comparing international co-authorship for the SFI-centres with that of Norwegian universities show that it is also not above average. Also here the potential is clear as we can see that for all generations of centres international co-authorship implies a higher impact relative to both the EU and Nordic benchmarks. Particularly, when comparing to a Nordic benchmark.

Differences and important impact factors for SFI centres goal achievement?

As part of the evaluation, we have conducted a cluster analysis containing all available quantitative data used to assess the performance of the SFI centres. The analysis shows that while time is an important factor for the outputs from the centres it is not the only explanatory variable. There are large variations in performance and types of outputs between centres within the same lifespan.

The results of the quantitative analysis suggest that the centres that are composed with a strong emphasis on excellent research are more focused on generating academic results whereas more commercially oriented centres tend to focus on commercialisation based on either IPR or on open innovation output performance.

The analysis also shows that there is not a cluster of centres that excels in both academic publications and commercial innovation. It points to an overall challenge for the SFI scheme, namely to achieve a balance between developing excellent research and to, on this basis, produce innovations that are truly new to industry and markets.

The results also indicate that the active participation of companies in specific projects and in research collaboration is very important for the ability to generate commercially oriented outputs. The cluster analysis shows that cash contributions are important, but not sufficient, to goal attainment. This is likely to be due to the fact that the contributions are dominated by large industry partners, who contribute cash to support research, rather than to engage actively in innovation activities.

The complementing survey results find that the top-3 most important factors for the individual SFI centres goal attainment according to the partners is the geographical closeness of partners, being able to manage IPR and cooperation agreements, and finally the in-cash payment of participating companies.

It is interesting to note that the partners in the SFI centres are geographically spread, while at the same time up to 90 pct. of the partners believe that geographical closeness of the partners is important for the goal attainment of the SFI centres.

The SFI scheme and the support for public sector and services innovation

When it comes to supporting service innovation and public sector innovation, the SFI scheme is considered less successful. The scheme does not contain optimal support measures and the performance metrics do not fit well to the types of innovation results created in the commercial services sector and in public sector organisations.

The interviews and the workshop discussions, as well as document studies, clearly communicate the message that the SFI scheme should contain a number of other measures to be able to promote public sector innovation and innovation in the commercial service sector.

The challenges and constraints are not the same for public sector and service sector innovation, but one thing in common is the need to focus much more on the customer or enduser in the research and innovation processes. Also, the performance metrics for the SFI scheme should be targeted at reporting

public innovation and service innovation which is more about organisational and cultural changes, developing new guidelines, and improved satisfaction of the user or customer, as well as many other conditions that are different.

On the basis of the analysis, a number of challenges of service innovation and public sector innovation, which the SFI scheme does not handle, are identified. For public sector innovation these includes that the environment is more complicated as there are often more partners and all partners have different motives and thus incentives have to be different. There are no profit motives in the public sector and it is extremely dependent on security, quality, trust and certainty. It must rest much more on user interaction to be successful and relevant. There are many risks concerned with implementing large-scale innovations in complex and politically sensitive arenas and the metrics for assessing public sector performance have to be different from the ones used in the SFI scheme.

It is generally argued in the interviews that the SFI scheme is not well targeted at service sector innovation. The SFI-scheme is technology- and product-oriented – whereas service innovation is about organisational and cultural changes, new guidelines, improving the satisfaction of the end-user or customer, etc. We also hear the reasons that Norwegian companies are generally very product oriented. Service companies are also very short sighted and show little interest in research-based innovation, as service innovation projects are often short- termed.

Norway used to lack research volume and quality in the field of services innovation, but it is now increasing although it is still very concentrated to a few research environments.

It is also argued that successful service innovation (identified in research or in one regional marketplace) may not translate well in other places where cultural norms for a positive user experience vary. It has to rest primarily on user interaction to be successful and relevant. Organisations should be more than willing to accept risk and failures as a part of their innovation plans, as service-based initiatives and testing often take place in the actual marketplace where the customer experience occurs, instead of in a lab.

Finally, the metrics for assessing service innovation performance also must be different from the ones used in the SFI scheme.

Changes in framework conditions and in research and innovation systems

The evaluation team has tested and discussed a large number of trends through interviews, surveys and the two workshops. It has also been a topic in the international reviews of schemes in other countries. On this basis five major changes in external framework conditions are identified, as well as some changes in the research and innovation system, which have been highlighted by the respondents as having an expected big impact on the future functioning of the SFI centres and the SFI scheme. These are summarised shortly below.

1) Falling oil prices challenges SFI centres

The fall in oil prices has made substantial parts of Norwegian industry unprofitable. It has also started a process of a slowly decreasing the Norwegian oil and gas engagement. The question is how fast the oil and gas sector will decrease. We are now seeing a slow increase in prices which makes the situation more stable. In all cases, the changes challenge the SFI centres related to oil and energy as the partners in these centres find it difficult to think long term and plan ahead and therefore have difficulty committing to the centres.

2) Climate changes and renewable energy

In light of climate change there has been an increase in global demand for renewable energy. This is recognized by governments in all advanced economies, including the Norwegian government which is looking for Norwegian growth in new areas, e.g. with policies to push sales of electric cars and help avert climate change abroad. The changes also challenge Norwegian research and industry to cooperate to create Norwegian areas of strength which can support the green shift of the economy. It should, however, be noted that RCN alreay has initiated the Scheme for Centres for Environment-friendly Energy Research (FME) with the aim to establish centres which conduct concentrated, focused and long-term research of high international calibre in order to solve specific environmental challenges.

3) Circular economy in the centre

Talks and ideas about a circular economy has moved from the grassroots and periphery to the centre of political attention. Governments in all advanced economies are now putting forward packages to support the transition to a circular economy. This will also be an important tendency for the Norwegian SFI scheme to contain and support. The question is how to support research that can spur investments and new business opportunities and identify what obstacles need to be removed.

4) Digitalisation will disrupt the economy

Digitalisation will continue to disrupt industries and sectors in the economy. All business processes are converted from “analog to digital” and the boundaries between “physical and virtual” are becoming increasingly blurred. Governments, organisations and companies are all struggling to respond. The question is how the SFI scheme can support a positive development of new business models in the era of strong digitalisation which will surely disrupt sectors and industries.

In the questionnaire survey, we asked the companies participating in the SFI scheme if they believed that digital technologies would disrupt their industry. 45 pct. believed that would happen to a great extent. When asked if their own product innovation would have the same effect to a great extent, only 18 pct. replied ‘yes’.

It is similarly interesting to note that almost 40 pct. of both the research partners and industry partners in the SFI centres argue that the SFI scheme should set the agenda for the next industrial (digital and disruptive) revolution.

5) Recruiting the best talent is now global

A final tendency that many participants have mentioned concerns the global recruitment of talented researchers and R&D personnel to the universities, research institutes and companies connected to the SFI centres. It is mentioned as a general tendency that there is a global competition for talent and that it has become harder to attract and recruit the most talented researchers. Most importantly for the future priorities of the SFI scheme, we see that international recruitment and access to personnel are some of the primary strengths of the SFI centres according to both industry and research partners. More than 40 pct. of the research partners argue that their SFI centre contribute to their internationalisation to a great extent by helping to recruit foreign PhD candidates and/or master students. The same share of industry partners argues that their SFI centre contribute to their internationalization by giving improved access to competent personnel and knowledge institutions.

When asked about changes in the research and innovation landscape, nationally and internationally, that will impact the SFI scheme and the SFI centres, the following changing tendencies are highlighted as the most important.

1) EU funding is not seen as attractive

There is tendency among the participants in the SFI scheme to see EU funding as different from national funding schemes, and the application processes as more complicated, burdensome and bureaucratic, and with much lower success rate. We hear the argument again and again among the participants that they have no big incentive to apply for EU funding since the funding opportunities in Norway are much better. This might also be the reason why EU funding is given such a low priority by both industry and researchers in the SFI centres. However, this is contradictory to the fact that shows that the researchers with the most external funding also tend to receive significant EU funding. They also tend to be the researchers with the most patents and collaboration with industry. The big question is then, how should the SFI scheme deal with this tendency and lack of motivation affecting the centres internationalisation efforts.

2) Open access challenges research systems

The open access movement, where research papers are made freely available online, rather than published in journals has grown rapidly in recent years. It challenges the research system because the open access journals are less established than subscription journals and many are not being tracked for impact factors. For researchers (especially young researchers), research groups and research centres that are highly dependent on publication records as they are judged on the impact factors of the journals in which they publish, this is a real challenge. The question is how it should be dealt with in the context of the SFI scheme?

3) Defence R&D spending will increase

With the demands by the US government that the European partners in NATO should increases their contributions to two percent of GDP, participants in the workshop has also made the prediction that European countries' defence R&D will see a big rise in coming years. The question is how this will affect the European and Norwegian research and innovation systems. The participants argue that it could have a knock-on effect on the entire research system as research funding will not increase but will have to be transferred from other areas to this new area. The question is then also, if Norway should have a SFI in the area of defence R&D?

Ambitions and recommendations for the future

During the evaluation process, we have noted, tested, discussed and nuanced a great deal of ambitions and suggestions for changes in the SFI scheme. We have also sought for inspiration to this part in our review of comparable schemes in Sweden, Austria and the UK. The following strong future ambitions for the SFI scheme are proposed on this basis.

1. There needs to be more **committed, competent and active industry partners** in the SFI centres. This will also support the ambition of stronger user/industry control of the centres.
2. The SFI scheme should **set the agenda for the next industrial (digital and disruptive) revolution** and the future challenges in society.
3. Participants in the centres must have a much **stronger focus on commercialising research results**.
4. SFI centres need give much **higher priority to internationalization** in all its forms – from attracting EU funding, international co-publication to recruiting researchers and students abroad.
5. **Public innovation and services innovation** needs to be supported more and by other measures – and its performance should be measured by other metrics.
6. **SFI centres need a faster start**. The centres need to be operational from day 1. This is also about the function of the consortia agreements, the partners' commitment and how to organise an application process, which will result in the best selection of SFI candidates.

Proposed changes in the support measures of the SFI scheme

What changes are then necessary in the support measures of the SFI scheme to help realise the proposed future ambitions. Based on interviews, survey results, international outlook to comparable schemes in Austria, UK and Sweden and the final workshop, we have arrived at the following proposed changes in the support measures of the SFI scheme.

(a) Start with business model and support implementation

To be able to better set the agenda for the next industrial agenda and solve future challenges in society, the SFI centres should start with business model innovation rather than business as usual. To ensure that this will happen it should be built in as an expectation to the participants already in the application process.

To become more oriented towards commercialisation there needs to be a parallel focus on how to support implementation of research results at the level of the industry partners and further into the direct go-to-market activities of the partners. It will require special and flexible IPR support. It should be considered if the TTO's at the host institutions can have a more formalised role to help the push for more commercial results that are introduced to the market.

A stronger focus on providing support for implementation of research results, innovation and commercialisation is extremely important but it should not come at the cost of excellent and experimenting research. Research and innovation are two sides of the same coin. Therefore the goals of the SFI scheme regarding the relationship between research and innovation must be formulated very clearly hence leaving no doubt of what is expected of the centres and the partners. From the interviews and the discussions at the workshops there are seemingly some differences in the participants understandings and interpretations of the objectives of the scheme.

It should be well-known and stated clearly what the SFI scheme is not about, and how it differs from other RCN schemes, such as FORNY Scheme, SkatteFunn, FME, SFF or the BIA Scheme.

According to the objective of the SFI scheme, all research conducted by the centre, including research funded by the partners, is to be longterm in nature and is expected to provide a basis for innovation and value creation.

The SFI centres are selected on the basis of not only their scientific merit but also their potential for innovation and value creation. It is the hence the overall objective of the SFI scheme to enhance the ability of the business sector to innovate.

According to the objectives, the centres' research results and competence shall furnish a platform for innovation and value creation among user partners. User partners shall participate in the centres' governance, funding and research, and must have significant innovation activities of their own as well as the ability to take advantage of advanced research when developing their activities.

Finally, according to the objective of the SFI scheme, it is primarily the companies participating in a centre that are expected to exploit the results of research. However, this does not mean that the research partners and RCN are without responsibilities for implementation of research result, innovation and commercialisation. The respondents in the survey clearly confirm that the participating researchers do not have sufficient innovation and market understanding. Therefore, it should also be

a future priority for the SFI scheme to encourage career researchers to think and act more like innovators. The goal is to ensure that the researchers achieve a better understanding and appreciation of market mechanisms.

What falls outside the core areas of the business can be commercialized differently, for example through research-based start-ups. The Norwegian Research Council has a role in facilitating how the SFI tool can be linked with other instruments such as the FORNY Scheme, SkatteFunn, FME, SFF or the BIA Scheme, which previous evaluations have documented as possible step stones to and from the SFI centres in the partners research and innovation processes.

(b) Strong industrial focus in application processes

The SFI scheme needs stronger industrial focus, in the sense of more committed, competent and active industry partners. This can be realised without jeopardising the objective of creating research-based innovation. There needs to be a stricter screening of the industrial partners in the application process to ensure that the industry partner is really committed and really will be active as stated with their in-kind contributions. The screening should also ensure that the application is acknowledged and preferably involves both the C-level and the leading R&D personell in the participating companies.

One challenge is that only few of the industry partners conduct research themselves. This is also one of the reasons that some companies are not as actively involved in the research at the centres. Rather, the innovation of many of the companies is based on experience, not research. It is important then to ensure that if the companies do not conduct research, they need to have sufficient competencies to implement the research from their SFI centre. In many companies, this competency is lacking according to respondents in both the interviews, the survey and the workshops. To ensure more research competent companies in the future, it should therefore be considered whether the companies that are to participate in an SFI must document research skills or make visible measures to obtain this competence.

The industrial focus of the SFI scheme would benefit from imposing requirements of in-cash payment by the participating companies. The current private funding requirement is 25 pct. (including both in-kind and cash). It should be considered if the requirement should be linked to cash contribution only. However, it is not a popular proposed change among neither business partners nor research partners. Almost none are in favour of higher cash contributions. That should be taken into consideration in moving forward with this suggestion. It will meet opposition and it will require a change in understanding among the partners. It may have to be implemented stepwise, and it is important to ensure that it will not exclude smaller companies. It should also be noted that, it is not a matter of only cash, or only in-kind, but rather the optimal share of each that has to be considered. The magnitude can be discussed, but the point is that the partners must contribute with both. The SFI scheme can look to the COMET Scheme in Austria for inspiration as to how the split for financing can be handled. Cash contributions have the further impact that they allow the centres to do more innovation related activities.

Several partners also mention flexible financing as a way forward to allow for more industry involvement. This could be through annual fees or different types of private memberships.

Finally, it is noted that the industrial focus can also be strengthened by having a larger share of industrial PhDs connected to the centres. This will ensure more mobility and knowledge translation from

industry to research and vice versa, which many of the industry partners can benefit from.

It is recommended that the judging panel in RCN has interviews both with centre leaders and one of the industry partners as part of the application process. The interviews should be followed by meetings with the centres three months after funding has been granted, to ensure that the centres get a head-start and know what is expected of them.

(c) Competition between centres and clear termination procedures

To push the centres to a faster start and to facilitate more fundamentally disruptive innovation, some elements of competition can be introduced to the SFI scheme, in two ways. First, there can be a competition process after the first 3 years where the centres are reviewed and evaluated. The top-80 pct. of the centres with the best results can then continue while the latter 20 pct. will have one year to terminate their activities. The suggested model is inspired from a new measure recently introduced to the Swedish VINN Excellence Scheme. Also, the SFI scheme can introduce a common pot that SFI centres can bid into and compete for to allow for further additional innovation activities.

Though the aims of the competition should be clear, as stated above, it is important to carefully observe that the more competitive environment does not just encourage to more incremental research and innovation at the cost of intellectual experimentation and breakthrough innovations. We believe that this is not a major risk, if the goals and ambitions of the SFI scheme are clearly defined and formulated to all centres.

It is equally important that the metrics for measuring performance are broadly and clearly defined, and applied in a flexible way. We, discuss and make more detailed recommendations for the performance metrics below. However, it is important at this place to note that there might be a tension between a) service/public sector SFI centres and classical SFI centres needing very different performance measures and b) competition between centres. A judging panel will need to make an apples and oranges comparison to judge which SFI centres are doing best, as they will have to compare service/public sector and classical SFI centres.

In addition, it is recommended that RCN develops clearer procedures that can be activated when it is decided that a centre should terminate its activities before time. When many centres are supported, there will always be a centre that functions less well. If it proves too difficuelt to get this centre to perform, the difficult but necessary decision of closure has to be made. The challenge is then also how to move forward with the termination. The RCN needs clear procedures for that. Also, it needs to be formulated clearly to the centres at initiation that closure before the eight years is a possibility if they are not performing well.

(d) Criteria and incentives for internationalisation

To make the SFI centres further prioritise internationalization in all its forms, it is necessary to impose stricter criteria and to build in international supporting economic incentives into the SFI scheme.

The scheme should favour research that is conducted in close cooperation between Norwegian and international research communities and companies. This is best achievet if proposals for centres involves academic partners from abroad as well as international companies as partners, hence these are important criteria to apply if more internationalisation should be achieved. Applications should also be judged with an eye on the centre leaders experience with international cooperation and the centre's

potential to become a key player in international co-operation, such as within the EU.

A stronger focus should be imposed on attracting EU Horizon 2020 funding. One of the challenges is here that it is apparently easier for the researchers to attract Norwegian funding.

The SFI scheme has to establish more incentives to reward the centres that internationalise. Also several new performance criteria could be introduced to support the development, e.g. number of applications and success rate of applications, SFI centre lead in applications, international co-authorship, international recruitment of PhDs and international market introductions.

(e) Improving the metrics for assessing the performance of the SFI centres?

The stronger ambitions highlighted above can be supported by a stronger annual monitoring of progress and flexible but clearer performance metrics. This concerns the above mentioned internationalization indicators, but even more so the indicators used to measure innovation and commercialisations in the SFI centres. The existing way of self-reporting on innovation and commercialisation has been accused by several participants to be imprecise and not comparable. The evaluation confirms this. Several other challenges have been mentioned by the participants, e.g. that: Innovations both inside and outside the scheme are registered with the same source.

A large number of suggestions for revised performance metrics have been made by participants in the evaluation workshops, which complement the ones mentioned above regarding internationalization, public innovation and service innovation, e.g. spin-offs, implemented results, successful pilots, prototypes, PhDs, industrial PhDs, Postdocs and master students over time, new business models, new innovation methods, etc.

'Finally, it is important to note that the same performance metrics do not fit all. Some should for instance focus more on reporting on public sector innovation and service innovation indicators, which is more about organisational and cultural changes, new guidelines, improved user and customer satisfaction etc. To have precise metrics is important and probably more important than most stakeholders acknowledge. It is important because it is used as a guide for both participants and in evaluations. A very relevant example is here how to measure research and innovation to be able to balance the two and to support the goal attainment of the SFI centres. We as evaluators and stakeholders need to know, and the participants need to acknowledge what research topics they think can be refined to create innovations within a fairly short period of time (e.g. in the next 5 years) and what research topics can be expanded within 10 years. Measuring and valuing both in the same way is not relevant because basic or fundamental research will not create innovation results in the near future. For the centres with fundamental research, it then also has the implications that they need to be more careful ensuring that the industrial partners can anchor it to make it valuable.

(f) Support public innovation and services innovation with new measures

Public innovation and services innovation needs to be supported better and by other measures than exists today in the SFI scheme. This is generally acknowledged as important by all the respondents in the interview and survey. The analysis has contributed with some ideas about what to do differently in the attempt to better support public innovation.

Public innovation

First, there needs to be an incentive for public sector organisations to identify and engage in the processes and structures that can support and accelerate innovation.

Then there is the challenge of attracting public financing to establish research based innovation centres. This is a challenge due the budgetary constraining rules for most public sector organisations. In the VINN Excellence Scheme in Sweden this challenge has been attempted solved by allowing the public sector to contribute with in-kind financing. For public sector innovation to succeed it has more than other areas to be based on a platform of security, quality, trust and certainty. It also has to rest on user interaction. Finally, public sector innovation requires triple helix with both public and private partnership with research. This makes it more complicated as you combine actors that are driven by different interests and need different incentives.

Service innovation

The challenges mentioned in the interviews when it comes to supporting service innovation through the SFI scheme concerns that the service companies are more short-sighted and less interested in research-based innovation. Also there is no tradition for research, hence the volume and quality has been low. It is slowly changing but the research environment is still rather concentrated. The participants understand the SFI scheme as very technology and product oriented in contrast to the service sector, which is targeted more at new guidelines, culture, organisational changes, users and employees. Also, as mentioned the current performance metrics do not report on service innovation. The participants in the workshop and interviews suggest several ways forward, including:

a) More flexible start with a test period for the partners before they commit long term.
b) More focus on the translation of research to innovations
c) More flexible centres which are allowed to change centre focus and research areas
d) Use the centre to build the capacity needed
e) More focus on business models and integrated supply chains.
f) The following sectors are mentioned as mature service innovation areas: Financial sector, logistics, retail, tourism and media.
g) Following subject areas are mentioned as highly relevant: Digitalization/ big data, business models, employee vs robots, online shopping and block chain.

Norsk sammendrag

Denne rapporten inneholder resultatene av evalueringen av SFI-ordningen (Sentre for forskningsdrevet innovasjon). Målet med SFI-ordningen er å fremme innovasjon ved å støtte langsiktig forskning gjennom et nært samarbeid mellom FoU-intensive selskaper og fremtredende forskningsinstitusjoner. En viktig rolle i SFI-sentrene er videre å utdanne doktorgradsstudenter som skal forfølge karrierer i industrien. Siden starten i 2005 har SFI-ordningen støttet 38 sentre i tre generasjoner, som omfatter konsortier av forskningsinstitusjoner og kommersielle aktører fra hele Norge. Den første generasjonen av 14 SFI-sentre avsluttet sin operasjonsperiode i 2015. Dermed er det i dag 24 aktive sentre.

Et team av analytikere og forskere fra DAMVAD Analytics, Cambridge University og Rand Europe har evaluert SFI-ordningen ved hjelp av en rekke metoder, inkludert kvantitativ dataanalyse, intervjuer, spørreskjemaundersøkelser, dokumentstudier, workshoper og bibliometrisk analyse.

Formålet med evalueringen er todelt, i henhold til mandatet:

- Å gi innsikt i målsettingen for SFI-ordningen.
- Å levere forslag til tilpasning og endring for videreutvikling av SFI-ordningen.

Når det gjelder målsetting, svarer evalueringen på følgende fem spørsmål:

1. I hvilken grad har SFI-ordningen bidratt til å stimulere til innovasjon og internasjonalisering?
2. I hvilken grad har SFI-ordningen bidratt til å skape et aktivt samarbeid mellom et innovativt næringsliv og fremtredende forskningsmiljøer?
3. I hvilken grad har SFI-ordningen gitt økt langsiktighet, kontinuitet og risikoreduksjon i forskningsområder?
4. Har SFI-ordningen bidratt til å styrke og videreutvikle de beste norske privat-sektor FoU-miljøer – nasjonalt og internasjonalt?
5. Hvilke systematiske forskjeller i måloppfølging og effektivitet kan identifiseres mellom SFI-sentrene, og hva forteller det om faktorene som påvirker måloppnåelse?

Når det gjelder forslag til videreutvikling av SFI-ordningen, undersøker vi følgende:

6. Hva er betydningen av endringer i rammebetingelser og i forsknings- og innovasjonssystemet nasjonalt og internasjonalt?
7. Er det begrensninger i utformingen av SFI-ordningen som kan hindre etableringen av fremtidige sentre rettet mot offentlig sektor og servicesektoren?
8. Hvilke endringer bør gjøres i SFI-ordningen for å øke måloppnåelsen og verdiskapningen fra ordningen?

Samlet inntrykk

SFI-ordningen har hittil brakt mer enn 500 partnere fra industri, forskning og offentlig sektor sammen i 38 sentre, hvert med distinkte profiler og spesialiseringer. Samlet inntrykk fra alle evalueringsresultatene er at SFI-ordningen fungerer godt for å legge til rette for nært samarbeid mellom FoU-bedrifter og fremtredende forskningsgrupper. Forskningen er generelt av høy kvalitet, og ordningen er et viktig bidrag til å styrke forskerutdanningen i områder av betydning for norsk næringsliv og samfunnet som helhet. Innsikter fra evaluering tyder samlet på at mens SFI-setrene lykkes med å utdanne og ansette et stort antall akademiske medarbeidere, er det noen forbedringer som kan øke graden av kunnskapsoverføring til industrien. Samlet sett drar både forskningsmiljøet og de private sektordeltakere nytte av tilgang til kvalifisert personell og kunnskapsoppgradering.

Det er høy overordnet tilfredshet med ordningen blant både deltakere og interessenter. Nesten 90 prosent av alle respondentene rapporterer at SFI-

senteret de er en del av, er en suksess. Videre er det høy grad av tilfredshet med konsortieavtalen og med senterledelsen samt med administrasjonen av ordningen ved Norges forskningsråd. Vertsinstitusjonene blir av det store flertallet av respondentene ansett for å tilby gode fasiliteter og arbeidsforhold for forskning og innovasjon i sentrene.

Evalueringen viser imidlertid også til en rekke utfordringer som tyder på oppmerksomhetsområder hvor SFI-ordningen presterer mindre godt eller ikke så godt som det må forventes gitt målene og midlene i ordningen. Evalueringen er ikke i stand til å identifisere overbevisende resultater for SFI-ordningens bidrag til innovasjon, kommersialisering og internasjonalisering. Det er også tydelig at bedriftspartnerne ikke er like aktive i de forskningsbaserte aktivitetene til sentrene som man kan forvente. Evalueringen viser også utfordringer med hensyn til bedriftspartnernes forskningskompetanse og forskernes innovasjonskompetanse. Til slutt finner evalueringen at SFI-ordningen ikke fungerer bra når det gjelder å støtte serviceinnovasjon og offentlig innovasjon.

Det skal imidlertid bemerkes at resultatene ovenfor dekker et stort utvalg resultater for individuelle sentre som vi ikke rapporterer nyansert om. I henhold til mandatet gjelder evalueringen SFI-ordningen som helhet og er ikke ment å være en evaluering av individuelle sentre.

Analysen av resultatene som oppnås under ordningen, har ført til at evalueringen fokuserer på endringer i rammebetingelser og faktorer som understøtter eller hindrer systemets effektivitet og måloppnåelse. På denne bakgrunn er det formulert en rekke nye eller høyere ambisjoner, og det foreslås spesifikke endringer for SFI-ordningen. I det følgende oppsummerer vi alle resultater knyttet til de sentrale spørsmålene i evalueringen.

SFI-ordningens bidrag til innovasjon og internasjonalisering

SFI-ordningen har til og med 2016 bidratt til nesten 300 innovasjoner og 200 kommersialiseringer. 14 prosent av de deltakende selskapene har skapt varer eller tjenester som anses å være nye for næringen eller markedet de siste tre årene på grunn av SFI-ordningen. Totalt har 13 nye selskaper blitt opprettet som en del av SFI-ordningen.

Nesten 80 prosent av alle partnerne (både industri og forskning) angir at deres SFI-senter har skapt innovasjoner som vil styrke sektoren eller industrien de er en del av. Vi finner også at SFI-sentrene produserer mer over tid målt som både innovasjoner, kommersialiseringer, vitenskapelige publikasjoner og formidlinger, som alle øker, per senter per år.

Respondentene spår at forskningsresultater og innovasjonsresultater vil fortsette godt inn i fremtiden - selv respondenter fra sentrene som er ferdige med første generasjon (SFI-I).

SFI-ordningen bidrar til internasjonalisering, hovedsakelig ved å øke partnernes internasjonale nettverk og omdømme og forbedre tilgangen til og rekrutteringen av forskningspersonell. Når det gjelder forskningen, så har 44 prosent av alle publiserte artikler fra sentrene hatt internasjonale forskere som medforfattere.

Evalueringen har identifisert to utfordringer knyttet til SFI-ordningens bidrag til innovasjon og internasjonalisering. For det første har senterledere rapportert en rekke innovasjoner og kommersialiseringer som undersøkelsen blant industripartnerne viser er nye for industrien eller markedet. Undersøkelsen viser imidlertid også at kun en minoritet (14 prosent) av selskapene kan bekrefte at deres innovasjoner skyldes deres engasjement i SFI-sentrene. Dette suppleres med resultatet at bare få selskaper ser ut til å bruke SFI-senteret for å få hjelp med

kommersialisering. Hvis dette er tilfelle, kan det faktiske antallet innovasjoner som kan knyttes direkte til SFI-ordningen være lavere enn rapportert av sentrene. Det skal imidlertid bemerkes at mens vi vet mye om typer akademiske publikasjoner, deres forfattere og deres kvalitet, har vi lite kunnskap om de nøyaktige typene av innovasjoner og deres opprinnelse. Måten innovasjoner registreres og rapporteres på, påvirker derfor beregningene som kan brukes til å vurdere effekt og måloppnåelse.

En annen utfordring som kan fremheves gjelder internasjonalisering, som flere resultater indikerer har ganske lav prioritet i sentrene. Utfordringen ble først fremført i intervjuene, og ble igjen bekreftet av undersøkelsesresultater og diskusjoner fra workshopene. Undersøkelsen viser at spesielt EU-prosjekter og EU-finansiering har svært lav prioritet blant partnerne. Publikasjonsanalysen viser at andelen av internasjonale sampublikasjoner er omtrent gjennomsnittlig sammenlignet med norske universiteter generelt. Vi mener at ambisjonen bør være høyere med tanke på at internasjonalisering er et klart mål for SFI-ordningen.

En forklaring fra deltakerne i workshopene og intervjuene er at insentiver for internasjonalisering mangler på grunn av bedre finansieringsmuligheter i Norge. Deltakelse i EU-søknader og prosjekter blir dermed sett på som en byrde for sentrene, som bare bidrar til flere komplikasjoner og byråkratiske prosesser. Dette anses som problematisk da det er generelt anerkjent at internasjonalt samarbeid øker vitenskapelig kvalitet og forskernes evne til å tiltrekke seg finansiering fra nasjonale og private kilder.

SFI-ordningens bidrag til kontinuitet og langsiktig samarbeid

Evalueringen finner at SFI-ordningen i stor grad bidrar til kontinuitet og langsiktig forskning og innovasjonssamarbeid. Støtten til aktivt langsiktig samarbeid i store forsknings- og innovasjonsprosjekter er den største motivasjonsfaktoren for at deltakere blir med i et SFI-senter. Den ene tingen som skiller seg ut når partnerne svarer på hvorfor de tror at senteret har vært en suksess, er at sentrene åpner for samarbeid mellom forskning og bedriftspartnere, samt letter samarbeidet innenfor bestemte forretningsområder.

Omtrent to tredjedeler eller 77 prosent, 62 prosent og 71 prosent av partnerne i SFI-I, SFI-II og SFI-III kommer fra industrien. Det forteller oss at ordningen i høy grad bidrar til samarbeid mellom forskningsog industripartnere.

Når de blir spurt om deres primære bruk av SFI-senteret, svarer flertallet av både bedrifts- og forskningspartnere at de bruker sentrene til å samarbeide med hverandre. 57 prosent av bedriftspartnerne bruker senteret til å samarbeide med forskningspartnere, mens 50 prosent primært bruker senteret til å samarbeide med andre bedrifter. 66 prosent av forskningspartnerne bruker primært senteret til å samarbeide med andre forskere, mens 45 prosent sier at de bruker senteret til å samarbeide med bedrifter i forskningsprosjekter.

Målene for deltakelse varierer imidlertid mellom partnere. 80 prosent av bedriftspartnerne bruker senteret først og fremst for å lære om nye forskningsresultater, mens bare 13 prosent bruker sentret til å publisere artikler sammen med forskere. Bare 34 prosent av forskerne sier at de bruker sentret til å publisere artikler sammen med bedrifter. Den bibliometriske analysen viser at totalt 11,9 prosent av de publiserte publikasjonene har medforfatterskap fra industrien. Det er ingen klar trend over tid med 12,5 prosent, 9,5 prosent og 12,7 prosent sampublisering for industrien for henholdsvis SFI-I, SFI-II og SFI-III. En sammenligning med forskningsog innovasjonsordninger i Sverige og Danmark indikerer at andelen av medforfatterskap med industrien i SFI-ordningen er under gjennomsnittet. Man

kan forvente at ambisjonen burde være høyere gitt målet med ordningen om å støtte samarbeid mellom forskning og industri. I tillegg ser det ut til at den store mengden av publikasjoner med industriens medforfatterskap er konsentrert om et ganske lite antall selskaper.

Det kan måles noe kontinuitet i samarbeidet i den forstand at 17 partnere fra et SFI-I-senter har fortsatt samarbeid i SFI-II, mens 23 partnere deltar i både SFI-II og SFI-III. I SFI-III har 69 partnere (24 prosent) erfaring fra tidligere generasjoner. Flertallet kommer fra første generasjon (46). Flertallet av disse er private partnere. 30 prosent av alle bedriftspartnere i SFI-III kommer fra tidligere generasjoner.

Samlet viser data at SFI-ordningen har fungert bra i forhold til å inkludere nye bedrifter i norsk forsknings- og innovasjonsagenda.

En utfordring er at mange av de deltakende selskapene ikke er forskningskompetente, og mange er ikke så aktive som man kan forvente gitt SFI-sentrets aktiviteter. Dette er viktig siden kompetanse og aktiv deltakelse av bedrifter i spesifikke prosjekter og i forskningssamarbeid er en av de sterkeste drivkreftene for SFI-sentrenes evne til å generere kommersielt orienterte produksjoner på grunnlag av forskning. Denne observasjonen går begge veier. Tilbakemeldinger fra bedriftspartnere indikerer at deltakende forskere ikke har tilstrekkelig innovasjonskunnskap og markedsforståelse. Det hevdes at forskerne mangler kunnskap om markedsmekanismer og generelt ikke tenker eller handler som innovatører.

Kontantbidrag til sentrene kan ses som en indikator på bedrifters motivasjon til aktivt å delta i forsknings- og innovasjonsaktiviteter. Undersøkelsesresultater viser at kontantbidrag er blant de nest viktigste kriteriene for måloppnåelse. 60 prosent av partnerne i SFI-I er av den oppfatning at partnernes vilje til å engasjere seg i langsiktige partnerskap øker når en del av partnerens bidrag er i kontanter.

Resultatene i klyngeanalysen tyder imidlertid ikke på at kontant betaling i seg selv er tilstrekkelig. Her synes forklaringen å være at de betydelige kontantbidragene som er registrert, kommer fra noen av de store bedriftene til sentre i forskningsdominerte klynger, uten at de er veldig aktivt engasjert på daglig basis.

Dette kan enten forklare eller være en konsekvens av det faktum at ingen av sentrene i den forskningsdominerte klyngen har en sterk forretningsorientert innovasjonsprofil. Svarene fra forskningsmiljøene tyder på at i de store forskningsklyngene gis privat finansiering i stor utstrekning som støtte til forskning fremfor som støtte til innovasjonsaktiviteter.

SFI-ordningens bidrag til forskningsresultater

SFI-ordningen har bidratt med nesten 5000 publikasjoner, heri inkludert 2 980 fagfellevurderte artikler. Den vitenskapelige kvaliteten er generelt høy på nesten alle fagområder. På de fleste fagområder ligger publikasjonene under SFI-ordningen over både nordisk gjennomsnitt og EU-28-gjennomsnitt.

Det er videre interessant å merke seg at de 5 toppområdene for publikasjoner publisert under SFI-ordningen er medisin (31 prosent); ingeniørfag (20 prosent); biokjemi, genetikk og molekylærbiologi (17 prosent); kjemi (14 prosent) og datavitenskap (14 prosent). Av de 10 beste fagområdene scorer de 7 høyere end både EU og Norden på vitenskapelig kvalitet.

1839 doktorgradsstudenter har hittil blitt rekruttert gjennom SFI-ordningen. Ordningen er sett på som et viktig støttemål for utdanning av forskningspersonell til industrien av alle deltakere. For et flertall av bedriftspartnerne er rekruttering av forsknings-

kompetent personell på både ph.d.- og masternivå en primær motivasjon for å delta i SFI-sentrene.

Ved sammenligning av gjennomsnittlig vitenskapelig produksjon for hvert senter hvert år på tvers av generasjonene, skiller SFI-II seg ut med nesten dobbelt så mange formidlinger som SFI-I og SFI-III. Selv om SFI-II ikke har avsluttet sin 8-årige periode, er denne generasjonen av sentre på nivå med SFI-I når det gjelder vitenskapelige publikasjoner per senter per år. Ser man på tvers av de tre generasjonene, ser vi en felles trend når det gjelder andel sampubliseringer:

- 45-55 prosent av alle publikasjoner er utarbeidet i samarbeid med nasjonale forskningsmiljøer.
- 35-45 prosent av alle publikasjoner er basert på minst ett samarbeid med internasjonale forskningsmiljøer.
- 3-5 prosent av alle publikasjoner har minst en nasjonal bedrift som medforfatter (men ingen internasjonale medforfattere).
- 5-10 prosent av alle publikasjoner har minst en internasjonal medforfatter og minst ett samarbeid med industrien.

Den store mengden publikasjoner er konsentrert på få store universiteter og institutter som også er vert for sentrene. NTNU og Universitetet i Oslo er hver medforfatter på over 30 prosent av alle fagfellevurderte publikasjoner produsert under SFI-ordningen til og med 2016. Den tredje største medforfatteren samlet er SINTEF, som bidrar til over 15 prosent av alle publikasjoner. Med tanke på at NTNU er vert for 9 sentre og SINTEF er vert for 7 sentre mens Universitetet i Oslo kun er vert for 2 sentre, så fremstår Universitetet i Oslo som mer produktivt i forhold til å bidra til SFI-publikasjoner enn de to andre vertsinstitusjonene. Det skal likevel bemerkes at denne observasjonen ikke tar hensyn til sentrenes viktigste fagområder, f.eks. innenfor helse og biovitenskap.

Vi finner at andelen av medforfatterskap med industrien er under gjennomsnittet i forhold til andre lignende ordninger. Nivået er dermed lavere enn det som kan forventes gitt at målet med SFI-ordningen er å bidra til aktivt samarbeid mellom næringsliv og forskningsmiljøer. Det er stort potensial for forbedring her. Publikasjoner under SFI-ordningen med industrimedforfatterskap har betydelig høyere kvalitet i forhold til både nordisk gjennomsnitt og EU-28-genomsnitt enn publikasjoner uten medforfatterskap. Det samme potensialet eksisterer for internasjonale sampublikasjoner. En sammenligning av SFI-sentrene med norske universiteter generelt viser at internasjonalt medforfatterskap for SFI heller ikke er over gjennomsnittet. Her er potensialet også tydelig da vi vet at internasjonalt medforfatterskap gir en høyere vitenskapelig gjennomslagskraft målt i forhold til både EU og Norden. Spesielt i forhold til Norden er dette tydelig.

Forskjeller og viktige faktorer for SFI-sentres måloppnåelse

Som en del av evalueringen har vi gjennomført en klyngeanalyse av alle tilgjengelige kvantitative data som er brukt til å vurdere SFI-sentrenes karakteristika og prestasjoner. Analysen viser at mens tid er en viktig faktor for sentrenes prestasjoner, så er ikke tid den eneste forklarende variabelen. Det er store variasjoner mellom sentre med samme levetid.

Resultatene av den kvantitative analysen viser at sentrene som er sammensatt med sterk vekt på forskning, også er mye mer fokusert på å generere akademiske resultater, mens de mer kommersielt orienterte sentrene har en tendens til å fokusere mer på kommersialisering basert på enten IPR eller åpen innovasjon.

Analysen viser også at det ikke finnes en klynge av sentre som utmerker seg i både vitenskapelige publikasjoner og kommersiell innovasjon. Det peker på en overordnet utfordring for SFI-ordningen, nemlig

å oppnå balanse mellom å utvikle den beste forskningen og på den bakgrunn produsere innovasjoner som er helt nye for industri og markeder.

Resultatene tyder også på at aktiv deltakelse av selskaper i konkrete prosjekter og i forskningssamarbeid er svært viktig for evnen til å generere kommersielt orienterte resultater. Klyngeanalysen viser at kontantbidrag er viktige, men ikke tilstrekkelige for måloppnåelse. Dette skyldes sannsynligvis at bidragene domineres av store industripartnere som bidrar med midler for å støtte forskning, fremfor å engasjere seg aktivt i innovasjonsaktiviteter.

I forhold til å skape resultater så finner vi at især tre faktorer er viktige. Disse er geografisk nærhet av partnere, å være i stand til å håndtere IPR og samarbeidsavtaler, og til slutt at en del av finansieringen fra deltakende bedrifter er kontantbetaling.

Det er interessant å merke seg at partnerne i SFI-sentrene er geografisk spredte, samtidig som opptil 90 prosent av partnerne mener at geografisk nærhet av partnere er viktig for måloppnåelse i SFI-sentrene.

SFI-ordningen og støtten til innovasjon i offentlig sektor og tjenesteinnovasjon

Når det gjelder å støtte tjenesteinnovasjon og innovasjon i offentlig sektor, er det vår vurdering at SFI-ordningen fungerer mindre vellykket. Ordningen inneholder ikke optimale støttetiltak, og målekriteriene passer ikke godt til de typene av innovasjonsresultater som oppnås i tjenestesektoren og i offentlige organisasjoner.

Intervjuene og workshopdiskusjonene samt dokumentstudier understøtter vår konklusjon om at SFI-ordningen må inneholde en rekke andre tiltak for å kunne fremme offentlig innovasjon og innovasjon i tjenestesektoren.

Utfordringene og begrensningene er ikke de samme for innovasjon innenfor offentlig sektor som innenfor tjenesteyting, men en ting de har felles, er behovet for å fokusere mye mer på kunden eller sluttbrukeren i forsknings- og innovasjonsprosessene. Måleindikatorer for SFI-ordningen bør også være rettet mer mot rapportering av offentlig innovasjon og tjenesteinnovasjon som handler om organisatoriske og kulturelle endringer, utvikling av nye retningslinjer og bedre tilfredshet hos brukeren eller kunden, samt mange andre forhold som er forskjellige.

På bakgrunn av analysen identifiseres en rekke utfordringer for tjenesteinnovasjon og offentlig innovasjon som SFI-ordningen ikke håndterer. For offentlig innovasjon innebærer disse at miljøet er mer komplisert siden det ofte er flere partnere og alle partnere har forskjellige motiver, og insentivene må derfor også være forskjellige. Det er blant annet ingen profittmotiver i offentlig sektor, og sektoren er ekstremt avhengig av sikkerhet, kvalitet og tillit. Innovasjon må hvile mye mer på brukerinteraksjon for å bli vellykket og relevant. Det er større risiko involvert med å implementere innovasjoner på komplekse og politisk sensitive arenaer, og kriterier for å vurdere offentlig sektors prestasjoner må være forskjellige fra de som brukes i SFI-ordningen.

Et hovedresultat i intervjuene er at SFI-ordningen ikke er rettet tilstrekkelig mot innovasjon innenfor tjenestesektoren. SFI-ordningen er teknologi- og produktorientert mens tjenesteinnovasjon handler om organisatoriske og kulturelle endringer, nye retningslinjer, bedre sluttbruker- eller kundetilfredshet osv. Norske selskaper er generelt svært produktorienterte. Tjenestebedriftene er også svært kortsiktige og viser liten interesse for langsiktig forskningsbasert innovasjon, da tjenesteinnovasjonsprosjekter ofte er kortsiktige.

Norge har manglet forskningsmiljø og kvalitet innenfor tjenesteinnovasjonsområdet, men dette øker nå,

selv om det fortsatt er svært konsentrert til noen få forskningsmiljøer.

Det hevdes også at vellykket tjenesteinnovasjon identifisert innenfor forskning eller i én regional eller nasjonal kontekst, ofte ikke kan overføres til andre områder der kulturelle normer for en positiv brukeropplevelse varierer. Den må først og fremst hvile på brukerinteraksjon for å være vellykket og relevant. Organisasjoner bør være mer enn villige til å akseptere risiko og feil som en del av deres innovasjonsplaner, da tjenestetiltak og testing ofte foregår på den faktiske markedsplassen hvor kunden er til stede, i stedet for i et laboratorium. Endelig må målekriteriene for tjenesteinnovasjon også være forskjellige fra de som brukes i SFI-ordningen generelt.

Endringer i rammevilkårene og i forsknings- og innovasjonssystemer

Evalueringsteamet har testet og diskutert et stort antall trender gjennom intervjuer, undersøkelser og de to workshopene. Det har også vært et tema i internasjonale vurderinger av ordninger i andre land. På denne bakgrunn er det identifisert fem viktige endringer i eksterne rammebetingelser, samt enkelte endringer i forsknings- og innovasjonssystemet som har blitt fremhevet av respondentene som trender med en forventet stor innvirkning på SFI-sentrenes og SFI-ordningens fremtidige drift. Disse er kort oppsummert nedenfor.

1) Fallende oljepriser utfordrer SFI-sentrene

Fallet i oljeprisen har gjort deler av norsk industri ulønnsom. Det har også startet en prosess med å langsomt redusere det norske olje- og gassengasjementet. Spørsmålet er hvor raskt olje- og gassektoren vil redusere. Vi ser nå en treg prisøkning som gjør situasjonen mer stabil. I alle tilfeller utfordrer endringene SFI-sentrene relatert til olje og energi, da partnerne i disse sentrene finner det vanskelig å tenke langsiktig og planlegge på forhånd og derfor har problemer med å forplikte seg til sentrene.

2) Klimaendringer og fornybar energi

I lys av klimaendringene har det vært en økning i den globale etterspørselen etter fornybar energi. Dette gjenkjennes av myndigheter i alle avanserte økonomier, blant annet den norske regjeringen som ser etter norsk vekst på nye områder, for eksempel med politikk for å øke salget av elbiler og bidra til å motvirke klimaendringer i utlandet. Endringene utfordrer også norsk forskning og industri til å samarbeide for å skape norske styrkeområder som kan støtte det grønne skiftet i økonomien.

3) Sirkulær økonomi i sentrum

Visjoner og ideer om en sirkulær økonomi har flyttet fra periferi til sentrum for politisk oppmerksomhet. Regjeringene i alle avanserte økonomier legger nå fram pakker for å støtte overgangen til en sirkulær økonomi. Dette vil også være en viktig tendens som den norske SFI-ordningen må ta aktiv stiling til. Spørsmålet er hvordan man støtter forskning som kan anspore investeringer og nye forretningsmuligheter og identifisere hvilke hindringer som må fjernes på dette området.

4) Digitalisering vil virke disruptivt på økonomien

Digitalisering vil fortsette å føre til disruptive endringer innenfor næringer og sektorer i økonomien. Alle forretningsprosesser blir konvertert fra "analoge til digitale", og grensene mellom "fysisk og virtuell" blir stadig mer uklare. Regjeringer, organisasjoner og bedrifter har alle problemer med å svare igjen. Spørsmålet er hvordan SFI-ordningen kan støtte en positiv utvikling av nye forretningsmodeller i en tid med sterk digitalisering som med sikkerhet vil føre til disruptive endringer innenfor sektorer og næringer.

I spørreskjemaundersøkelsen spurte vi bedriftene som deltar i SFI-ordningen om de trodde at digital

teknologi ville virke disruptivt på deres bransje. 45 prosent trodde det ville skje i stor grad. Da vi deretter spurte om deres egen produktinnovasjon i stor grad vil ha samme effekt, var det bare 18 prosent som svarte 'ja'.

Det er også interessant å merke seg at nesten 40 prosent av både forskningspartnerne og industripartnerne i SFI-sentrene hevder at SFI-ordningen bør sette tydelig dagsorden for neste industrielle (digitale og disruptive) revolusjon.

5) Rekruttering av det beste talentet er nå global

En viktig tendens som mange deltakere har nevnt, gjelder rekruttering av talentfulle forskere og FoU-ansatte til universiteter, forskningsinstitutter og selskaper knyttet til SFI-sentrene. Denne er nå blitt global. Det er nevnt som en generell tendens at det er en global konkurranse om talenter, og at det har blitt vanskeligere å tiltrekke seg og rekruttere de mest talentfulle forskerne. Viktigst for de fremtidige prioriteringene i SFI-ordningen, ser vi at internasjonal rekruttering og tilgang til personell er noen av de viktigste styrkene til SFI-sentrene ifølge både bedriftspartnere og forskningspartnere. Mer enn 40 prosent av forskningsmiljøene hevder at deres SFI-senter bidrar til internasjonalisering i stor grad ved å hjelpe til med å rekruttere utenlandske doktorgradskandidater og/eller masterstudenter. Samme andel av bedriftspartnere hevder at deres SFI-senter bidrar til internasjonalisering ved å gi bedre tilgang til kompetent personell og kunnskapsinstitusjoner.

Når det blir spurt om endringer i forsknings- og innovasjonslandskapet, nasjonalt og internasjonalt, som vil påvirke SFI-ordningen og SFI-sentrene, fremheves følgende tendenser som de viktigste.

1) EU-finansiering ses ikke som attraktivt

Det er en tendens blant deltakerne i SFI-ordningen til å se EU-finansiering som forskjellig fra nasjonale finansieringsordninger, og søknadsprosessene ses som mer kompliserte, byrdefulle og byråkratiske, og med mye lavere suksessrate enn for norske støtteordninger. Vi hører argumentet igjen og igjen blant deltakerne at de ikke har noe stort incitament til å søke om EU-finansiering siden finansieringsmulighetene i Norge er mye bedre. Dette kan også være grunnen til at EU-finansiering er gitt så lav prioritet både av bedrifter og forskere i SFI-sentrene. Dette er imidlertid motstridende med det faktum at forskerne med størst ekstern finansiering også har en tendens til å motta betydelig mer EU-finansiering. De har også en tendens til å ha flere patenter og mer samarbeid med industrien. Det store spørsmålet er da hvordan SFI-ordningen kan håndtere denne mangelen på motivasjon som påvirker sentrenes internasjonaliseringsarbeid.

2) Open Access utfordrer forskningssystemer

Open Access-bevegelsen, der forskningsartikler blir gjort fritt tilgjengelige på nettet i stedet for publisert i tidsskrifter, har vokst raskt de siste årene. Den utfordrer forskningssystemet fordi artikler som publiseres for åpen tilgang ikke blir registeret i samme grad etter hvilken påvirkning, impact, de har. For forskere (spesielt unge forskere), forskergrupper og forskningsinstitusjoner som er svært avhengige av publiseringsresultater og som vurderes på impactfaktorene i tidsskriftene de publiserer i, er dette en reell utfordring. Spørsmålet er hvordan dette kan håndteres i sammenheng med SFI-ordningen?

3) Forsvarets FoU-utgifter vil øke

Med nye krav fra den amerikanske regjeringen om at de europeiske partnerne i NATO skal øke sine bidrag til to prosent av BNP, har deltakerne i workshopene spådd at europeiske lands forsvars-FoU vil se en stor økning de kommende årene. Spørsmålet er hvordan dette vil påvirke de europeiske og norske forsknings- og innovasjonssystemene. Deltakerne hevder at det kan påvirke hele forskningssystemet, da forskningsfinansieringen ikke samlet vil øke, men det må overføres midler fra andre områder til dette nye området. Spørsmålet er da også

om Norge skal ha en SFI som bedriver forskning og innovasjon innenfor forsvarsrelaterte fagfelter?

Ambisjoner og anbefalinger for fremtiden

Gjennom hele evalueringsprosessen har vi notert, testet, diskutert og nyansert mange ambisjoner og forslag til endringer i SFI-ordningen. Vi har også søkt etter inspirasjon til denne delen i vår gjennomgang av sammenlignbare ordninger i Sverige, Østerrike og Storbritannia.

Følgende sterke fremtidige ambisjoner for SFI-ordningen er foreslått på dette grunnlaget.

1. Det må være mer **engasjerte, kompetente og aktive bedriftspartnere** i SFI-sentrene. Dette vil også støtte ambisjonen om sterkere brukerkontroll/ styring av sentrene.
2. SFI-ordningen bør **sette dagsorden for neste industrielle (digitale og disruptive) revolusjon** og sikte på løsning av fremtidige utfordringer i samfunnet.
3. Deltakere i sentrene må ha et mye **sterkere fokus på kommersialisering av forskningsresultater**.
4. SFI-sentrene må gi mye **høyere prioritet til internasjonalisering** i alle sine former - fra å tiltrekke seg EU-finansiering og internasjonal sampublisering, til å rekruttere forskere og studenter i utlandet.
5. **Offentlig innovasjon og tjenesteinnovasjon** må støttes mer og ved andre tiltak - og prestasjoner bør måles med andre indikatorer.
6. **SFI-sentre trenger en raskere start**. Sentrene må være operative fra dag 1. Dette stiller krav til konsortieavtalen, partnernes engasjement og hvordan det kan organiseres en søknadsprosess som vil resultere i den beste utvelgelsen av kandidater til nye SFI-sentre.

Forslag til endringer i SFI-ordningens virkemidler

Hvilke endringer i virkemidler er da nødvendige for SFI-ordningen for å styrke realiseringen av de foreslåtte fremtidige ambisjonene. Basert på intervjuer, resultatene fra spørreskjemaundersøkelsen, den internasjonale gjennomgangen av tilsvarende ordninger i Østerrike, Storbritannia og Sverige og den siste workshopen, har vi kommet frem til følgende forslag til endringer i virkemidler for SFI-ordningen.

1. Start med forretningsmodellen og støtt implementering

For å kunne bedre sette dagsorden for den neste industrielle revolusjonen og løse fremtidige utfordringer i samfunnet, bør SFI-sentre starte med innovasjon i forretningsmodellen heller enn 'business-as-usual'. For å sikre at dette vil skje, bør dette bygges inn som en forventning til deltakerne allerede i søknadsprosessen.

For å bli mer orientert mot kommersialisering må det være et parallelt fokus på hvordan man kan støtte implementering av forskningsresultater hos bedriftspartnerne og videre de direkte 'go-to-market'-aktivitetene. Det vil kreve spesiell og fleksibel IPR-støtte. Det bør vurderes om TTO-enhetene på vertsinstitusjonene kan ha en mer formalisert rolle og hjelpe til med å sikre at flere kommersielle resultater introduseres på markedet.

Et sterkere fokus på å yte støtte til implementering av forskningsresultater, innovasjon og kommersialisering er ekstremt viktig, men det bør ikke komme på bekostning av excellent og eksperimenterende forskning. Forskning og innovasjon er her to sider av samme mynt. Derfor må målene for SFI-ordningen om forholdet mellom forskning og innovasjon formuleres veldig tydelig, så ingen er i tvil om hva som forventes av sentrene og partnene. Fra intervjuene og diskusjonene på workshopene er det

tilsynelatende noen forskjeller i deltakernes forståelser og tolkninger av målene i ordningen.

Det bør være kjent og klart uttalt hva SFI-ordningen ikke handler om, og hvordan den adskiller seg fra andre ordninger under Forskningsrådet, for eksempel FORNY, SkatteFunn, FME, SFF eller BIA-ordningen.

I henhold til formålet med SFI-ordningen skal all forskning som gjennomføres av sentrene, herunder forskning finansiert av partnerne, være langsiktig og forventes å kunne danne grunnlag for innovasjon og verdiskaping.

SFI-sentrene velges ut å støttes ikke bare på grunn av deres vitenskapelige fortrinn, men også deres potensial for innovasjon og verdiskapning. Det overordnede målet med SFI-ordningen er således å styrke næringslivets evne til å innovere.

I henhold til målet med SFI-ordningen skal sentrenes forskningsresultater og kompetanse utgjøre en plattform for innovasjon og verdiskapning blant partnerne. Partnerne skal delta i styringen, finansieringen og forskningen, og må ha egne innovasjonsaktiviteter, og ha muligheten til å utnytte avansert forskning i sine utviklingsaktiviteter.

Ifølge formålet med SFI-ordningen er det først og fremst de bedriftene som deltar i et SFI-senter, som forventes å utnytte resultatene av forskningen. Men dette betyr ikke at forskningspartnere og Forskningsrådet er uten ansvar for implementering av forskningsresultater, innovasjon eller kommersialiseringsdelen. Respondentene i undersøkelsen bekrefter at de deltakende forskerne ikke har tilstrekkelig innovasjonskunnskap og markedsforståelse. Derfor bør det også være et fremtidig satsingsområde for SFI-ordningen å oppmuntre karriereforskere til å tenke og handle mer som innovatører. Målet er å sikre at forskerne oppnår en bedre forståelse og verdsettelse av markedsmekanismer.

Det som faller utenfor kjerneområdene av virksomheten kan kommersialiseres annerledes, for eksempel gjennom forskningsbaserte nyetableringer. Norges forskningsråd har her en rolle i å tilrettelegge hvordan SFI-ordningen kan ha sammenheng med andre virkemidler som FORNY-ordningen SkatteFunn, FME, SFF eller BIA-ordningen, som tidligere evalueringer har dokumentert som mulig steppingstones til og fra SFI-sentrene i partnernes innovasjonsprosesser.

2. Sterkt industrifokus i søknadsprosessen

SFI-ordningen må ha et sterkere industrielt fokus i form av mer engasjerte, kompetente og aktive bedriftspartnere. Dette må realiseres uten å risikere at det hemmer den forskningsbaserte innovasjonen. Det må være en strengere screening av de industrielle partnerne i søknadsprosessen for å sikre at bedriftspartnerne er virkelig engasjerte og vil være aktive som det er angitt med bedriftenes in-kind-bidrag. Screeningen skal også sikre at søknaden kjennes og involverer både C-nivået og den ledende FoU-personell i de deltakende selskapene.

En utfordring er også at det bare er få norske bedrifter som driver forskning selv. Dette er en av grunnene til at noen selskaper ikke er så aktivt involvert i forskning ved sentrene. Snarere er innovasjon i mange av bedriftene basert på erfaring, ikke forskning. Det er da viktig å sikre at hvis selskapene ikke forsker, må de ha tilstrekkelig kompetanse til å oppta og implementere forskning fra SFI-senteret. I mange bedrifter mangler denne kompetansen ifølge respondentene i både intervjuene, spørreundersøkelsen og workshopene. For å sikre flere forskningskompetente deltakende bedrifter i fremtiden, bør det derfor vurderes om de bedriftene som skal delta i et SFI, må kunne dokumentere forskningsferdigheter eller synliggjøre tiltak for å oppnå denne kompetansen.

Det industrielle fokus for SFI-ordningen ville ha nytte av å stille krav til kontant betaling fra deltakerbedriftene. Det nåværende private finansieringskravet er 25 prosent (inkludert både in-kind og in-cash). Det bør vurderes om dette kravet bør knyttes bare til in-cash-bidraget. Det vil imidlertid ikke være et populært forslag til endring blant verken bedriftspartnere eller forskningspartnere. Nesten ingen er for høyere in-cash-bidrag. Forslagets realisering vil derfor kreve en endring i forståelsen blant partnerne. Det kan også implementeres trinnvis, og det er viktig å sikre at det ikke vil utelukke mindre bedrifter. Det bør også bemerkes at det ikke er et spørsmål om bare in-cash eller bare in-kind, men heller den optimale andelen av hvert som må vurderes. Størrelsen kan diskuteres, men poenget er at partnerne må bidra med begge deler. SFI-ordningen kan se til COMET-ordningen i Østerrike for inspirasjon til hvordan et nytt forslag til privat finansiering kan håndteres. In-cash-bidrag har videre den betydningen at de tillater sentrene å gjennomføre flere innovasjonsrelaterte aktiviteter.

Flere partnere har også nevnt mer fleksibel finansiering som en vei videre for å tillate mer privat engasjement. Dette kan være gjennom årlige avgifter eller ulike typer private medlemskap.

Endelig bemerkes det at det industrielle fokus også kan styrkes ved å ha en større andel av industridoktorgrader knyttet til sentrene. Dette vil sikre mer mobilitet og omsetting av kunnskap fra forskning til industri og vice versa, noe som mange bedriftspartnerne kan dra nytte av.

Det anbefales at RCN har intervjuer både med senterlederne og en av bedriftspartnerne som en del av søknadsprosessen. Intervjuene bør følges opp av møter med sentrene tre måneder etter at bevilgningen er gitt, for å sikre at sentrene får en god og hurtig start og vet hva som forventes av dem.

3. Konkurranse mellom sentrene

For å motivere sentrene til en raskere start og legge til rette for mer innovasjon kan noen elementer av konkurranse bli introdusert til SFI-ordningen, på to måter. Først kan det være en prosess med konkurranse etter de første 3 år hvor sentrene bliver gjennomgått og vurdert. Topp-80 prosent av sentrene med de beste resultatene kan deretter fortsette mens sistnevnte 20 prosent vil ha ett år til å avslutte sin virksomhet. Den foreslåtte modellen er inspirert av et tiltak nylig introdusert til den svenske VINN Excellence-ordningen. Dessuten kan SFI-ordningen innføre en felles pott som SFI-sentrene kan by inn og konkurrere om for å tillate flere innovasjonsaktiviteter.

Selv om målene for konkurransen burde være klare, som nevnt ovenfor, er det viktig å nøye observere at det mer konkurransepregede miljøet ikke bare oppmuntrer til mer inkrementell forskning og innovasjon på bekostning av intellektuelle eksperimenter og mere fundamentale innovasjoner. Vi mener at dette ikke er en stor risiko hvis målene og ambisjonene til SFI-ordningen er klart definert og formulert til alle sentre.

Det er også viktig at målepunkter for å vurdere SFI-sentrenes resultater er brede og klart definert og anvendes på en fleksibel måte. Vi diskuterer og gir mer detaljerte anbefalinger for dette senere. Det er imidlertid viktig her å merke seg at det kan være en spenning mellom a) klasiske SFI-sentre og SFI-sentre i tjeneste sektor og offentlig sektor, som må ha forskjellige målepunkter, og b) konkurranse mellom sentre. Et bedømmelsespanel må her kunne sammenligne epler og appelsiner for å bedømme hvilke SFI-sentre som perfomer best.

I tillegg anbefales det at RCN utvikler klare prosedyrer som kan aktiveres når det er bestemt at et senter bør avslutte sin virksomhet før tiden. Utfordringen er da hvordan man går videre med oppsigelsen. Forskningsrådet trenger klare prosedyrer for

dette. Det må også formuleres tydelig til sentrene ved initiering at lukking før de åtte årene er en mulighet hvis de ikke klarer seg godt.

4. Kriterier og insentiver for internasjonalisering

For å få SFI-sentrene til å prioritere internasjonalisering høyrere og i alle sine former, er det nødvendig å innføre strengere kriterier og å bygge økonomiske insentiver som kan understøtte internasjonalisering til SFI-ordningen.

Ordningen bør i praksis favorisere forskning som foregår i nært samarbeid mellom norske og internasjonale forskningsmiljøer og selskaper. Dette oppnås best hvis søknader til sentre involverer akademiske samarbeidspartnere fra utlandet, samt internasjonale selskaper som partnere. Det bør derfor være viktige kriterier i søknadsbehandlingen at dette inngår. Søknader bør også vurderes med et øye på senterlederens erfaring med internasjonalt samarbeid og senterets potensial til å bli en sentral aktør i internasjonalt samarbeid, som for eksempel i EU.

Det bør legges et sterkere fokus på å tiltrekke EU Horizon 2020-finansiering. En av utfordringene er her at det er lettere for forskerne å tiltrekke seg norsk finansiering. EU-samarbeid og internasjonalisering har også lav interesse for de fleste av de deltakende bedriftene. SFI-ordningen kan etablere flere belønningsmekanismer for sentrene som prioriterer det internasjonale.

Flere nye målekriterier kan bli introdusert for å understøtte utviklingen, for eksempel med fokus på antall EU-søknader og suksessrate på EU-søknader, SFI-sentres plassering i søknader, internasjonalt medforfatterskap, internasjonal rekruttering av doktorander og introduksjon av nye produkter på internasjonale markeder.

5. Bedre målepunkter for å vurdere SFI-sentrenes resultater

De sterkere ambisjonene fremhevet ovenfor kan støttes av en sterkere årlig overvåkning av fremdriften og fleksible, men tydeligere, målepunkter. Dette gjelder de ovennevnte internasjonaliseringsindikatorene, men enda mer indikatorene som brukes til å måle innovasjon og for kommersialisering innenfor SFI-sentrene. Den eksisterende adgangen til selvrapportering av innovasjon og kommersialisering angis av flere deltakere for å være upresis og ikke sammenlignbar. Evalueringen bekrefter dette. Flere andre utfordringer har blitt nevnt av deltakerne, for eksempel at innovasjon innenfor og utenfor SFI-ordningen er registrert med samme kilde.

Et stort antall forslag til reviderte resultatmål og indikatorer har blitt foreslått av deltakerne i workshopene. De supplerer dem som er nevnt ovenfor om internasjonalisering, offentlig innovasjon og tjenesteinnovasjon, for eksempel spin-outs, implementerte resultater, vellykkede pilotprosjekter, prototyper, doktorgrader, industrielle doktorgrader, postdocs og antall masterstudenter over tid, nye forretningsmodeller, nye innovasjonsmetoder m.m.

Til slutt er det viktig å merke seg at de samme resultatmålene ikke passer alle. Noen bør for eksempel fokusere mer på rapportering av innovasjon innenfor offentlig sektor og tjenesteinnovasjon, som handler mer om organisatoriske og kulturelle endringer, nye retningslinjer, forbedret brukeropplevelse og kundetilfredshet osv. Å ha nøyaktige målekriterier er viktig og trolig viktigere enn de fleste interessenter erkjenner. Det er viktig fordi dette kan brukes som en veiledning for både deltakerne selv og i evalueringer.
Et veldig relevant eksempel er her hvordan du måler forskning og innovasjon for å være i stand til å balansere de to og for å støtte måloppnåelse i SFI-sentrene. Både analytikere, interessenter og deltakere trenger å vite mer om forskningens stadier og modenhet. En del forskning kan være langt fremme

og skape innovasjoner innenfor en relativt kort tidshorisont (for eksempel i de neste 5 årene). For andre forskningstemaer kan det gå 10 år eller mer. Å måle og verdsette begge på samme måte i SFI-ordningen er ikke relevant fordi grunnforskning ikke vil skape innovasjon i nær fremtid. For sentrene med grunnforskning har dette den implikasjonen at de trenger å være enda mer fokusert på at bedriftspartnerne kan forstå det og forankre viten for å skape verdi.

6. Styrk offentlig innovasjon og tjenesteinnovasjon med nye virkemidler

Offentlig innovasjon og tjenesteinnovasjon må støttes med andre virkemidler enn det som finnes i dag i SFI-ordningen. Dette er generelt anerkjent som viktig av alle respondentene i intervjuer og i spørreundersøkelsen. Analysen har bidratt med noen ideer om hva som må gjøres annerledes i forsøket på å bedre støtte offentlig innovasjon.

Offentlig innovasjon

Først må det være et insentiv for offentlige aktører å engasjere seg i de prosessene og strukturene som kan støtte og akselerere offentlig innovasjon. Så er det en utfordring å tiltrekke offentlig finansiering for å etablere forskningsbaserte innovasjonssentre. Dette er en utfordring på grunn av budsjettmessige regler for de fleste offentlige virksomheter. I VINN Excellence-ordningen i Sverige har man forsøkt å løse dette ved å la det offentlige bidra med in-kind-finansiering.

For at innovasjon innenfor offentlig sektor skal lykkes, må den mer enn innenfor andre områder være basert på en plattform av sikkerhet, kvalitet og tillit. Den må også hvile på samhandling. Offentlig innovasjon må basere seg på trippel heliks med både offentlig og privat samarbeid og i partnerskap med forskning. Det gjør det mer komplisert når offentlig innovasjon samtidig er drevet av aktører ned ulike interesser og ulike insentiver.

Tjenesteinnovasjon

Flere utfordringer er nevnt i intervjuene når det gjelder å støtte tjenesteinnovasjon gjennom SFI-ordningen. Det er blant annet bekymring for at tjenestebedriftene er mindre interessert i forskningsbasert innovasjon. Det er ingen tradisjon for forskning i tjenestesektoren, både volum og kvalitet har vært lav. Det er langsomt i endring, men forskningsmiljøet er fortsatt ganske lite og konsentrert. Deltakerne oppfatter SFI-ordningen som svært teknologi- og produktorientert i motsetning til tjenestesektoren, som er rettet mer mot nye retningslinjer, kultur, organisatoriske endringer, brukere og ansatte. Som nevnt tidligere trenger området for tjenesteinnovasjon nye kriterier for å måle effektivtet og måloppnåelse. Deltakerne i workshopen og intervjuer foreslår flere måter fremover, blant annet:

a) Mer fleksibel start med en testperiode for bedriftspartnerne før de binder seg på lang sikt.
b) Mer fokus på å omsette forskning til innovasjoner.
c) Mere fleksible sentre som får lov til å ha fokuseringer og forskningsområder.
d) Bruke sentre for å bygge opp den kapasiteten som er nødvendig.
e) Mer fokus på forretningsmodeller og integrerte forsyningskjeder.
f) Følgende sektorer er nevnt som modne for mer tjenesteinnovasjon: Finansiell sektor, logistikk, detaljhandel, reiseliv og media.

Følgende fagområder er nevnt som svært relevante i samme sammeheng: Digitalisering/stordata, forretningsmodeller, ansatte vs. roboter, netthandel og blokkjedeteknologi.

1 Introduction

This report, commissioned by the Research Council of Norway (henceforth RCN), presents results of a thorough analysis of the SFI scheme.

The SFI scheme is intended to promote innovation by supporting long-term industrially oriented research and forging close alliances between research-active enterprises and prominent research groups. The scheme is also expected to enhance technology transfer, internationalization and researcher training.

Specifically, the SFI-scheme aims to:

- Stimulate firms to innovate through increased investment in long-term R&D, while also attracting foreign investments in R&D to Norway.
- Create active collaboration between an innovative private sector and prominent research environments
- Bring Norwegian R&D to the forefront of international research environments and networks, with a commercial focus.
- Promote researcher training in areas that are important to business as well as research-based knowledge and technology transfer.
- Contribute to promoting quality and efficiency in the public sector.

The SFI scheme must therefore strengthen:

- Technology transfer,
- Internationalization, and
- Research

Background

The establishment of the SFI scheme was based on the following needs, which were expressed prior to the establishment of parliamentary reports and the Research Council's initiatives:

- Need to stimulate established companies with high ambitions to increase their focus on R&D. It must be made more attractive for companies that work internationally to place R&D business in Norway.
- Need to stimulate business-oriented research and greater long-term sustainability both in companies and within research institutions.
- Need to concentrate efforts to promote internationally visible research environments.
- Need to strengthen the interaction between R&D active enterprises and research institutions and stimulate cooperation across institute and subject boundaries.

The centres are co-financed by enterprises, host institutions and the Research Council. The annual grant from the RCN is 9-12 million NOK. Together with the contribution of the host institution and partners, this will provide an annual total budget for each centre of NOK 20-30 million.

Enterprises participate actively in a centre's governance, funding and research. The main criterion for selecting centres is their potential for innovation and value creation. The scientific quality of the research has to be of a high international standard. The target group for the SFI scheme is especially the established companies and the R&D active part of the Norwegian business sector, and it is primarily the companies participating in a centre that are expected to exploit the results of the research.

When the centres are established, they are given a contract for five years. Based on a successful midway evaluation, the contract may be extended for another three years. Thus far, there are three generations of the SFI-scheme:

- SFI-I: 14 centres from 2007 to 2015 (concluded)
- SFI-II: 7 centres from 2011 to 2019 (active)
- SFI III: 17 centres from 2015 (active)

In total, 24 centres are still active in 2017.

DAMVAD Analytics is thus tasked with evaluating the success of the SFI-scheme as a whole, as well as across the three generations thus far.

The purpose of the evaluation is according to the mandate to provide both:

1) An insight into goal fulfillment for the SFI scheme, and
2) A proposal for adaptation and amendment for further development of the SFI scheme.

In regard to goal fulfillment, we seek to answer the following:

To what extent has the SFI scheme contributed to stimulating innovation and internationalization?

To what extent has the SFI scheme contributed to creating active cooperation between an innovative business community and prominent research communities?

To what extent has the SFI scheme provided for greater long-term, continuity and risk reduction in given research areas?

Has the SFI scheme helped to strengthen and further develop the best Norwegian, business-oriented R&D environments – nationally and internationally?

What systematic differences in goal fulfillment and effectiveness can be identified between the SFI centres and what does it tell us about the factors that shape goal achievement?

In regard to proposals for further development of the SFI scheme, we explore the following:

7. What changes should be made for the SFI scheme in the future, e.g. at future announcement rounds in order to increase the goal fulfillment and value creation of the scheme?
8. Are there limitations in the design of the SFI scheme that may hamper the establishment of future centres targeted at the public sector and the services sector?
9. What is the significance of changes in framework conditions and in the research and innovation system nationally and internationally?

Evaluation Method

In order to answer the above questions, we apply a mixed-methods approach, using both quantitative data on results and goal achievement in combination with both questionnaire survey and interview results, to provide a holistic and evidence-based insight into the strengths, weaknesses and areas of improvement for the SFI scheme.

Given that the three SFI generations have differing levels of maturity, the evaluation will focus on providing both results across the generations, while also comparing annual performance of centres included in the three generations.

The evaluation makes use of the following key data inputs:

- ***Centre self-evaluation schemes*** filled out by centre leaders in June 2017. These include result indicators, including innovations, commercial results and company results, as well as data on partners participating in the firm.
- ***SFI reports*** provide main indicators on funding from both RCN and partners of the centre.
- ***Surveys*** passed out to research and business partners of the centres provide insights on the contribution of the SFI to innovation and collaboration, as well as areas of strengths and improvement. The survey was sent out to 491 partners out of 551 in total, of which 225

responded. Private partners made up 152 of these respondents while research partners made up 73

- ***Interviews*** add depth from centre leaders, host institutions, industry representatives, and government entities on the value of the SFI scheme.
- ***International outlook*** to comparable schemes in *Austria, Sweden and UK.*
- ***Bibliometric publication analysis*** of scientific specialization and quality of research in the SFI-centres
- ***Documents*** from partners and stakeholders, i.e. annual reports, guidelines, announcements, etc.

Please see Appendix I for an in-depth description of these methodologies.

Structure of the evaluation report

The report is structured as follows: Chapter 2 provides an overview of the characteristics of the SFI generations, the centres within each, host institutions and partners. Chapters 3-5 will evaluate the results of the SFI scheme I terms of: innovations and internationalization, research performance, and active cooperation, respectively. Chapter 6 will perform a cluster analysis to better evaluate which characteristics of centres or SFI generations are conducive to success, measured by different parameters. These are supplemented by survey results. Chapter 7 provides international reviews of comparable schemes to provide a basis of comparison for the results of the scheme at hand, while chapter 8 reflects on the schemes ability to support public sector and service sector innovation. Lastly chapter 9 summarizes challenges and presents suggestions for future improvements.

2 Characteristics of the SFI Generations and Centres

2.1 Summary of SFI generations

This section will describe the characteristics of the different SFI generations and SFI centres, business partners and funding of the centres.

As per table 2.1, there are three generations, initiated in 2007, 2011 and 2015, respectively. As such, only SFI-I has concluded its 8-year term, for which reason the figures for SFI-II and SFI-III are subject to future changes.

The distribution of partners and centres across the generations differs greatly. SFI-I and SFI-III include roughly twice as many centres as SFI-II.

From each generation there are a number of partners who continue into later generations. A total of 17 partners from SFI-I continue into SFI-II while 23 partners continue from SFI-II to SFI-III. In SFI-III a total of 69 partners (24 pct.) have experience from earlier generations with the majority coming from the first generation (46). The majority of these are private partners, with 30 pct. of all business partners in SFI-III coming from earlier generations.

Table 2.1 further show that the partners of the centres are roughly split with two thirds private industry partners and one third public research partners, including both research institutes and universities. The share of business partners for SFI-II is slightly lower than the other generations, with only 62 pct. private partnership.

The centres included in each SFI generation vary both in their partner composition and sectoral focus, as well as host type and funding types. The following sections will present an overview of centre and generation characteristics.

2.2 Characteristics of SFI centres

Figure 2.2 presents the focus areas of the participating centres for each generation. From centre descriptions each centre is classified according to its strategic focus area, not taking into account sectoral affiliation. As such, a centre might score on multiple parameters or no parameters, if their strategic focus areas pertain only to process optimization and new methods of one particular sector.

These will be explored more thoroughly in the following. It is clear from the figure that there are some similarities across all generations, namely in terms of digitalization and sustainability.

TABLE 2.1
Overview of SFI generations

Generation	Time period	Number of centres	Number of Partners	Share business partners
SFI-I	2007-2015	14	168	77%
SFI-II	2011- present	7	90	62%
SFI-III	2015- present	17	281	71%
Total		38	539	71%

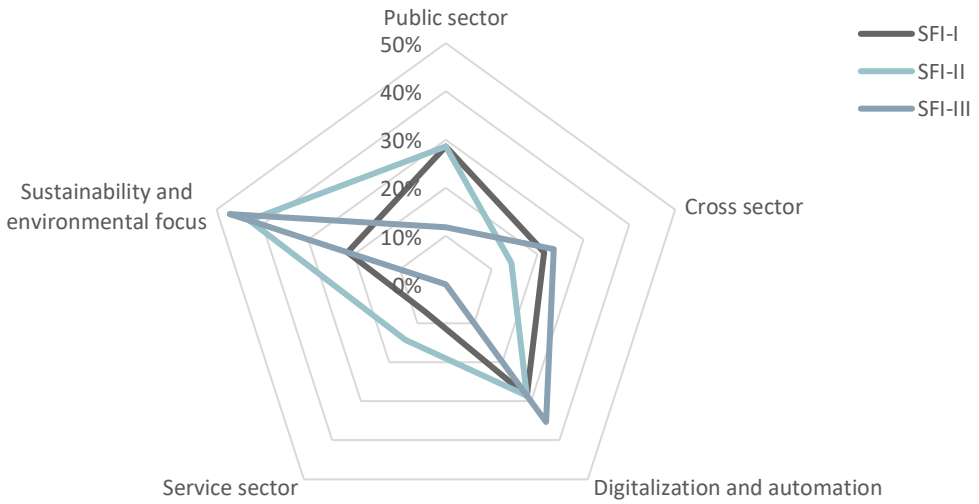
Source: The Research Council of Norway, self-evaluation reports by centre leaders and own quality assurance and calculations.
Note: Business partners are defined as industry partners in the yearly reports and final reports as well as The Brønnøysund Register Centre.

Over time, the SFI scheme has become more focused on sustainability and environmental impact as well as digitalisation and automation. Conversely, while the first two generations had a 30 pct. share of centres with a public-sector focus, this was only the case for 12 pct. of SFI-III centres. Innovations aimed at the service sector are also limited, with only a couple of centres creating services innovations. For all three generations, roughly 20 pct. of centres have a cross sectoral focus.

Figure 2.3 shows the partner composition of each of the centres included in each SFI generation. We see large variation in not only the number of partners, but also the share of business partners. In SFI-I, we see that particularly the two largest centres (in terms of number of partners), IO-Center and NORMAN, are largely made up of business partners. The opposite is true of SFI-II, where the two largest centres, SAMCoT and CSI, have a larger relative share that are research partners. The average size in terms of partnerships also varies greatly, with an average of 12 partners for SFI-I centres, 12,9 for SFI-II centres, and 16,5 for SFI-III centres. We thus see a growth in size and percentage of business partnerships from the first to the last SFI generation. The average share of business partners, fluctuates between generations, starting at 74 pct. for SFI-I, falling to 63 pct. for SFI-II and rising to 71 pct. for SFI-III.

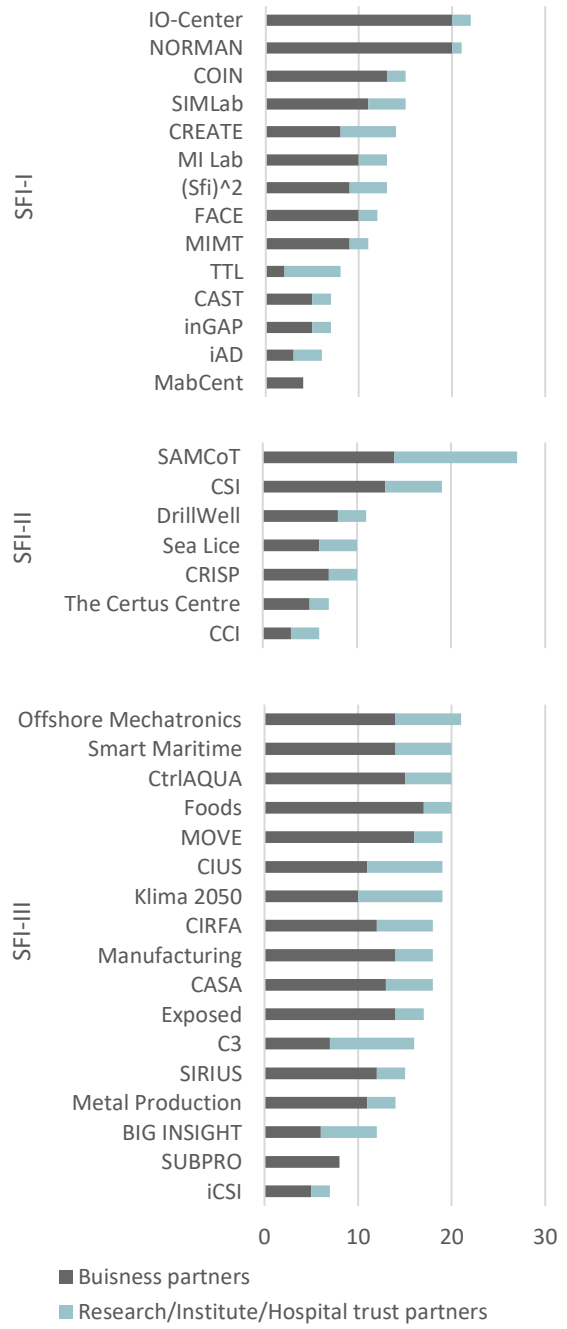
Figure 2.4 shows the composition of host institutions across centres. The two largest host institution types are research institutes and universities, with hospitals and private companies only in a few cases being hosts. Only SFI-I has a centre with a private host institution. Over time, the largest share of centres has universities as host institution.

FIGURE 2.2
Centre focus by generation (share of centres which are affiliated with each of the 5 themes)



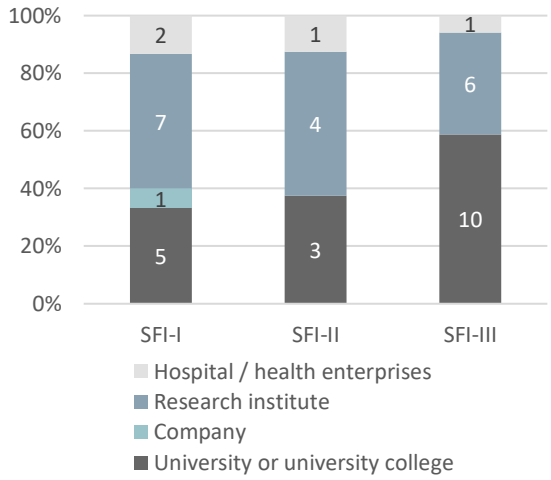
Source: Centre descriptions, processed by DAMVAD Analytics, 2017.
Note: Centre focus areas are not mutually exclusive. A centre may fall within neither or multiple categories.

FIGURE 2.3
Partner composition by generation and centre



Source: Self-evaluation reports by centre leaders and calculations processed by DAMVAD Analytics, 2017.
Note: Business partners are defined as industry partners in the yearly reports and final reports as well as The Brønnøysund Register Centre

FIGURE 2.4
Host type by SFI generation



Source: Self-evaluation reports by centre leaders and calculations processed by DAMVAD Analytics, 2017

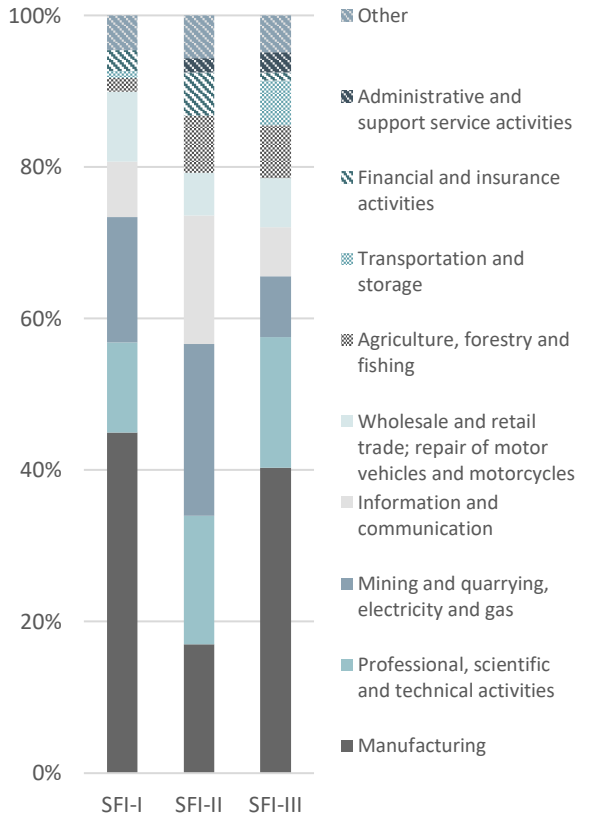
2.3 Characteristics of business partners

Figure 2.5 shows the sectoral focus of the business partners of each SFI generation. The three strongest sectors for all three are *manufacturing, professional, scientific and technical services*, and *mining and quarrying, electricity and gas,* making up over 60 pct. of the partners of each generation. The absolute number of partners in the energy sector has remained fairly stable across the three generations, however the share has greatly increased in SFI-II. This comes at the expense of manufacturing partners, who are reduced greatly in both numbers and shares in SFI-II.

Agriculture, forestry and fishing partners begin to have a larger role in later generations, making up only 2 pct. in the first generation, and increasing to 8 pct. and 7 pct. in SFI-II and SFI-III, respectively. They have also grown in numbers, doubling from SFI-I to SFI-II and tripling from SFI-II to SFI-III.

Partners in *administrative and support service activities* and *transportation and storage* join the SFI scheme in later generations, with the former making up 2 pct. in SFI-II, and together with the latter making up 6 pct. in SFI-III.

FIGURE 2.5
Business partner sectors, by generation

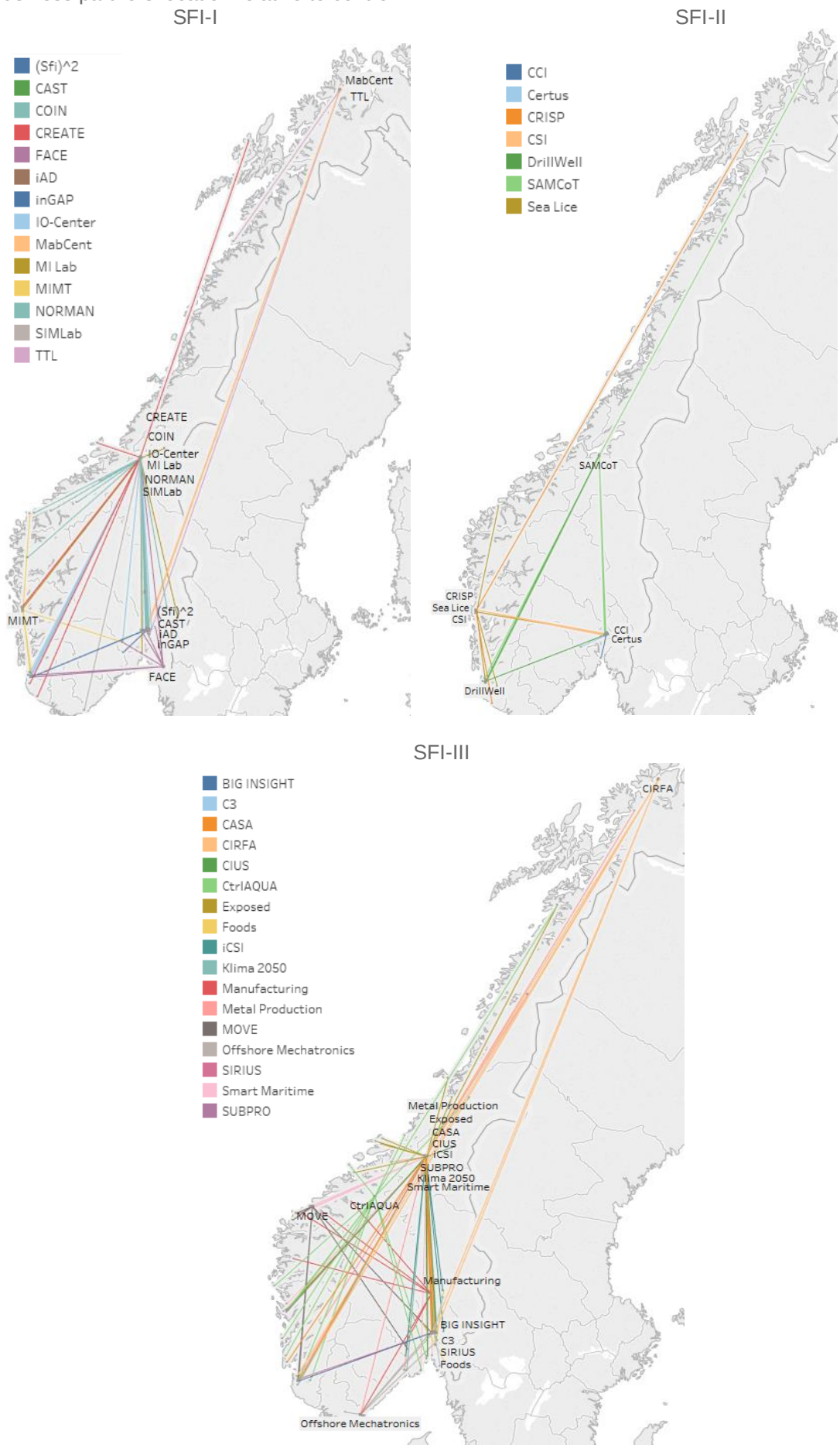


Source: Self-evaluation reports by centre leaders.
Note: Other includes 10 partners in the following sectors: Construction, Real estate, Education, Human health and social work activities, Arts, entertainment and recreation, and Other service activities, unknown. Sector only given for partners where sector is given. Mining and Quarrying refers to extraction of crude petroleum and natural gas and mining support service activities among others.

The geographical closeness of partners is determined in figure 2.6 for the centres in SFI-I, SFI-II and SFI-III respectively. The individual centres represented by different colors are connected to each of the business partners in the specific centre. Across the three generations the centres are primarily located in Oslo, Bergen, Trondheim and Tromsø. The maps also show that geographical closeness of the partners is not a priority today.

The centres in SFI-I and SFI-III do have business partners geographically spread both within centres with few and many business partners. SFI-II does generally have fewer business partners within each centre than across the three generation. Though again geographical closeness of the partners is not indicated to be a big priority for the centres.

FIGURE 2.6
Business partners location relative to centre



Source: Self-evaluation reports by centre leaders and The Research Council of Norway and The Brønnøysund Register Centre.
Note: The partners represented in the graph are the business partners with an address in The Brønnøysund Register Centre. The origin corresponds to the specific centre and the destination to the business partner. Specific colours refer to partners within the same centre.

2.4 Funding

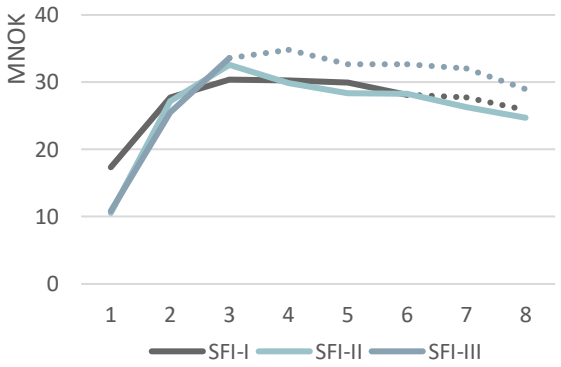
Funding of the SFI centres come from the different partners cooperating with a specific SFI centre. The total budget of the SFI is shown in table 2.7. Total budget has been 4814,9 MNOK where 1704,3 MNOK of the financing comes from The Research Council of Norway (RCN).

TABLE 2.7
Budget in MNOK

Generation	Total	RCN
SFI-I	3098,5	1108,0
SFI-II	1098,1	376,3
SFI-III	618,3	220,0
Total	4814,9	1704,3

Source: The Research Council of Norway

FIGURE 2.8
Average MNOK financed over time (years since start) per centre, by generation



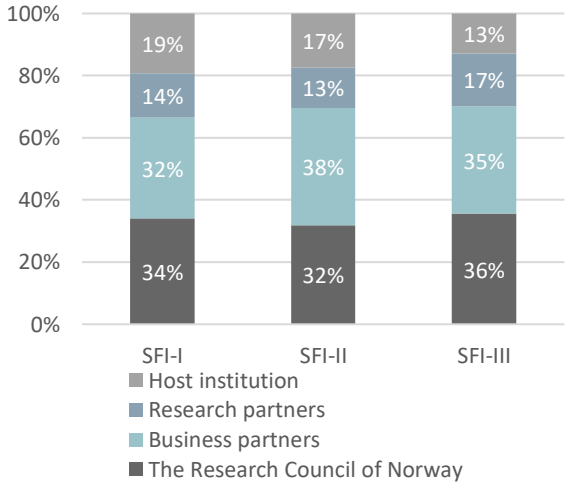
Source: The Research Council of Norway
Note: The dashed lines refer to expected MNOK in centres in years 2017 and forward.

Figure 2.8 shows the budgeted funding over time per centre in the three SFI generations. It shows that the centres get the highest contribution two to three years after beginning of the centre. Afterwards the funding decreases slowly towards the end.

Given this the RCN has financed 34.3 – 35.8 pct. of the total funding in the centres. In the period 2007-2015, SFI-I has budgeted with 3098.5 MNOK. SFI-II has in 2011-2016 budgeted with 1098,1 MNOK and SFI-III in the period 2015-2016 with 618,3 MNOK. In total, 4.8 billion NOK have financed the SFI scheme.

Annual average funding for the three generations are 28,9 MNOK, 31,4 MNOK and 26,2 MNOK for SFI-I, II and III respectively. Figure 2.9 shows average annual funding grouped by partners. The shares of funding in each of the generations are overall approximately the same, and no major differences appear in the figure. The main contributions are from RCN financing 9,3– 10,0 MNOK annually and business partners financing 9,0–11,9 MNOK annually. Other partners that contribute with funding are host institutions, research partners and public partners.

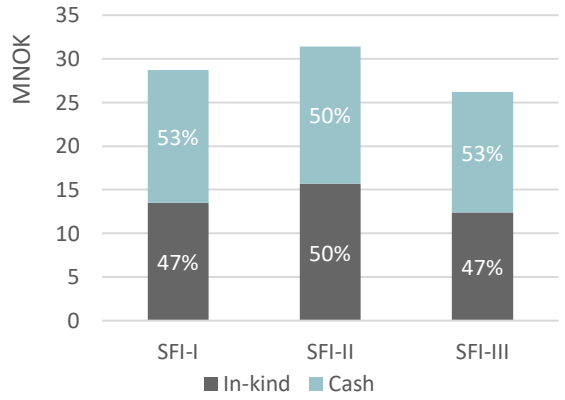
FIGURE 2.9
Annual funding by generation and funding source



Source: The Research Council of Norway

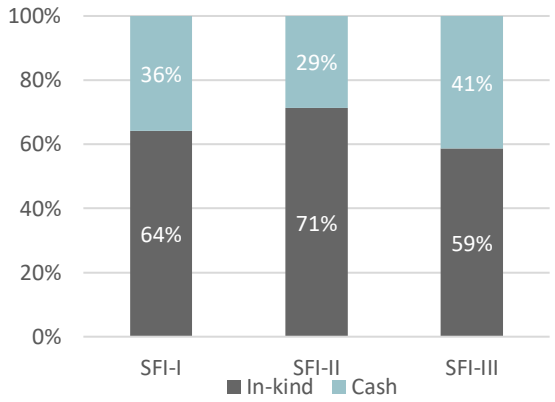
Investigating the type of contributions, figure 2.10 shows the shares of cash and in-kind for each of the SFI generations. Here the shares for each of the funding types are also approximately the same with no major differences.

FIGURE 2.10
Average annual funding by generation and type



Source: The Research Council of Norway
Note: In-kind and cash are contributed by The Research Council of Norway, Business partners, Research partners and Host institutions.

FIGURE 2.11
Average annual funding contributed by business partners by generation and type



Source: The Research Council of Norway

Within SFI-I, 15.2 MNOK corresponding to 53 pct. of the funding is contributed in cash by partners while 13.5 MNOK is contributed in in-kind. In SFI-II these contributions are equally distributed between in-kind and cash with 15,7 MNOK in both. Lastly, in SFI-III, 53 pct. of the contributions are in cash corresponding to 13.8 MNOK and 47pct. is contributed in in-kind.

The contributions in cash are primarily financed by The Research Council of Norway and business partners. In-kind contributions are on the other hand primarily financed by business partners, host institutions and research partners.

The share of in-kind and cash contributions financed by private companies are showed in figure 2.11. The average in cash contributions across the three generations is 37 pct. The in-cash contributions vary between 29 pct. and 41 pct. within the three generations. The average in-kind contribution between the three generations are 63 pct.

3 SFI contribution to innovation and internationalisation

This section will explore the extent to which the SFI scheme meet the goal, to:

Stimulate firms to innovate through increased investment in long-term R&D, while also attracting foreign investments in R&D to Norway.

10. We explore the goal through the first evaluation question: *To what extent has the SFI scheme contributed to stimulating innovation and internationalization?*

We observe the SFI scheme's contribution to innovation by data and documents on:

- New R&D innovations completed,
- Number of firms within a scheme who created R&D results,
- Number of new business areas and business created, and
- Commercial results of the projects.

We observe the SFI scheme's contribution to internationalisation through qualitative insights on:

- Increased international network and reputation as well as business opportunities
- International recruitment for both research institutions and firms
- Attracting international funding and participation in EU projects.

Figures in the following sections are presented for the three generations, including SFI-III, though concrete innovation results are expected to be limited for this generation thus far.

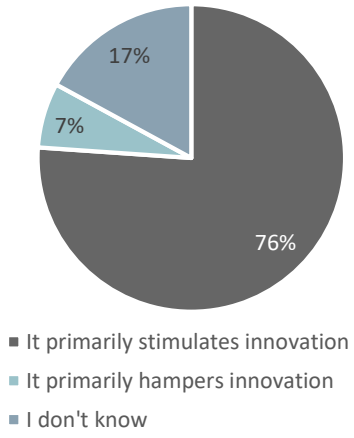
3.1 Contribution to Innovation

This section will explore whether the participating firms have been able to apply results from research to create tangible R&D results.

3.1.1 The overall contribution to innovation

The partners in the centres are generally satisfied with the consortia agreement. As per figure 3.1, 76 pct. of the partners say, that the consortia agreement for the SFI primarily stimulates innovation, whereas only 6 pct. argue that it hampers innovation. The private partners are more positive on the agreement as 79 pct. say it stimulates innovation, while this is only true for 71 pct. of research partner respondents. The reason for asking this question was that it was stated in some of the early interviews that the consortia agreements could have the effect of hindering innovation if not drafted properly. The survey result shows that this is not a general challenge.

FIGURE 3.1
"In your opinion, does the consortia agreement for the SFI primarily stimulate or primarily hamper innovation?"



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: n=205

Figure 3.7 compiles a number of survey questions posed to both research institutions and business partners. The questions have been inspired by the insight gained in the qualitative interviews.

Figure 3.7.A shows the extent to which the partners within the SFI believe digital technologies and their product innovation will disrupt their industry. Of these, 45 pct. reported that digital technologies will disrupt their industry to a great extent, while only 18 pct. reported that their own product innovations will disrupt industry to some extent. We can conclude that digital technologies are highly important to the

industries included, and that the industry partners are not their own innovations will have big role in disrupting the industry.

With respect to innovations created, 72 pct. of respondents reported introducing a new product during the past three years that was new to their industry or market (figure 3.7.B). However, only 14 pct. responded that they introduced the new products due to the SFI scheme, while 58 pct. Introduced the new products due to other reasons.

Asking respondents whether innovations are recorded, 9 pct. say that not all innovations are being registered and reported, while only 34 pct. pct. said they did (figure 3.7.D). The rest did not know. This suggests that not all information about the innovations are known by the individual partners in the centre. Survey responses suggest that this is in part due to the types of innovations being difficult to register, as they are small implementations in larger developments or it is to early. Another reason is administrative in nature, regarding the registration process. The reason for asking this question were some of the answers we got in the previous interview round which suggested that not all innovations are reported which could lead one to underestimate the level of innovations. The survey results tell us that this is not a major challenge.

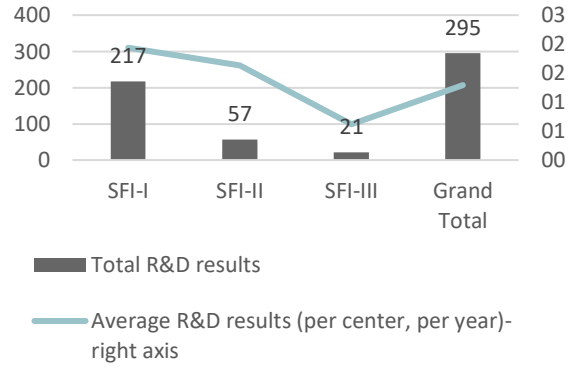
Similar to the result above, 79 pct. of the respondents say that their innovations strengthened the sector they are part of (figure 3.7.C). Naturally, partners who experienced commercialization believe this to a higher extent, with 90 pct. of those who have commercialized their innovation saying yes, and only 55 pct. of these who have not commercialized saying yes.

3.1.2 Innovation in terms of R&D results

Figure 3.2 presents the overall results in terms of R&D results created across the three SFI generations in total and on average per centre. R&D results cover all completed new or improved methods, models or prototypes.

Naturally SFI-I has most completed R&D results, given that it is the only generation which has concluded its term. It is also the generation which has the most completed results per centre per year. The SFI scheme overall has generated a total of 295 R&D results, in average 1,3 innovations per year per centre. The average results per year per centre follow the trend in total results, with SFI maturity largely determining the extent of R&D results.

FIGURE 3.2
Number of R&D results recorded by the

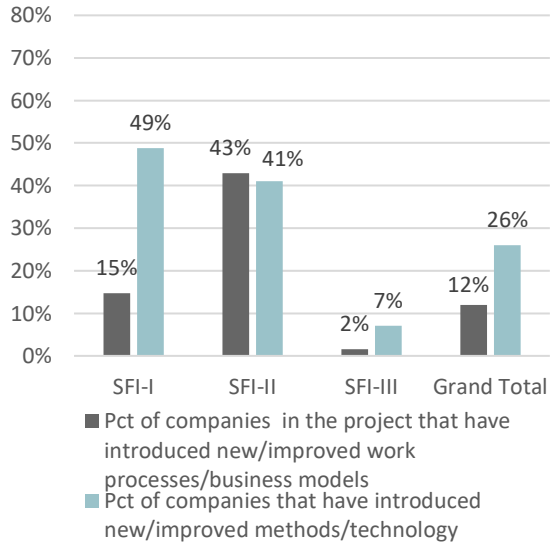


Source: Self evaluation reports by centre leaders.
Note: R&D results covers all completed new or improved methods/models/prototypes, average refers to the average across generations

Figure 3.3 takes a closer look at the types of innovation that the firms participating in the project produced, and the share of business partners with results. In terms of producing *new methods and technologies*, the share of firms which produced R&D results follows the trend in total R&D produced overall. There is a higher percentage of companies with new methods and technologies, for a higher number of years of participation. However, in terms of *new work processes and business models*, a higher percentage of participating firms in SFI-II reported R&D results than for SFI-I and SFI-III.

In addition to the results in figure 3.3, a number of companies outside the project also produced R&D results in terms of work processes, business models, methods and technology. In total 18 firms outside the project produced R&D results, with SFI-I accounting for 11, SFI-II accounting for 6, and SFI-III accounting for just 1.

FIGURE 3.3
Percentage of companies that have produced R&D results.

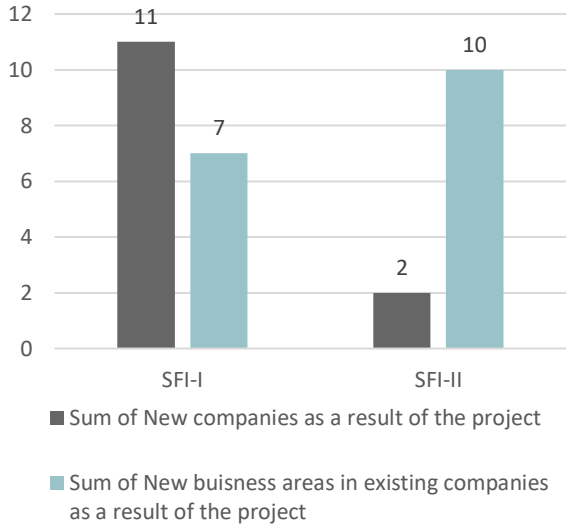


Source: Self-evaluation reports by centre leaders.

3.1.3 Innovation in terms of new business areas and business creation

In terms of new companies developed as a result of the SFI scheme, SFI-I has contributed 11 new companies to the Norwegian economy (figure 3.4). So far, SFI-II has produced 2. This is relatively low, considering the number of years SFI-II has existed, however, it is reasonable to believe that company creation is timely, and requires a high degree of certainty in regard to the results created by the project. For this reason, company creation may to a higher extent occur at the end of an SFI generation. In regard to new business *areas*, however, SFI-II exceeds the results of SFI-I, having added 10 new business areas to existing companies, compared to just 7 in SFI-I. This may indicate that SFI-II is more explorative in sectors where Norway did not previously excel. SFI-III does not yet have outputs in this indicator.

FIGURE 3.4
Sum of new business areas and new companies in SFI-I and SFI-II



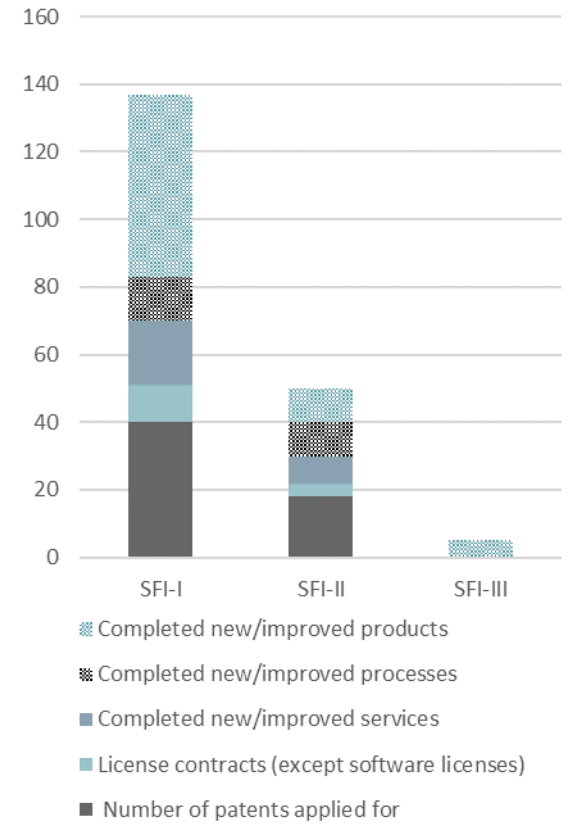
Source: Self-evaluation reports by center leaders.
Note: SFI-III has no results on this area.

3.1.4 Commercial results

This section will explore the extent to which the results from the centre-collaborations have led to commercial results.

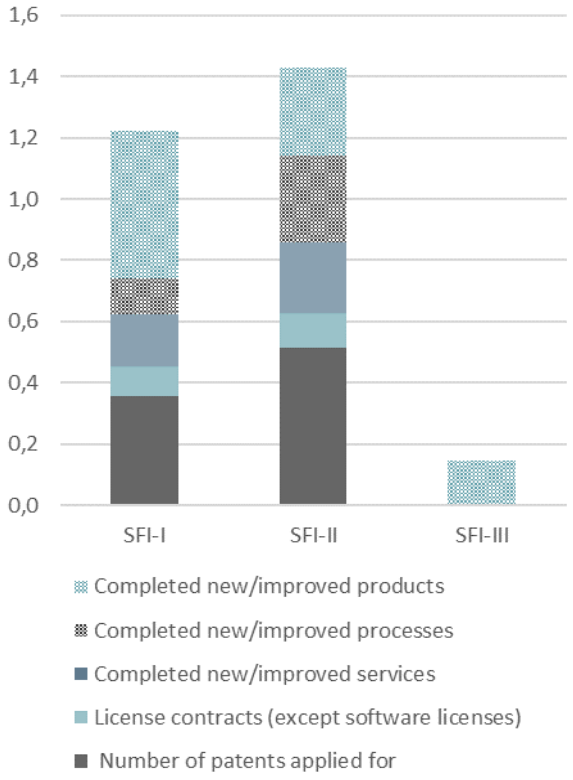
Across the three generations, a total of 192 commercial outputs have thus far been created, as per figure 3.5. SFI-I stood for 137 results, SFI-II stood for 50, while SFI-III stood for 5. The commercial outputs consist of patents (30 pct.), license contract (8 pct.), new or improved services (14 pct.), new or improved processes (12 pct.), and new or improved products (36 pct.). The distribution of commercial results is relatively even across the first two generations, though SFI-II has a higher relative output in the form of patents and new or improved processed, while SFI-I has a higher relative output in the form of new or improved products.

FIGURE 3.5
Total commercial results by generation



Source: Self-evaluation reports by centre leaders.

FIGURE 3.6
Average commercial results per centre per year, by generation



Source: Self-evaluation reports by centre leaders.

Figure 3.6 shows the commercial output per centre per year, in order to compare across the three generations. As expected, SFI-III is far from commercial maturity, however, SFI-II already exceeds the commercial output per centre of SFI-I. This is particularly true for number of patents, created every other year per centre, and number of new or improved processes, created at the rate of one every three years.

In the survey 54 pct. of the respondents across the generations say that they still expect to commercialize and go to market with their innovation (figure 3.7.E). Looking across the three generations, 57 pct. within SFI-I expect to commercialize, whereas 40 pct. and 55 pct. expect to commercialize within SFI-II and SFI-III, respectively. The SFI-II has the lowest share of respondent who expect to commercialize and the highest share (40 pct.) that answer that they don't know. If we conclude that SFI-II is more explorative,

FIGURE 3.7

Figure A: To what extent do you believe the following will disrupt your industry?

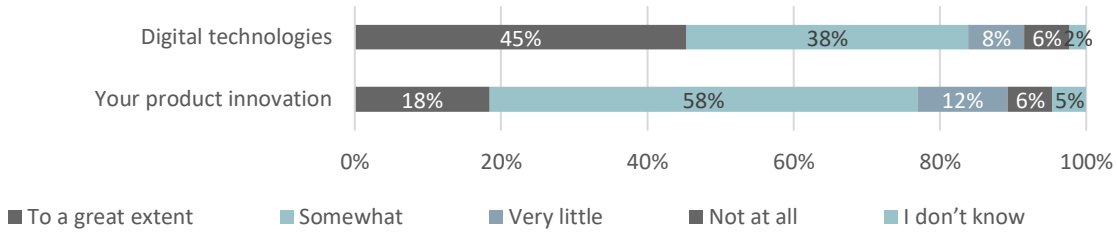


Figure B: Has your company introduced a new product (good or service) during the past three years, that was new to your industry or market?

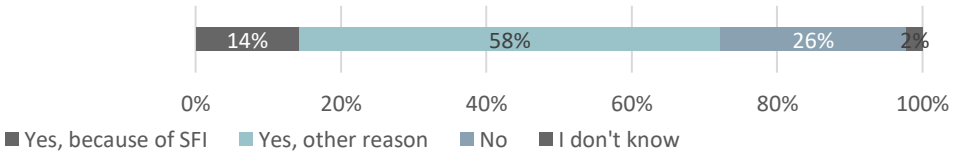


Figure C: Have the partners at the SFI center made any innovations that you believe will strengthen the sector or industry you are part of?

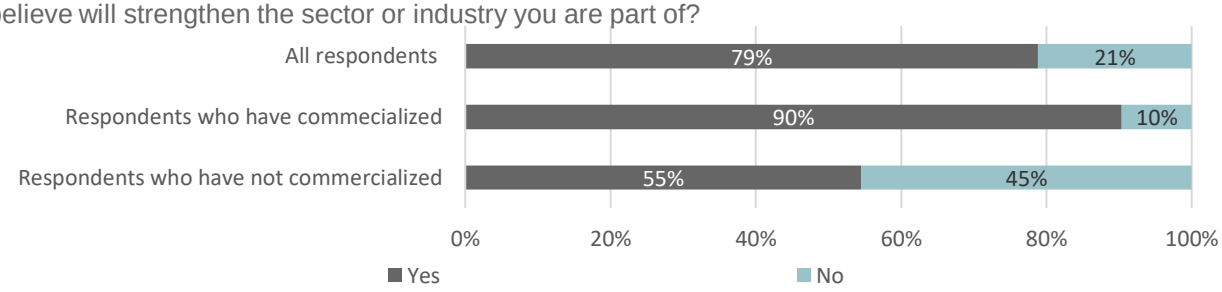


Figure D: Have all innovation results at the SFI center been registered and reported?

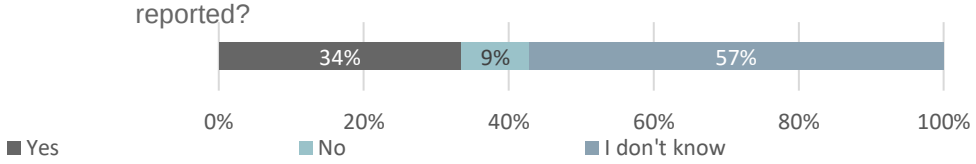


Figure E: Do you expect to commercialize and go to market with your innovation?

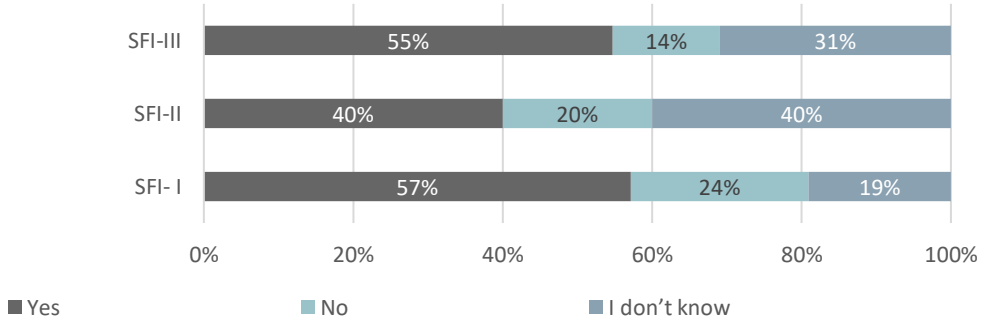
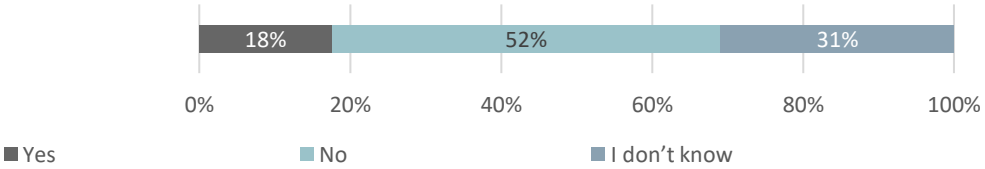


Figure F: Have you been part of or registered any innovation at your SFI center that has the potential to be commercialized - but is not?



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.

Note: Figure A: n=130. Figure B: n=96, Questions: "Has your company introduced a new product, which is a new good or service, during the past three years? Please only include goods or services that were new to your industry or market. Figure C: All respondents: n=194, Respondents who have commercialized: n=104, respondents who have no commercialized: n=33. Figure D: n=194. Figure E: SFI-I: n=42, SFI-II: n=25, SFI-III: n=126. Figure F: n=194

this may also play a role in uncertainty regarding commercialization.

Figure 3.7.F displays the shares of the partners that have experienced innovations that had the potential to be commercialized, but was not. 52 pct. answers no, whereas 18 pct. answers yes. Within the SFI generations the highest share that answer yes is found within the SFI-II where 28 pct. answers yes. The lowest is found within SFI-III corresponding to 13 pct.

One of the reasons provided by respondents for commercialization not yet taking place is that commercialization occurs outside of the SFI centre, based on the research conducted within the SFI. Another reason pertains purely to the maturity of the projects, with many projects needing more time to reach commercial maturity. Furthermore, respondents, particularly research partners, cite lack of a commercial partner or interest in the industry as a main barrier.

3.2 Contribution to internationalisation

This section will explore the extent to which the SFI scheme has been able to strengthen the ability of participating partners to increase their international visibility, better their recruitment, and improve their participation in EU projects and attract international funding. The section builds on qualitative input from the survey that was given to partners of the SFI centres as well as the interviews.

Figure 3.8 presents responses of research partners and business partners of centres, respectively, to ways in which the SFI scheme contributes to internationalization. The options listed were gathered through interview insights on internationalization, while an open ended question allowed partners to add any additional insights.

Overall, we see that research partners report positive feedback for a number of channels through which internationalization is promoted through the scheme, with very many reporting *to a high extent* and very few reporting *not at all.* The opposite is the case for business partners, for which very few report *to a high extent* and relatively more report *not at all*. From insights given in the interviews, this is mostly due to high degree of internationalization among participating firms, with many of them being large global companies. As such, with an already international profile, it is difficult to see gains through this channel.

In the following, we summarize how the scheme contributes to internationalization through increased visibility and collaboration, recruitment, and funding.

3.2.1 International visibility and collaboration

The two options which score highest in terms of positive feedback (*to a great extent* and *somewhat)* for research partners was *increasing international reputation* (94 pct.), and *extending the international network* (84 pct.). A nearly equal share of these reported *to a great extent* and *somewhat*.

Furthermore, 69 pct. report that the SFI scheme furthers internationalisation through *hosting visiting foreign researchers.*

For business partners, as mentioned, a lower share overall reported positive feedback. However, *increasing international reputation as a company* ranked second highest, with 56 pct. reporting positive feedback. Only 10 pct. of these fall into the category *to a great extent.* Only 34 pct. report *increased export opportunities*, while 33 pct. report increased international market access. Very few (16 pct.) report increased *number of companies in merger and acquisition.*

As such, the SFI scheme primarily benefits the research community with respect to increasing international reputation and collaboration.

3.2.2 International recruitment and access to qualified personnel

For both research and business partners, international recruitment is a large benefit of SFI participation. Among research partners, 76 pct. believe that the SFI scheme to some extent allows for increased international recruitment of foreign students and PhDs. Only 28 pct. of these reported *to a great extent.* Furthermore, 63 pct. also believe the scheme helps with *international exchange of researchers,* with nearly 40 pct. reporting this *to a great extent*.

The schemes ability to attract qualified personnel is even more clear for business partners. The outcome which scores highest for business partners with respect to internationalization is *improved access to competent personnel and knowledge institutions*. 44 pct. business partners report *to a large extent* while 39 pct. report *somewhat.* This speaks to both a higher international recruitment ability, but also increased global knowledge sharing. Furthermore, 42 pct. report increased i*nternational recruitment of candidates*, though only 10 pct. report this to *a high extent.*

The scheme is thus rather successful when it comes to attracting highly qualified labour to Norway, both when it comes to developing excellent research environments, and when it comes to building a competitive and innovative private sector.

3.2.3 Attracting international funding

Lastly, we explore the extent to which the scheme is able to attract international funding and participation in EU projects. This is the overall goal which scores the lowest for the scheme, for both partner types.

With respect to *participating in EU projects*, only 56 pct. responded positively (19 pct. to a large extent), and 7 pct. responded *not at all.* With respect to *being lead investigator in EU projects,* only 46 pct. responded positively, with very few responding *to a large extent* (9 pct.) and 9 pct. responding not at all. Lastly, only 48 pct. respond positively to *attracting more international funding e.g. through Horizon2020,* with only 13 pct. responding *to a great extent.*

For business partners the same is true. A very low share report positively on both *participating in EU projects (*34 pct.) and *attracting more international funding e.g. through Horizon2020* (32 pct.). Under 5 pct. responded *to a great extent* to either of those criteria.

These inputs illustrate that the scheme does not perform particularly well, in the eyes of its participants, in terms of attracting EU funding and either participating in EU projects or being lead investigator in them. Furthermore, it does not perform well in terms of attracting international funding through competitive EU programmes, such as Horizon2020.

FIGURE 3.8

Figure A: To what extent does the SFI scheme contribute to internationalization by…? Answered by research partners

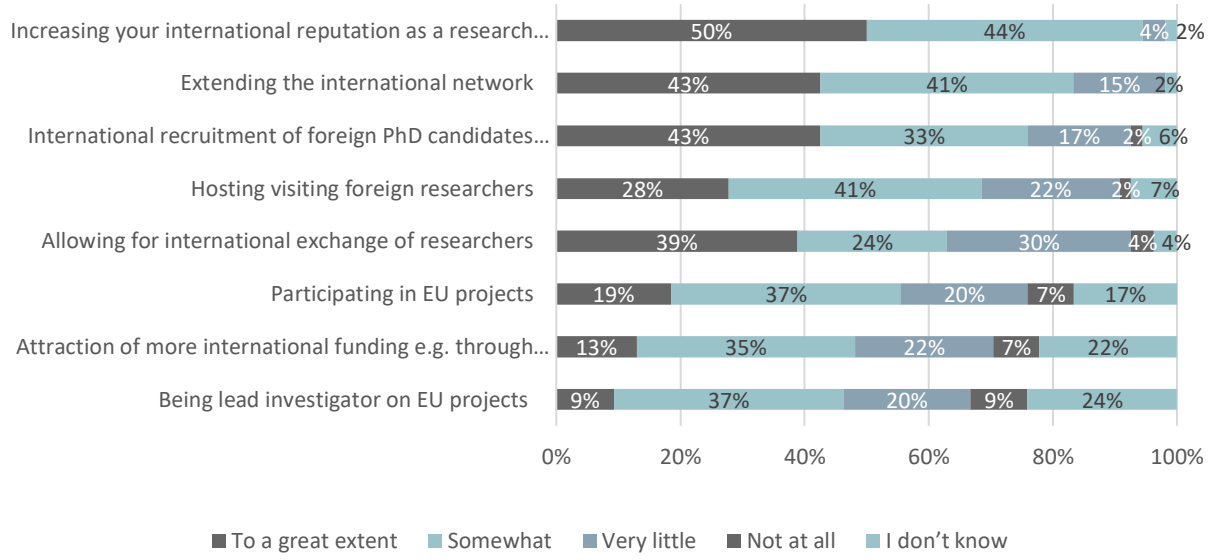
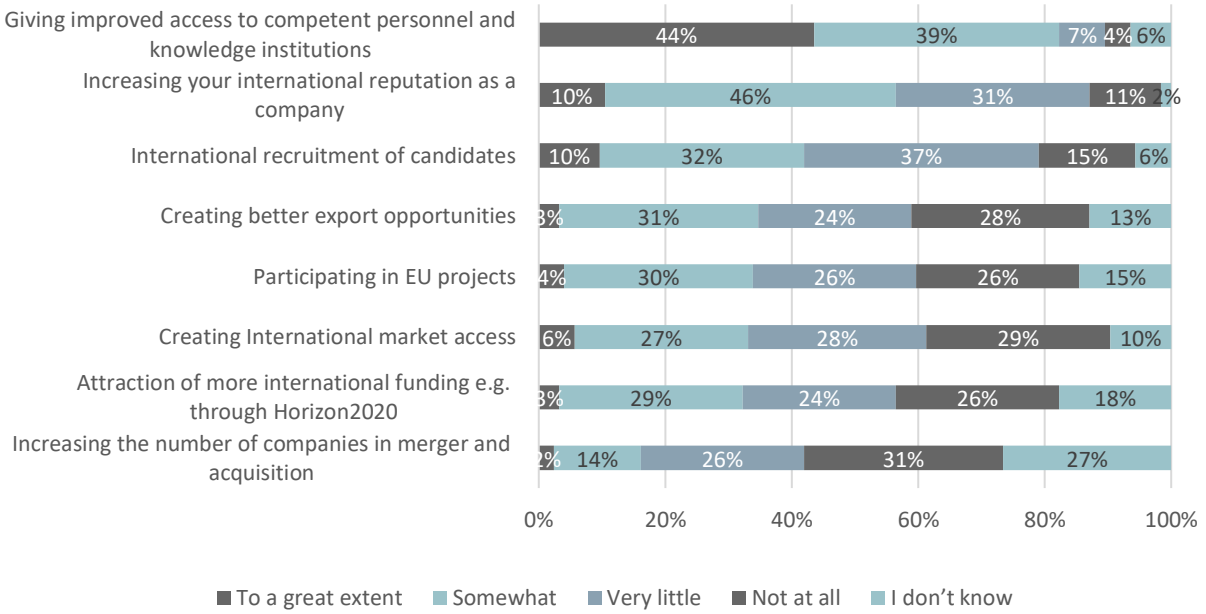


Figure B: To what extent does the SFI scheme contribute to internationalization by…? Answered by business partners



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: Figure A: n=54, Figure B: n=124

4 SFI scheme contribution to research performance

This section explores the fulfilment of the following goals:

Bring Norwegian R&D to the forefront of international research environments and networks, with a commercial focus.

Promote researcher training in areas that are important to business as well as research-based knowledge and technology transfer.

We explore these goals through the following evaluation question:

Has the SFI scheme contributed to strengthening and further developing the best Norwegian R&D environments - nationally and internationally?

We first present the data provided by each of the SFI centres on the number of researchers employed to provide an overview of the type and volume of research personnel involved in each generation. We then comment on the scientific output and other dissemination methods reported by the centres, and how these differ across generations.

We then review the results from an in depth bibliometric analysis of the peer reviewed publications. The bibliometric analysis will provide insight into:

- The number of scientific outputs created (publications and disseminations)
- The quality of these publications and the performance across research areas.
- The degree of collaboration with industry partners in creating publications
- The degree of collaboration with international research communities in creating publications.

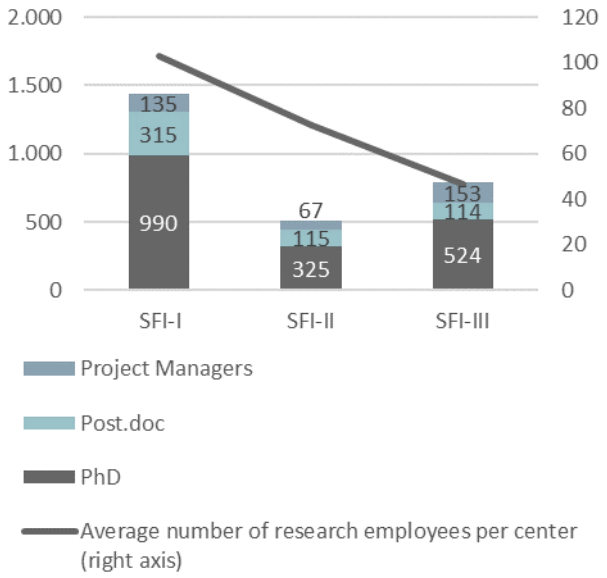
4.1 Research Employees

4.1.1 Researcher training and academic staff

It is a central goal of the SFI scheme to educate researchers in areas which are relevant to Norwegian private sector development. Centre leaders reported that among academic staff employed in connection to the scheme, they employed 1.800 PhDs, roughly 550 postdocs, and just over 350 project managers.

Figure 4.1 shows the total number of project managers, postdocs and PhDs employed per centre and on average per centre. SFI-I naturally has had the time to employ most, employing 1.440 of the three types of employees, while SFI-II and SFI-III only employed 507 and 791, respectively. SFI-II naturally lags behind SFI-III due to size. Though it is difficult to compare researcher employment across different projects, the number of PhDs employed in the SFI scheme is very close to that of Comet, which employed just under 1.900.

FIGURE 4.1
Number of research employees

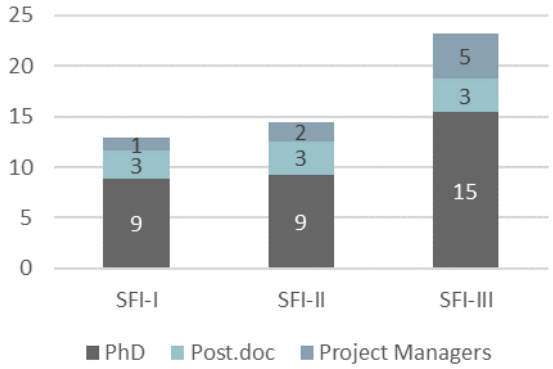


Source: Self evaluation reports by centre leaders. Academic staff in total is not limited to the above categories.

The average number of employees per centre follows a more downward sloping trend, indicating more employees per year the SFI has existed.

The trend is reversed if we count employees *per year* per centre, as shown in figure 4.2, whereby the oldest SFI-I employs only 13 persons, SFI-II employs just under 15 persons, and SFI-III employs just over 23 persons annually.

FIGURE 4.2
Average number of research employees per centre, per year



Source: Self evaluation reports by centre leaders.

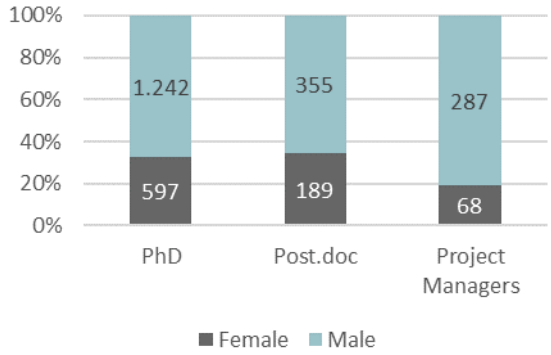
These trends suggest that on the one hand, the bulk of employees join the centre in the beginning of the SFI, while on the other hand, several staff join SFI's over time, adding a higher volume per centre, for centres which have been in existence for longer time.

Employees as measured by the above figures, are made up of PhDs, postdocs and project managers. Though absolute figures differ, the distribution of employees in each centre is relatively stable, with nearly 65-70 pct. PhDs, and the remaining made up of postdocs, and project managers. For SFI-I and SFI-II, 22-23 pct. make up postdocs (and 9-13 pct. project managers) while for SFI-III closer to an equal share are respectively postdocs and project managers (14 pct. and 19 pct.).

Though this evaluation primarily focuses on education and employment of PhDs and postdocs, final reports also reflect on the importance of master and bachelor students. Though these are not in the same way primary contributors, some centres report several masters dissertations written on the subject areas explored in the particular SFI centre. As such, academic staff and students contribute and benefit from the SFI centres in multiple ways.

With respect to the gender representation in research employees, across all SFIs, roughly 30 pct. are women (figure 4.3). Among project managers, only 20 pct. are women. SFI-II employed the highest share of women (35 pct.), while SFI-I employed 33 pct. and SFI-III employed only 26 pct. so far. Compared to the overall picture in Norway, this is relatively low. In the Norwegian research environment overall, women made up just over 50 pct. of PhDs and 40 pct. of research personnel (postdocs and PhDs) in 2015.[1]

FIGURE 4.3
Gender distribution among research employees, total SFI



Source: Self evaluation reports by centre leaders.

[1] Indikatorrapporten, 2016. Det norske forsknings- og innovasjonssystemet – statistikk og indikatorer 2016." Forskningsrådet.

4.1.2 Knowledge transfer to businesses

Though on the one hand it is important to employ a high number of research personnel, a central goal of the scheme is also to ensure technology transfer to the business environment. From survey responses from business partners, we know that when asked about their use of the centre, 57 pct. use it to cooperate with the researchers, while 20 pct. responded that they used them to recruit persons affiliated with the centre. Furthermore, as reviewed in section 3, the partners value the international recruitment possibilities through the scheme. A total of 76 pct. of research partners responded positively to international recruitment of PhDs, while 83 pct. of business partners primarily experienced increased internationalization through higher access to competent personnel and knowledge institutions. The responses are not mutually exclusive.

The open answers from the survey nuance these insights. From the responses given by research partners, a large motivation for joining is the ability to recruit qualified personnel and ensure funding to educate more PhDs. They also mention that the centres provide an opportunity to make research relevant, by ensuring knowledge transfer to Norwegian industry. Private partners are also motivated by the opportunity to educate and employ PhDs (hereunder industrial PhDs) and increase their in-house competencies. Furthermore, PhDs focused on developing research in their core areas alone, is cited as a motivation. Likewise, respondents comment that a part of the success of the SFI centres, is the ability to attract talented researchers that are more application-oriented. From the midway evaluation of SFI-II, the industrial PhD mechanism as well as the involvement of other PhDs, postdocs and other academic staff was praised for the same reasons.

A large indicator of knowledge transfer is the share of PhDs that become employed in the private sector after completing their PhDs. This is also an indicator of the relevance and quality of the PhDs completed. Though SFI-II and SFI-III are not concluded, the final reports for SFI-I provide insights on career paths of PhDs directly employed by the SFI scheme. Overall, researcher training is an important element in all final evaluations of the individual centres. For those centres which track mobility of PhDs, an average of 19 pct. of completed PhDs became employed by private companies which were a part of the SFI scheme. In total 36 pct. were employed by the private sector overall. Interviews with PhDs in the centres reveal that while some go on to conduct research in companies, some also assume managerial positions in spin-offs created by the scheme.

However, some challenges were also found in regards to knowledge transfer from researcher to private sector. In particular, it is mentioned in the SFI-II midway reports that researchers would benefit from additional “transferable skills training” which are useful in the private sector. These include training in leadership, project management, commercialisation and entrepreneurship.

The market-oriented competencies of researchers are also mentioned in the survey. When private partners were asked to which extent they believe that researchers have an innovation perspective and market understanding, only 14 pct. responded *to a great extent* while 69 pct. responded *somewhat*. A high share even reported that researchers had *very little* competencies in this area (13 pct.).

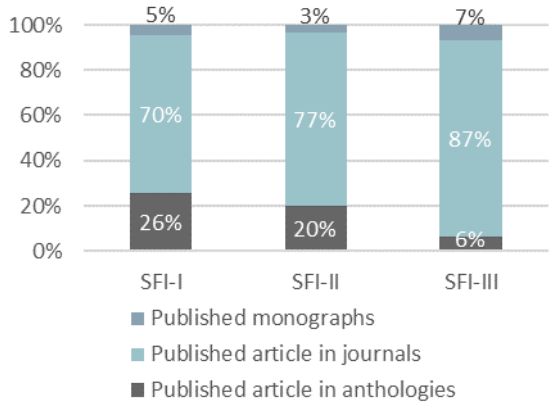
These insights suggest that while the SFI succeeds in educating and employing a great number of academic staff, there are some improvements which might increase the degree of knowledge transfer to the Norwegian private sector. Overall, however, both the research community and the private sector participants benefit from access to qualified personnel and knowledge upgrading.

4.2 Self-reported scientific publications and other dissemination measures

For the purpose of this evaluation each of the centre leaders were asked to fill out a self-evaluation report wherein they identified and quality assured the disseminations activities and publications that can be directly tied to the SFI-scheme. The reported scientific publications from the centre leaders sums to a total of 4.817 publications, covering all three SFI schemes. Of these, 3.387 were published within SFI-I, 1.133 were published within SFI-II, and 297 were published within SFI-III.

Figure 4.4 shows the distribution of publications among types of publications. Scientific publications cover articles published in anthologies, journals and monographs.

FIGURE 4.4
Share of scientific publications published in monographs, journals and anthologies

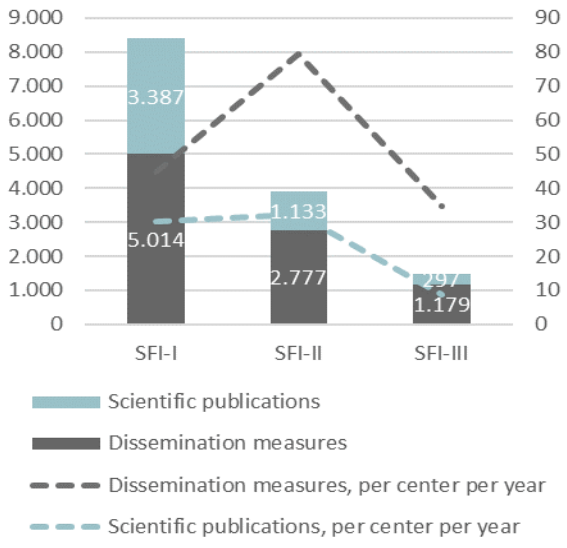


Source: Self evaluation reports by centre leaders.

For SFI-I and SFI-II, the two SFIs with most scientific outputs, the vast majority of publications are in journals (70 pct. and 77 pct., respectively), while anthologies make up 26 pct. and 20 pct. respectively. The remaining 3-5 pct. are monographs. For SFI-III nearly 90 pct. of publications are in journals. The relative high share of journal publication is in line with the expected as the SFI scheme primarily is focused on research within natural and technical science, where monographs and anthologies to a lesser extent are used as publication outlets.

I addition to the scientific publications, nearly 9.000 other dissemination measures were created across the three generations. Roughly 5.000 of these pertain to SFI-I, 2.800 pertain to SFI-II, and 1.200 pertain to SFI-III. User oriented measures such as reports, notes, non-scientific articles, and lectures at meetings or conferences make up 72 pct. of all disseminations. The remaining are made up of public-oriented outputs, of which 22 pct. are mass media disseminations and 6 pct. are publications (articles, books, debates, articles, and hearings). The distribution across the three generations is relatively stable, though a higher share of disseminations are mass media disseminations for later generations (27 pct. and 32 pct. for SFI-II and SFI-III, respectively, compared to just 17 pct. for SFI-I).

FIGURE 4.5
Self-reported output: Scientific publications and other dissemination methods



Source: Self-evaluation reports by Centre leaders.
Note: Scientific publications covers anthologies, periodicals and series and monographs. Dissemination measures include user-oriented reports, notes articles, lectures and meetings, as well as public-oriented mass media measures and publications in articles, books, debates, and hearings.

Figure 4.5 shows the distribution of total academic outputs (scientific publications and other

dissemination measures) across the three generations, both in terms of total output and average output per centre per year.

As such, clearly older generations lead in terms of output. However, when comparing the average output each centre creates each year across the generations, SFI-II stands out, with nearly twice as many dissemination measures as SFI-I and SFI-III. Furthermore, although SFI-II has not concluded its 8-year term, it is on level with SFI-I in terms of scientific publications per centre per year. Given the short term of SFI-III, it naturally lags behind the other generations in terms of academic output (both overall and per centre per year).

4.3 Publications for bibliometric analysis

While the above summarises input from centre leaders in terms of publications and other dissemination methods, this section extracts all publications from annual reports, in order to perform a bibliometric analysis on the academic quality of all peer reviewed publications, impact of the publications, and the degree of collaboration among international and industry partners in creating scientific publications.

The bibliometric analysis follows three steps.

1. Firstly, in this section, publications directly affiliated with the SFI scheme are mapped and located in Elsevier's Scopus bibliometric database.
2. Secondly, all authors of the SFI affiliated publications are identified, revealing their affiliations and hence the type of co-authors. This reveal the degree of collaboration among Norwegian research environments, international research environments, and industry/ private business collaboration.
3. Lastly, the scientific impact of said publications is measured against a benchmark of Nordic and international peers. This is done for different collaboration types as well as different research areas.

4.3.1 Scientific publications

From 4.817 publications identified by centre leaders in section 4.2, 3.846 have been identified for analysis through annual centre reports.[2] From these publications, we were able to identify a total of 3.557 peer reviewed publications (93 pct.) in Scopus (table 4.6). The share of Scopus identified publications is in accordance with figures we see for similar research fields in other evaluations[3]. SFI-I is responsible for nearly three fourths of the publications found, while SFI-II only accounts for 20 pct. and SFI-III accounts for 7 pct. This is consistent with the distribution of publications reported by centre leaders above.

TABLE 4.6
Number of Scopus identified publications for each centre

Generation	Number of publications	Publications identified in Scopus	Percentage identified
SFI-I	2.806	2.615	93,2%
SFI-II	780	725	92,9%
SFI-III	274	238	86,9%
Total	3.846	3.557	92,5%

Source: Scopus and annual centre reports
Note: Figures do not sum as there are circa 20 publications which are cited in more than one SFI generation due to overlap in collaboration.

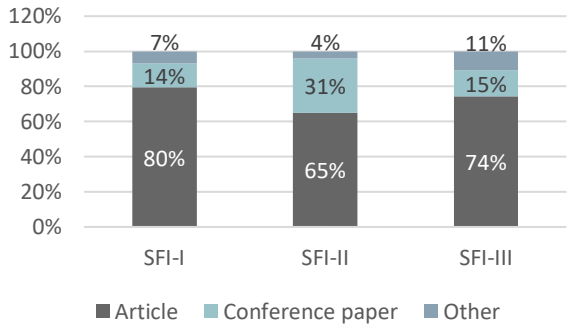
Publications can be classified in different ways. Just over 75 pct. of all publications take the form of articles while 17 pct. are conference papers. The

[2] Differences in figures found from the annual reports and those collected through self-reports can stem for overlap between centres and generations, or differing interpretations of the definition of types of scientific publications. As an example, there can differing views on the definition of conference papers in proceedings and contributions to anthologies.

[3] Samproduktion för tillväxt – Resultat och effekter av forskningsfinansiering - DAMVAD Analytics 2017
Social science research in Norway - DAMVAD Analytics 2017

remaining 7 pct. primarily take the form of books, book chapters, others (being reviews, notes, letters etc.). Though the shares are relatively similar across the three generations (figure 4.7), SFI-II clearly has a higher share that are identified as conference papers. Many conference papers are considered works in progress, which may indicate that when SFI-II reaches more maturity, some of the publications in this section will result in published articles.

FIGURE 4.7
Type of publication



Source; Centre annual reports
Note: Other publication types primarily consists of books, book chapters, patents. Publication types are not mutually exclusive and as such a publication can first be publication can in some cases be published first as a conference paper and later as an article.

4.3.2 Research areas covered by SFI of publications

Scopus classifies each journal and its publication at two levels; at the level of subject areas and at the level subject terms. The subject areas classification scheme assigns the publications to at least one of 27 overarching research fields like medicine, engineering or computer science. For each of the subject areas Scopus has subdivided the research within e.g. computer science (the subject area) into the second level of classification, subject terms, being e.g. Artificial Intelligence or Software. As most journals covers more than one research field, Scopus can assign up to five different subject terms per journal. For the simplicity of the evaluation we report at the level of subject areas solely.

From table 4.8 we see that the top 5 subject areas for publications published within the SFI scheme are medicine (31 pct.); engineering (20 pct.); biochemistry, genetics and molecular biology (17 pct.); chemistry (14 pct.) and computer science (14 pct.).

TABLE 4.8
Percentage of publications affiliated with each subject area (for subject areas with over 1%)

Subject Area	#pub	pct
Medicine	899	31%
Engineering	591	20%
Biochemistry, Genetics & Molecular Biology	506	17%
Chemistry	402	14%
Computer Science	400	14%
Materials Science	361	12%
Mathematics	340	12%
Physics & Astronomy	312	11%
Chemical Engineering	275	10%
Agricultural & Biological Sciences	211	7%
Earth & Planetary Sciences	119	4%
Decision Sciences	117	4%
Environmental Science	114	4%
Energy	94	3%
Health Professions	91	3%
Business, Management & Accounting	73	3%
Pharmacology, Toxicology & Pharmaceutics	60	2%
Immunology & Microbiology	59	2%
Neuroscience	56	2%
Social Sciences	50	2%

Source: Scopus and calculations by DAMVAD Analytics
Note: Subject areas included if they pertain to over 1 pct. of publications. Total publications with available subject areas is 2.893, from which percentages are calculated. Subject areas are not mutually exclusive.

It is clear that while a majority of subject areas are focused in the natural sciences, there is also large share dedicated to other areas such as engineering, energy, mathematics, medicine and pharmacology, and social sciences. It should be noted that an overweight in publications in the life science area is common, as this is a sector which is deeply rooted in academic publishing.

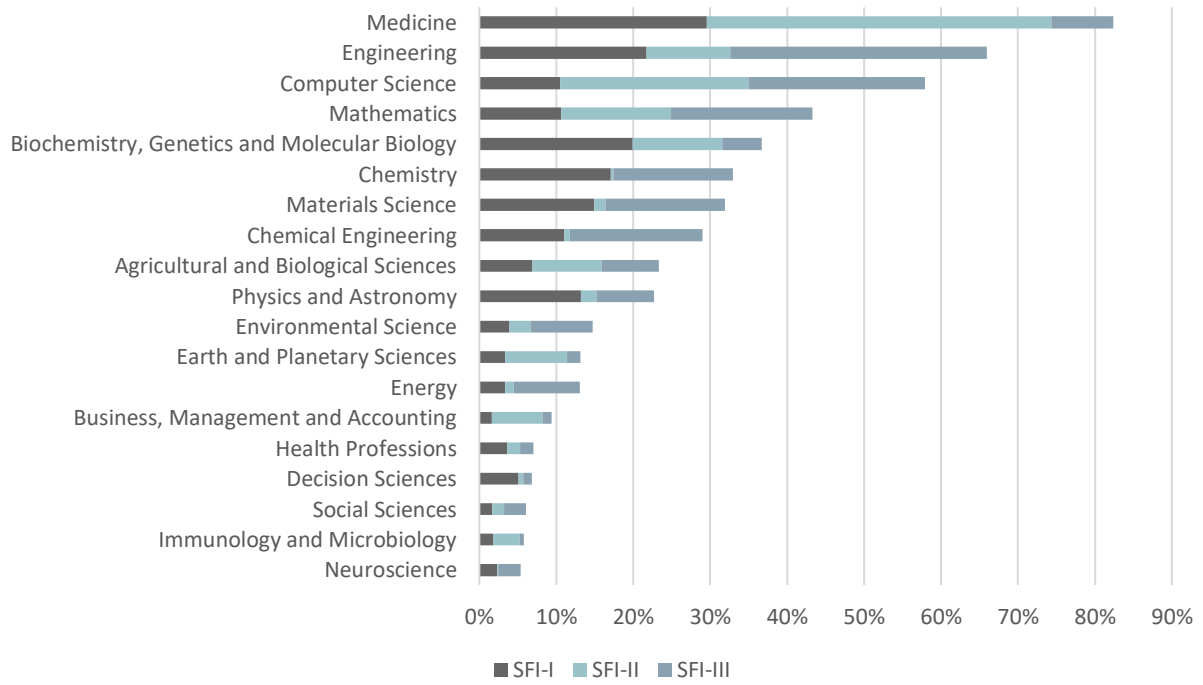
Figure 4.9 explores subject areas of the individual SFI generations, showing for each generation the percentage of publications which are affiliated with each subject area. As such, the sum of the bars simply indicates the compiled share of each generation, which is concentrated in each field. From this we see that medicine is the largest research field for publications with origin in both SFI-I and SFI-II. Engineering is the second largest research focus, though mostly for SFI-I and SFI-III, covering 22 and 33 pct. of publications, respectively. Computer science as a research field, sees some attention from researcher affiliated with both SFI-II and SFI-III, covering one fourth of all publications in each generation. Furthermore, it is clear that SFI-I and SFI-III are more dispersed in their research focus as they are covered by several subject areas, while SFI-II is more concentrated on few areas. SFI-II furthermore is more clearly focused on medicine as well as computer science, mathematics and biochemistry.

4.4 National, International and Industry co-publication

This section will explore collaboration through the types of co-authors affiliated with publications. Partners are classified according to whether they are industry partners or international partners. Figure 4.10 shows the distribution of publications across collaboration type. We see a common trend across all three generations:

- 45-55 pct. of publications are classified as collaborations with only national research environments.

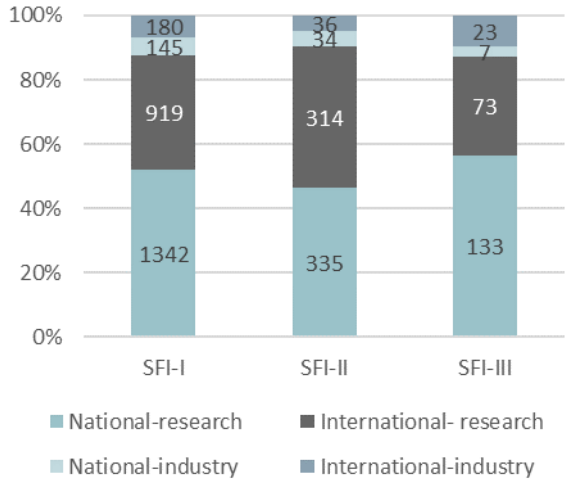
FIGURE 4.9
Share of publications affiliated with subject areas across generation



Source: Scopus
Note: A total of 19 pct. of publications could not be identified by subject area, thus the figure covers n=2893 unique publications. Subject areas are not mutually exclusive either within or across generations, for which reason percentages should not be summed to 100.

- 35 - 45 pct. of publications have at least one collaboration with international research environments.
- 3-5 pct. of publications have at least one national industry co-authorship (but no international co-authors).
- 5-10 pct. of publications have at least one collaboration with international authors and at least one collaboration with industry.

FIGURE 4.10
Collaboration types, pct. of total publications.



Source: Scopus and calculations by DAMVAD Analytics, 2017
Note: Figures do not sum to the full number of publications, as a collaboration types are not mutually exclusive.

4.4.1 Norwegian co-publication

Table 4.11 shows the top 10 Norwegian universities and research institutes that co-author publications with SFI's. It is clear that NTNU and University of Oslo account for the largest bulk of publications, with each co-authoring over 30 pct. of all peer reviewed publications produced in the SFI scheme. University of Tromsø is the third largest University collaborator, co-authoring nearly 9 pct. of publications. All other universities co-author under 5 pct. of publications. The third largest co-author overall is SINTEF, contributing to over 15 pct. of publications.

This is expected given that the top three co-author institutions are also hosts on multiple centres. However, considering that NTNU hosts 9 centres, SINTEF hosts 7 centres and University of Oslo only hosts 2, it would appear that University of Oslo is more involved in SFI publications than the other two hosts. Again, this also has to do with subject areas.

TABLE 4.11
Top 10 Norwegian universities and research institutes who co-author publications with SFI's, total

University	Unique publications	Pct.
NTNU	1.303	36,6%
University of Oslo	1.078	30,3%
SINTEF	542	15,2%
University of Tromsø	316	8,9%
University of Bergen	150	4,2%
University of Stavanger	47	1,3%
University College of Bergen	44	1,2%
Norwegian University of Life Sciences	41	1,2%
Norwegian School of Economics	26	0,7%
Sør-Trøndelag University College (HiST) *	16	0,4%

Source: Scopus and calculations by DAMVAD Analytics, 2017.
Note: Co-publication is not mutually exclusive- figures thus do not sum to 100 pct. and should not be added.
*) In January 2016, HiST merged with Norwegian University of Science and Technology (NTNU) and Aalesund University College and Gjøvik University College.

4.4.2 International co-publication

Table 4.12 shows the share of publications that are published with international co-authors across the three generations. Overall, 44 pct. of all SFI publications are co-authored with international authors. Though there are less observations for the later generations, SFI-II has performed better in terms of international co-authorship than the other generations. SFI-III thus far has the lowest rate of international co-publishing (41 pct.).

TABLE 4.12
Number and share of publications that are published with international co-authors

Generation	International co-authorship	Pct. of all publications
SFI-I	1.103	43%
SFI-II	350	49%
SFI-III	96	41%
Total	1.549	44%

Source: Scopus and calculations by DAMVAD Analytics, 2017

Table 4.13 shows the top 10 international universities that collaborate with the SFI-scheme. With the exception of the top collaborator, Cornell University, the remaining top 10 universities contribute to roughly 1 pct. of all publications each. The second part of figure 4.13 shows top 5 international university collaborators across the three SFI generations. We see that nearly all collaborations with the top two international Universities, Cornell University and University of Torino, are carried out by SFI-I. University of Luxembourg, the third largest collaborator overall, primarily collaborates with SFI-II.

Notably, there is not much overlap in top collaborators among the three generations. Furthermore, while SFI-I has its top collaboration with a US university, SFI-II has its top collaborators in Europe, and SFI-III has its top collaborator in China.

Table 4.14 further explores the country affiliated with each collaborating university. It is clear that international collaborators are to a large extent concentrated in the US and the UK, with roughly 15 pct. of collaborations in each of the largest European economies; Italy, Germany, and France. Denmark (not among the top 15 collaborators) and Sweden only contribute to 10-12 pct. of the publications.

It is interesting to note that the US sees as a decreasing role as country for international cooperation for the SFI generation of centres over time. The size of cooperation with the US in SFI-I is what should be expected given the size of the US economy and the size of US academic publishing.

TABLE 4.13
Top 10 international universities who co-author publications with SFI's, total, and top 5 universities across SFI generations

University	Unique publications	Pct.
Cornell University	62	1,7%
University of Torino	37	1,0%
University of Luxembourg	34	1,0%
East China University of Science and Technology	34	1,0%
University of California	33	0,9%
University of Liège	31	0,9%
Coimbatore Institute of Technology	30	0,8%
University of Washington	27	0,8%
KU Leuven	26	0,7%
Ghent University	24	0,7%

SFI-I	Unique publications	Pct
Cornell University	60	2,3%
University of Torino	34	1,3%
Coimbatore Institute of Technology	30	1,1%
University of Washington	26	1,0%
Dublin City University	23	0,9%
SFI-II		
University of Luxembourg	34	4,7%
University of Liège	29	4,0%
University of Vienna	18	2,5%
Beihang University	16	2,2%
King's College London	14	1,9%
SFI-III		
East China University of Science and Technology	12	5,0%
University of Oxford	8	3,4%
University of Bologna	4	1,7%
Ghent University	4	1,7%
University of Lübeck	4	1,7%

Source: Scopus and calculations by DAMVAD Analytics, 2017.
Note: Co-authorship is not mutually exclusive, thus figures should not be summed.

Lastly, figure 4.15 relates the share of international co-publication to the shares in Norwegian Universities. We see that the centres under the SFI scheme

as a whole are placed somewhat in the middle of universities, performing neither badly nor good.

TABLE 4.14
Top 15 international collaborators

#	Country	SFI-I	SFI-II	SFI-III
1	United States	50%	28%	16%
2	United Kingdom	17%	25%	25%
3	Italy	15%	18%	20%
4	Germany	15%	15%	
5	France	15%	13%	10%
6	Netherlands	13%	13%	10%
7	Sweden	12%	11%	2%
8	China	12%	7%	
9	Denmark	12%	10%	2%
10	Australia	11%	4%	2%
11	Spain	10%	9%	2%
12	Belgium	9%		
13	Switzerland	7%	5%	2%
14	Canada	7%		2%
15	India	6%		2%

Source: Scopus and calculations by DAMVAD Analytics, 2017.
Note: Co-authorship is not mutually exclusive, thus figures should not be summed.

4.4.3 Industry co-publication

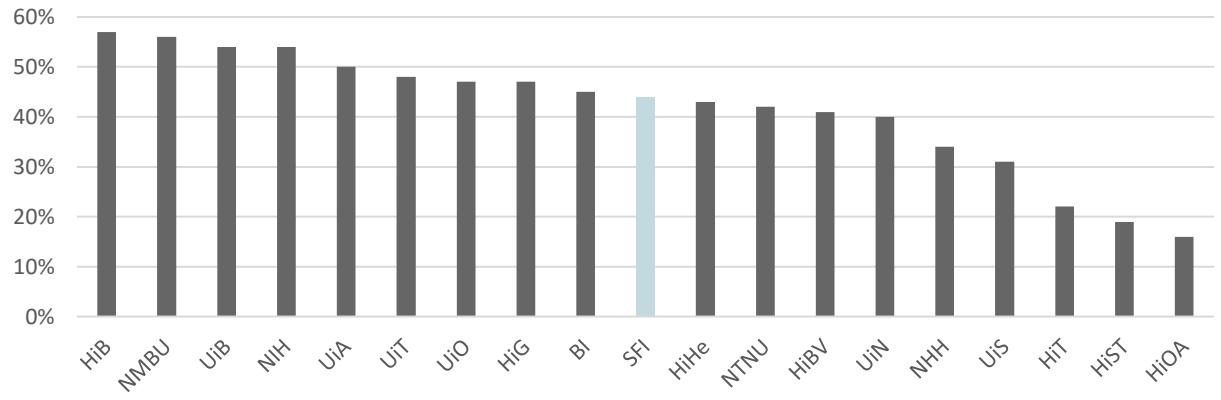
Table 4.16 shows the industry co-publication share. Overall, roughly 12 pct. of the publications are co-authored with industry partners. For SFI-I and SFI-III the industry participation is highest at roughly 13 pct. while SFI-II is the lowest with only just under 10 pct. industry co-authorship.

TABLE 4.16
Number and share of publications that are published with industry co-authors

Generation	Industry co-authorship	Pct. of all publications
SFI-I	325	12,5%
SFI-II	70	9,7%
SFI-III	30	12,7%
Total	425	11,9%

Source: Scopus and calculations by DAMVAD Analytics, 2017.

FIGURE 4.15
International co-authorship for the SFI scheme compared to Norwegian Universities



Source: Kunnskapsdepartementets brug af Cristin Data, *Share of articles with international co-authorship 2013.*

Table 4.17 shows top 10 industrial partners. We first notice that Statoil is by far the largest participant when it comes to industry co-authorship, participating in 91 publications (2,6 pct. of all publications). The remaining partners are also predominantly large firms in high-tech and the oil and gas sector.

TABLE 4.17
Top 10 private partners

Subject Area	Unique publications	Pct.
Statoil ASA	91	2,6%
PCI Biotech AS	34	1,0%
GE Vingmed Ultrasound AS	31	0,9%
Haldor Topsøe A/S	22	0,6%
Hydro Aluminium AS	22	0,6%
IBM	12	0,3%
Microsoft	11	0,3%
Netview Technology AS	8	0,2%
Petróleo Brasileiro SA (Petrobras)	7	0,1%
INEOS Technologies	5	0,1%

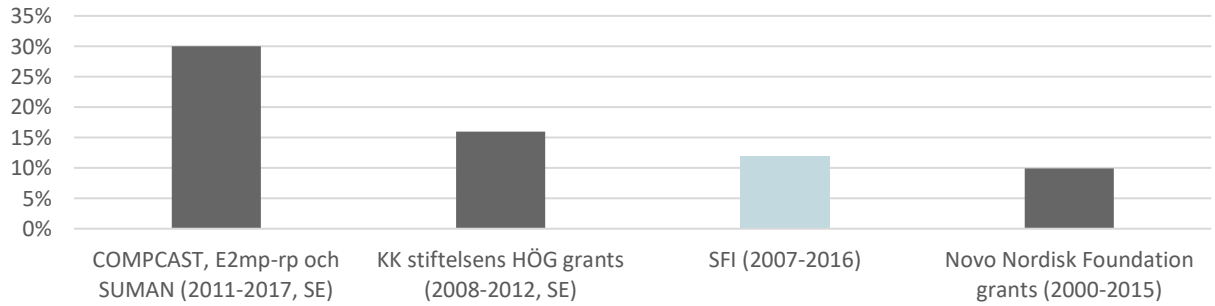
Source: Scopus and calculations by DAMVAD Analytics, 2017

Compared to the average industry co-publication rate of 5,8 pct. at the five largest universities in Norway (UiO, NTNU, UiB, NMBU, and UiT)[4], the share of industry co-authorship for SFI is twice as large. However, given that industry collaboration is a main goal of the scheme, it is also pertinent to compare with other schemes with similar goals. Figure 4.18 puts the degree of industry co-publication in perspective, comparing across a number of comparable schemes for which similar data is available.

We compare first with results found from an earlier evaluation of the three Swedish centres financed by KK-Stiftelsen (COMPAST, E2 mp-rp, SUMAN), and KK-Stiflesen's HÖG grants, in addition to Novo Nordisk Foundation research grants.

Prior to interpretation, it should be noted that schemes naturally may differ with respect to timeframe, generation, sectoral focus and partner composition . Firstly, with respect to sectoral focus, COMPAST, E2 mp-rp, SUMAN are predominantly focused in engineering and ICT, while HÖG grants are rather more dispersed in focus, and Novo Nordisk Foundation grants are concentrated on life science R&D. As such, though some similarities exist, primarily with the first group of programs, these sectors involve industry collaboration to a different extent. When considering the composition of partners, there are also differences. KK-stiftelsen HÖG grants (see DAMVAD Analytics 2017[5]) primarilly consist of small and medium sized companies with 80 pct. of the companies having less than 250 employees. The Novo Nordisk Foundation on the other hand constist to a greater

FIGURE 4.18
Industry co-authorship for the SFI scheme compared to other comparable schemes



Note: Indicators for comparable schemes collected by DAMVAD Analytics

[4] Leiden Ranking 2017, www.leidenranking.com

[5] http://www.kks.se/app/uploads/2017/06/samproduktion-for-tillvaxt-resultat-och-effekter-av-forskningsfinansiering.-damvad..pdf

extent of large companies with 33 pct. of the companies in this category (DAMVAD analytics 2016[6]).

Bearing these differences in mind, we see that the SFI Scheme is placed in the lower end of these schemes, when comparing industry co-authorship. At 12 pct. co-authorship, the SFI scheme is exceeded by COMPAST (30 pct.) and HOG (16 pct.) and exceeds the share of the Novo Nordisk Foundation (10 pct.). Given that the latter is not particulary focused on industry collaboration, it would seem that SFI falls short of comparable schemes with an aim to create research which invovles both excellent research and an innovative private sector.

Finally, it is interesting to note that SFI-II centres are on the same level as the Novo Nordic grants while the both have a focus in life science.

4.5 Scientific impact

This section will explore the impact of the publications created under the SFI scheme through the measured scientific quality.

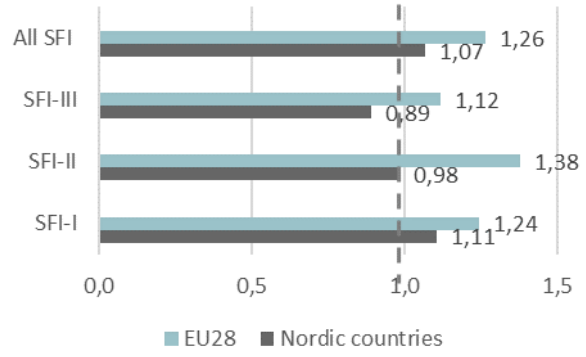
Scientific impact refers to the impact of an article on the scientific community. In the current analysis, impact is measured by a single indicator, derived from the number of citations for publications authored by researchers affiliated with the SFI centres. More precisely, we estimate impact based on the *Field normalised mean citation Score*.

The *Field normalised mean citation Score*[7] used in the analysis is state-of-the-art when it comes to citation analysis. The indicator considers differences in publication patterns for different scientific fields, publication types, and publication year. Finally, as an extra precaution to avoid overestimating the citation counts, we exclude self-citations, i.e. authors citing their own work. The calculation of the normalised mean citation score is based on the period from 2007 to 2016. Finally, we calculate the normalised mean citation score relative to two different benchmarks: the Nordic countries, and the EU28. Generally impacts calculated for 50 publications or less should be interpreted with caution as these figures will not be very robust. This is the case for some figures for SFI-III, when calculated for smaller groups.

4.5.1 Scientific impact across generations

Figure 4.19 shows the scientific impact of publications relative to EU28 and the Nordic countries, respectively. An impact above 1, marked by the dotted line, implies that the publications in the given SFI generation are above the given benchmark, while a measurement below 1 indicates a lower impact than the benchmark. As shown in the figure, the Nordic benchmark is a tougher benchmark, meaning that it is more difficult to outperform research in Nordic countries than research in EU28 countries overall.

FIGURE 4.19
Scientific impact of the publication relative to EU28 and Nordic countries



Source: Scopus and calculations by DAMVAD Analytics, 2017

[6] http://novonordiskfonden.dk/sites/default/files/societal_impact_of_nnf_grants_2016_net-version_0.pdf

[7] *Towards a new crown indicator: an empirical analysis* (2011), Ludo Waltman, Nees Jan van Eck, Thed N. van Leeuwen, Martijn S. Visser, and Anthony F. J. van Raan. Scientometrics, Vol87, No3, P467–481.

Looking first at all publications created within the SFI scheme, the publications have an impact which exceeds both the Nordic and EU28 benchmark by respectively 7 and 26 pct. This result is driven in large part by SFI-I generation, being the only generation to outperform the Nordic benchmark. Looking to SFI-II, it performs better against an EU28 benchmark but less so compared to the Nordic Countries. Implying that SFI-II publishes in fields which are highly competitive in the Nordic countries, as well as in areas which are not as strong in the rest of the EU. SFI-III manages to exceed an EU28 benchmark as well, but is 10 pct. below the Nordic benchmark. The results for SFI-III should be interpreted with utter most care as the scheme has only just started and munch research has not been published yet.

TABLE 4.20
Scientific impact of publications relative to Nordic countries and EU28 within top 10 subject terms

Subject Area	Pct.	Nordic	EU28
Medicine	8,0%	0,73	1,70
Cardiology and Cardiovascular Medicine	6,2%	0,97	1,96
Materials Science	5,7%	1,22	1,85
Chemistry	5,5%	1,36	2,27
Radiology, Nuclear Medicine and imaging	5,0%	1,78	2,50
Mechanics of Materials	4,8%	1,34	1,64
Mechanical Engineering	4,6%	1,66	2,15
Computer Science	4,4%	0,96	1,40
Catalysis	4,2%	1,28	1,34
Condensed Matter Physics	4,1%	1,71	3,18

Source: Scopus and calculations by DAMVAD Analytics, 2017.
Note: Subject terms are more specifically determined than subject areas. Subject terms not mutually exclusive. A total of 19% of publications could not be identified by subject area, thus the figure calculates top 10 subject areas for 2.893 unique publications

4.5.2 Scientific impact across subject areas

In order to explore strengths and weaknesses within the different research fields (subject terms) in focus for the SFI scheme, we explore impact across the different research fields. Table 4.20 shows the impact of all SFI publications compared to the Nordic and EU28 benchmark across the top 10 subject terms. We see that the subject term that most publications list is medicine, which corresponds to it being the largest subject area of SFI-I and SFI-II (as seen in figure 4.9). Compared to other Nordic countries, however, the publications have not had a higher impact, though they lie a great deal higher than EU28 publications in the same areas in the same years. This in large part accounts for why the SFI generations focused on medicinal research publications do not outperform the Nordic benchmark to a higher extent. However, of the top 10 subject terms, 7 outperform both benchmarks in terms of impact. Furthermore, when publications exceed a Nordic benchmark, the lead is quite large- on average 50 pct. higher. These areas include *radiology nuclear medicine and imaging, mechanical engineering,* and *condensed matter physics*, in particular.

Table 4.21 shows top 5 subject terms by generation, in order to show how each generation has contributed to developing the best Norwegian research environment over time. Firstly, we see that each generation excels in different areas. SFI-I excels in *mechanics of materials,* while SFI-II excels greatly at *radiology nuclear medicine and imaging,* and SFI-III in *mechanical engineering*. As indicated by the grey shading in figure 4.21, some SFI generations have published less than the 50 journal publications threshold in the given research field articles. Hence the figures for SFI-III should be interpreted with the utmost care.

Comparing performance across the same subject areas, we see that impact within *medicine* has increased on a Nordic benchmark from below 1 (0,77) to exactly 1 from SFI-I to SFI-II. This speaks to an improvement in competitive edge in medicine research compared to other Nordic countries. Another area which is popular in multiple generations is *Materials Science*, which remains above the Nordic benchmark in both SFI-I and SFI-III.

TABLE 4.21
Impact relative to a Nordic and EU28 benchmark across both generation and top 5 subject terms.

SFI-I	# Pubs.	Nordic	EU28
Medicine	191	0,77	1,74
Chemistry	184	1,25	2,04
Materials Science	183	1,13	1,68
Mechanics of Materials	156	1,30	1,61
Condensed Matter Physics	142	1,26	2,38
SFI-II			
Cardiology and Cardiovascular Medicine	174	0,94	1,98
Radiology Nuclear Medicine and imaging	93	2,35	3,42
Medicine	83	1,00	2,65
Software	64	1,64	2,20
Computer Science	49	0,87	1,30
SFI-III			
Computer Science	24	0,52	0,79
Mechanical Engineering	21	1,75	2,49
Theoretical Computer Science	19	0,57	0,67
Catalysis	18	0,96	0,91
Materials Science	17	1,11	2,00
Computer Science	24	0,52	0,79

Source: Scopus and calculations by DAMVAD Analytics, 2017.
Note: Subject terms not mutually exclusive. Please note that the figures in the table should be interpreted with caution, as all SFI-III top subject areas are calculated for less than 50 publications in the evaluation years.

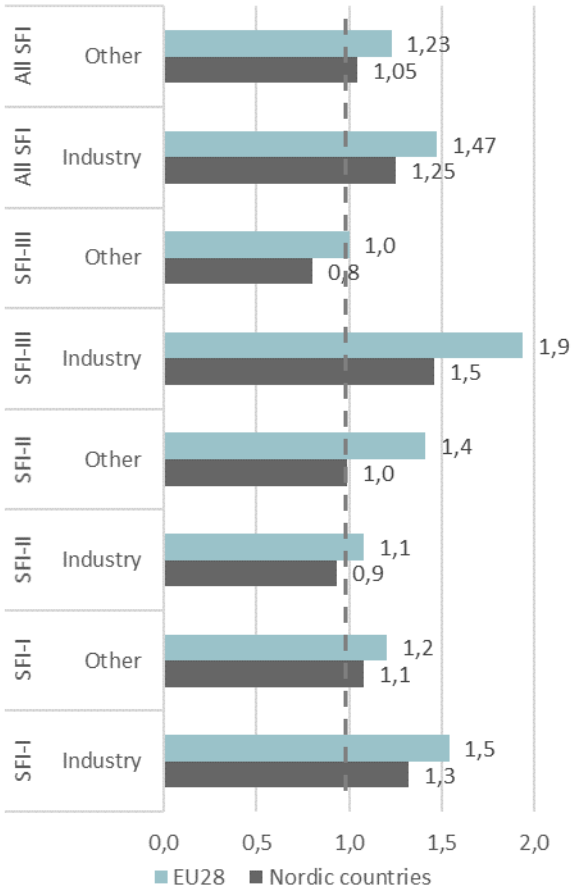
Looking to Computer Science, however, SFI-II outperformed the EU28 benchmark, while SFI-III falls far short of the same benchmark. Which could be explained by the fact that SFI-III scheme has only just started and munch research has not been published yet.

4.5.3 Scientific impact across types of co-authorship

Figure 4.22 explores impact across types of publications in terms of industry co-authorship. We see that overall (All SFI), industry co-authorship implies at least 20 pct. points higher impact relative to both the Nordic and EU28 benchmark, than publications without industry co-authorship. As such, though industry co-authorships are fairly limited, the ones made are overall of a high quality relative to those without industry co-authorship.

Looking to SFI-I, we see that these publications largely drive the results, with a 25-35 pct. points higher impact for industry co-authorship. Though SFI-III figures are not robust, given that they are calculated for under 50 publications, they follow the same trend, and to a great extent.

FIGURE 4.22
Impact for publications with industry co-authorship, compared to impact of other publications.



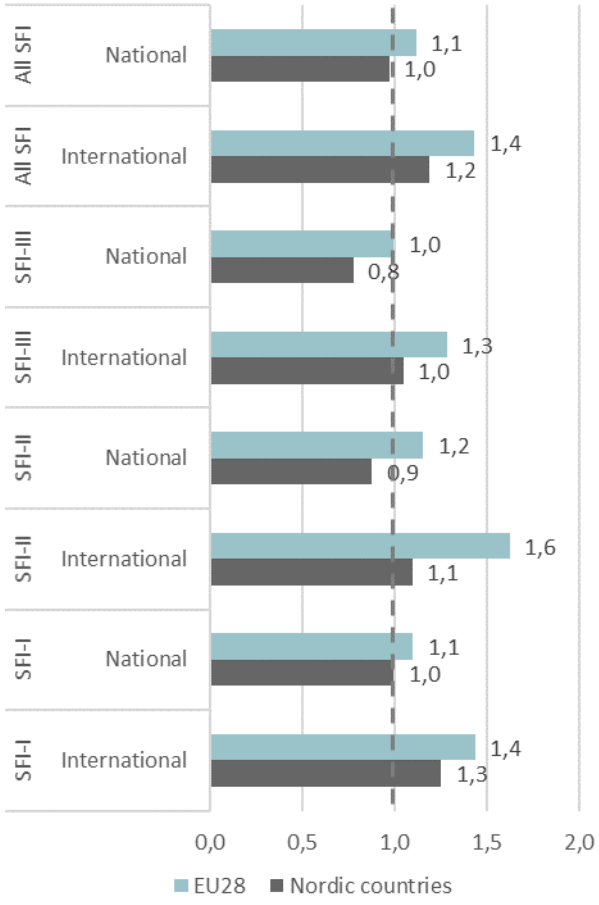
Source: Scopus and calculations by DAMVAD Analytics, 2017.
Note: Other refers to publications which do not have industry co-authorship

However, it is interesting that SFI-II does not follow the same trend. For this generation, industry co-authorship implies a lower impact than the articles which do not have industry co-authorship. In fact, against a Nordic benchmark, industry co-authorship

for SFI-II publications implies a relative impact below 1. Referring back to table 4.16, SFI-II is also the generation with fewest industry co-authorships, which might imply that industry does not play a large role in the types of research carried out, and when it does, it is not of as high quality.

Looking to table 4.23 we see international co-authorship. As expected, it is the case for all generations that international co-authorship implies a higher impact relative to both benchmarks. Particularly, when comparing to a Nordic benchmark, the international co-authored publications are above 1, while the national publications are below 1 or just at 1 (as is the case for only SFI-I). The findings stress that the SFI centres has succeed in putting Norwegian research and researcher on the forefront of the international research community within the focus areas of the centres. By making the researcher valuable partners for international peers, which again gives international recognizing in the research community.

FIGURE 4.23
Impact of publications with international co-authorship compared to publications with only national authorship



Source: Scopus and calculations by DAMVAD Analytics, 2017.

5 SFI scheme contribution to active long-term cooperation

This section will explore the goal of the SFI scheme to: *Create active collaboration between an innovative private sector and prominent research environments.*

We explore fulfillment of this goal through the following evaluation questions: "*To what extent has the SFI scheme contributed to creating active cooperation between an innovative business community and prominent research communities?"* and *"To what extent has the SFI scheme provided for greater long-term, continuity and risk reduction in given research areas?"*

This section will focus on answering the questions listed above by investigating first the extent of collaboration in the centres. We then assess the extent to which the scheme can be said to foster new collaborations, which would not have occurred absent the SFI scheme. Lastly, we explore how the SFI scheme performs on a number of criteria which are important for establishing a good environment for collaboration. These include the competencies of centre management and partners, the commitment of partners, the quality of the host institution, and the duration of the scheme.

5.1 Collaborations with industry

Given that 77 pct., 62 pct. and 71 pct. of the partners in SFI-I, SFI-II and SFI-III, respectively, are business partners (table 2.1) the SFI manages to secure a quite high collaboration between research partners and private partners, though this is true to a higher extent for SFI-I and SFI-III.

Figure 5.1.A elaborates on the nature of the collaborations. The figure displays the responses of respectively business partners and research partners, when asked about their primary use of the SFI centres, and their role.

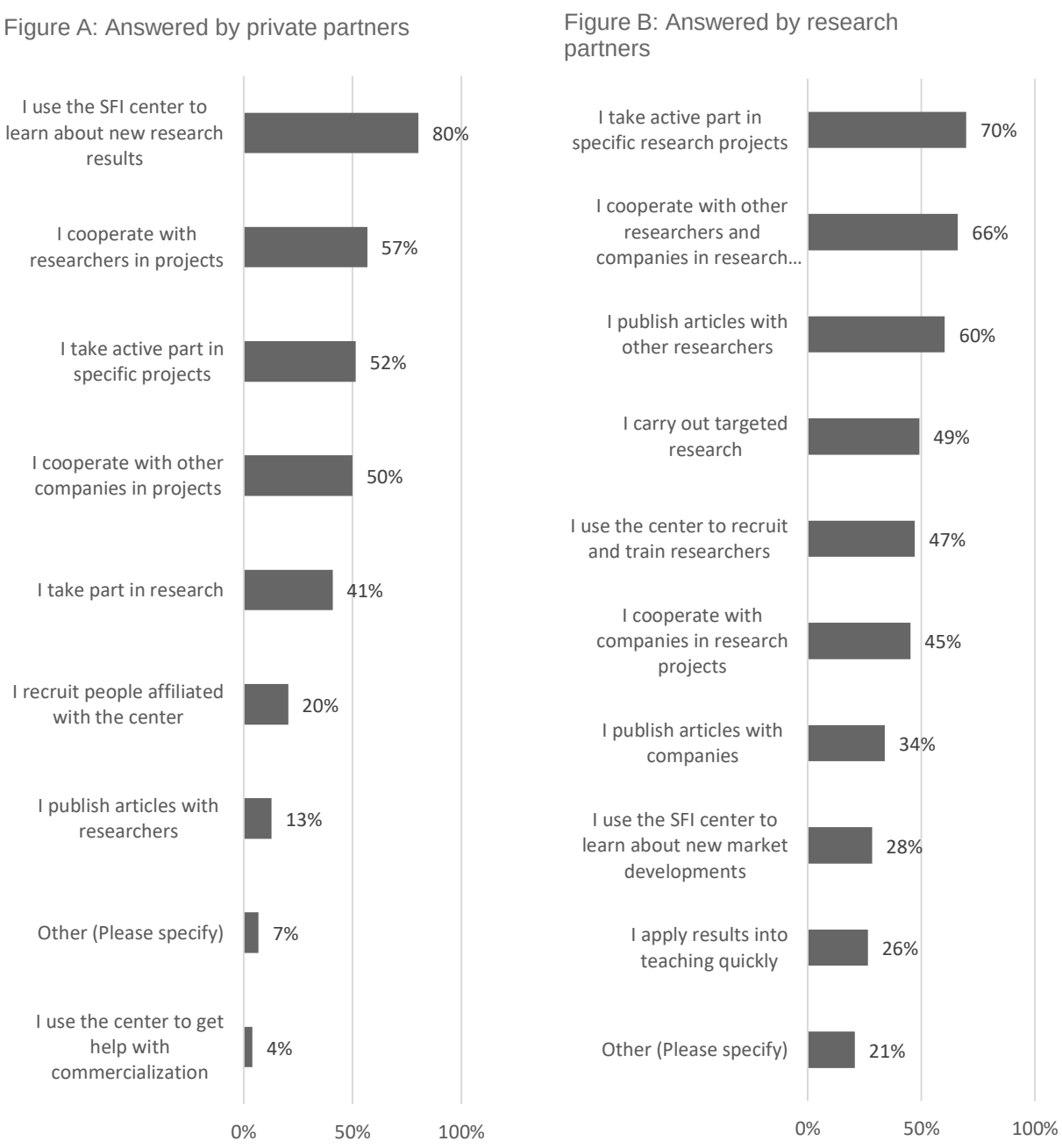
For business partners, we see that the vast majority primarily use the centre to learn about new research while a total of 57 pct. of the partners use the centre to cooperate with research partners, and 50 pct. of the partners use the centre to cooperate with other companies. This suggests that the majority do in fact use the centre to collaborate with research environments. With respect to taking an active role, more than half (52 pct.) report that they take an active part in specific projects, while 41 pct. report to taking an active role in research. Furthermore only 13 pct. report an active role in publishing articles with researchers, further confirming the result of a relatively low level of industry co-authorship (overall 11,9 pct., figure 4.16).

These results are mirrored in responses given by researchers in figure 5.1.B. Naturally the largest responserate is registered for taking an active role in research projects (70 pct) while 66 pct. say that they coorerate with researchers and other companies in research projects. With respect to pure cooperation with companies, 45 pct say specificly that they cooperate with companies in research projects.

A high percentage of research partners report to collaboratng with companies in publishing articles (34 pct.) compared to private partners (13 pct). This can be explained by industry co-authorship being concentrated on a smaller share of companies, as discussed in figure 4.17 in the bibliometric analysis. As also discussed in the above section, the degree of industry co-authorship was relatively low compared to comparable schemes (figure 4.18).

When asking the partners to describe why their centre has been a success, there are multiple partners who cite that the centres open up for collaboration between research and business partners, as well as collaboration within specific business areas.

FIGURE 5.1
How do you primarily use the SFI centre and what is your role in the SFI centre?



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: A given respondent could tick all that applied. Private partners: n=132, research partners n=53

These figures in addition to the survey responses showed in figure 5.1 suggest that although there is a high degree of collaboration and knowledge transfer between the research and business communities, which is valued by the participants, the concrete output in terms of co-publication is neither the goal, nor the observed outcome.

5.2 Establishing new collaborations

This section explores the extent to which the SFI scheme has fostered collaborations which would not otherwise have taken place. Figure 5.2 displays the answers from the survey regarding how many of the of the private companies and host institutions the respondents have worked with before the establishment of the SFI.

93 pct. of companies say that they have worked with all or some of the other research institutions, 84 pct. all or some of the companies and 54 pct. all or some of the other partners. The results are similar when asking the research institutions. 91 pct. have worked with all or some of the research partners, 87 pct. have worked with all or some of the companies and 64 pct. have worked with the other partners.

The responses imply that the SFI scheme does not primarily bring together partners who have not to some extent worked together before. This may suggest that the SFI scheme has rather allowed for more meaningful collaborations among companies and research environments which already were in collaboration. However, with respect to collaborations with companies (either from other companies or research institutions), very few had collaborated with *all* the companies before the scheme. As such, 99 pct. of companies in the scheme report to working together with at least some new business partners and 91 pct. of research institutions report to working together with at least some new business partners. This suggests that the scheme has at least to some extent succeeded in including new firms in the Norwegian innovation agenda, and fostered new relationships between the research community and the private sector.

FIGURE 5.2

Has your company or research institution previously (before the SFI was established) cooperated with any of the SFI project partners?

Figure A: Company

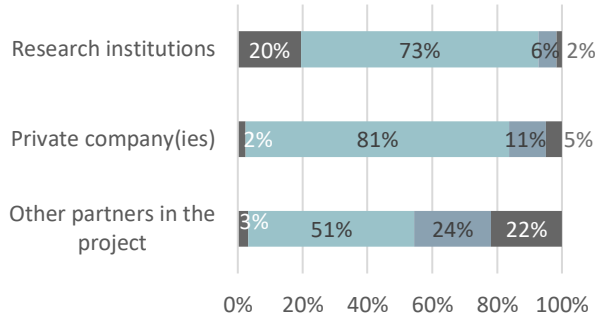
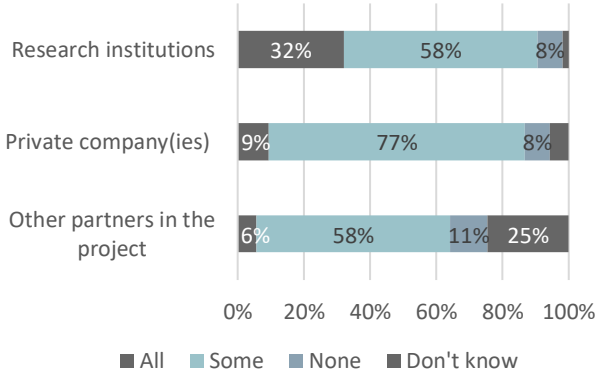


Figure B: Research institution



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: Business partners: n= 123, Research partners: n=53.

5.3 Criteria for establishing a good environment for cooperation

This section explores criteria for establishing a good environment for cooperation within the centres. These factors were gathered in interviews with centre management, and tested further in surveys sent to all partners. These include managerial competencies, openness of centres and commitment of partners, as well as host institution characteristic. Lastly, we touch on the time-frame of the centres.

5.3.1 Competencies of centre participants and management

Figure 5.3.A tests compiles survey responses to the extent of the competencies and qualities in their SFI, which can be said to contribute to a good environment for collaboration. These pertain mainly to the qualifications of participants, hereunder management, business partners and research partners.

Another important factor for a strong collaboration is educating PhDs with a strong industrial focus. As mentioned in section 4.1, the SFI scheme is considered successful by partners, in attracting and educating PhDs. Business partners are attracted by the possibility of working with and employing academic staff and upgrading their in-house competences. This can be considered a strength in securing strong collaboration between academic and business environments.

However, as also mentioned in section 4.1, the ability of the research community to see a business perspective - and likewise for the business community to see a research perspective, is central to a good collaboration. With respect to research competencies of companies, 31 pct. give a very positive feedback on the statement that the companies and have sufficient research competencies. With respect to researcher capabilities in having an innovation perspective and market understanding, only 14 pct. reported with a very positive feedback. A high share even reported that researchers had *very little* competencies in this area (13 pct.).

Interviews with centre leaders confirm that the innovation perspective of researchers and research competence of companies is a challenge, although it is noted that the SFI scheme is helpful in forcing researchers and universities to collaborate on research based innovation.

With respect to the managerial competencies, roughly 95 pct. provide positive feedback, of which 58 pct. provide very positive feedback. As such, centre management is experienced as strong by participants.

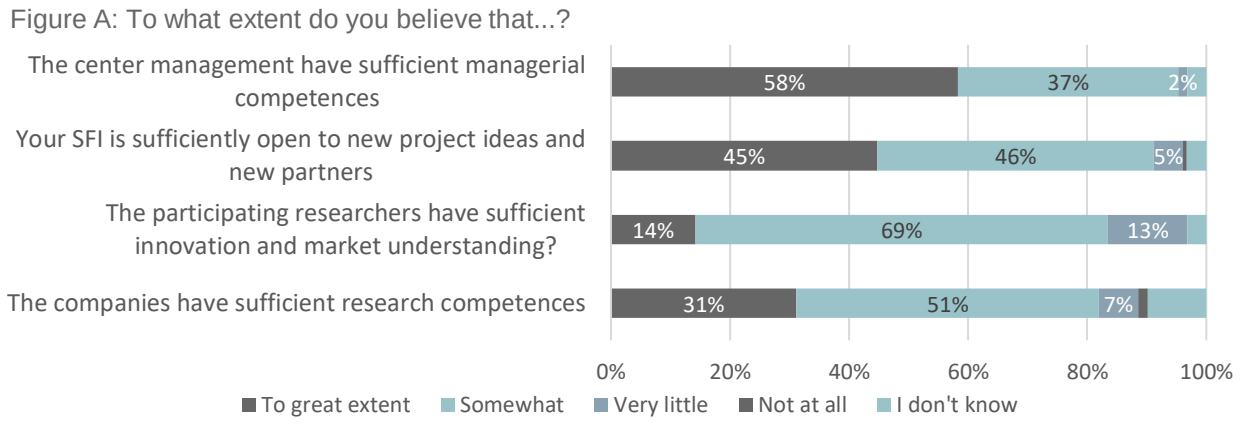
5.3.2 Commitment of existing partners and openness within centres

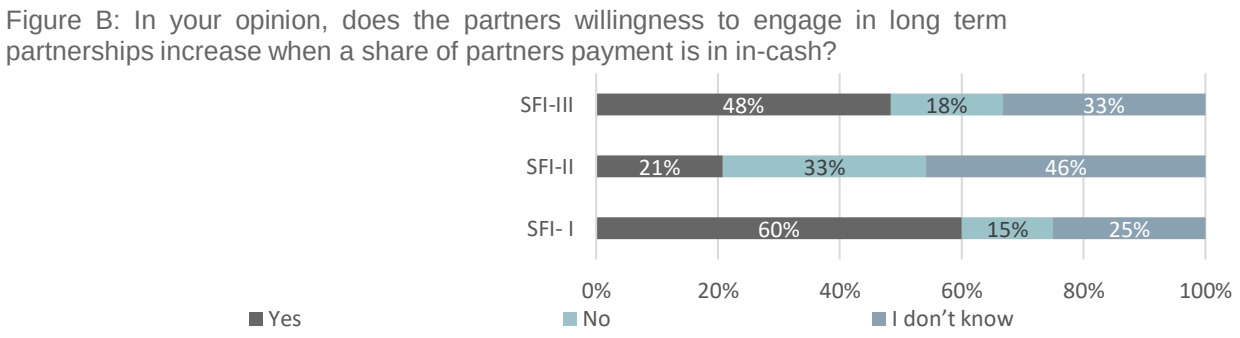
An important factor when examining the strength of the collaboration is the commitment of partners and trust established among partners. Figure 5.3.B shows the extent to which the willingness to engage in long term partnerships increases when a share of partners pay in-cash. The answers differ greatly across the SFI generations. For 60 pct. in SFI-I this is the case whereas 21 pct. and 48 pct. agree in SFI-II and SFI-III respectively.

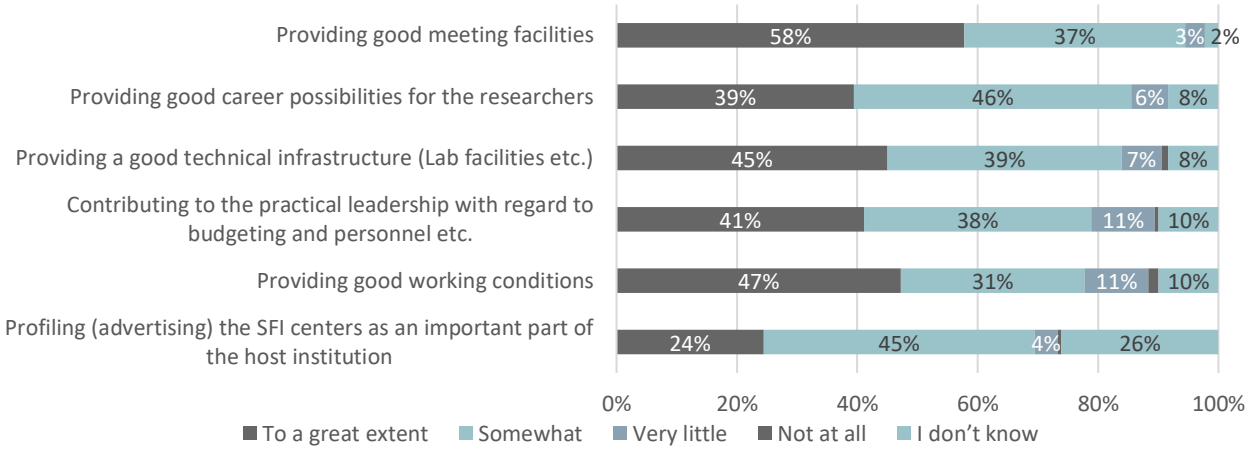
This ambivalence in response regarding the correlation between in-cash contributions and commitment reflects a general trade-off mentioned in the workshops and in interviews. On the one hand, higher cash contributions ensure commitment from firms seeking value for money in their investments. However, a higher in cash contribution may also give the contributor a sense of disengagement, believing that the cash contribution offsets any lack of in-kind participation or engagement. The workshop participants suggest that a combination of in-cash and in-kind contributions is necessary to ensure partner engagement and in turn mutual trust. Insights from the interviews suggest that trust and commitment of partners is also impacted by the degree of competition among partners.

Furthermore, it is important for the cooperative environment that centres are open to not only new ideas from partners in the centre, but also new partners throughout the innovation process Figure 5.3A shows that over 90 pct. of partners believe that the SFI scheme is sufficiently open to new project ideas and partners, with half of these agreeing to a great extent. This speaks to a dynamic collaboration environment, which is inclusive and flexible in the research process.

FIGURE 5.3







Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: Figure A: SFI-I: 43, SFI-II: 27, SFI-III: 134. Figure B: Question: "To what extent do the participating companies have sufficient research competencies to be full active and contributing members of the SFI centre?" n=61, Question: "To what extent is your SFI centre sufficiently open to new project ideas and new partners?" n=181. Question: "To what extent, do the participating researchers have sufficient innovation and market understanding?" n=127, Question: "To what extent, does the centre management have sufficient managerial competencies to run the SFI centre?" n=127. Figure C: n=180

5.3.3 Host institution ability to create physical environment

Figure 5.3.C scores the capabilities of the host institution to provide a good physical environment for collaboration. The overall trend is positive, with the vast majority of respondents providing positive feedback. 95 pct. of the respondents answer that the host institution provides good meeting facilities, 78 pct. say that the host institutions provide good working conditions, while 79 pct. report that the hosts provide good practical leadership. In interviews with host institutions, they agreed that the SFI to a large extent is a platform that secures interaction between business partners and research partners.

Though positive overall, input from interviews does suggest that there is a challenge with respect to geographical placement of host institutions, if the host is placed far from partners. Feedback from the workshop participants suggests that though this is acknowledged, it is difficult to mitigate in a geographically dispersed country like Norway.

5.3.4 Duration of the centres

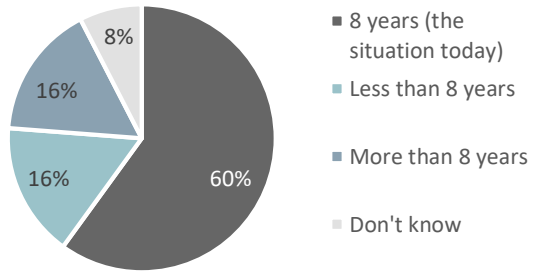
Lastly, we consider whether the length of the support period of the SFI scheme is sufficiently long (or short) to foster meaningful collaboration and continuity in research. Today the duration of each SFI centre is eight years. Figure 5.4 shows the response of partners as to the appropriateness of the length. 60 pct. believe that centre support should continue with the current length of 8 years, whereas 16 pct. believe it should be shorter and 16 pct. believe it should be longer.

Qualitative insights from the interviews with centre leaders suggest that 8 years is a good length to ensure that all stages of innovation are completed. In other words, a long program period ensures a holistic approach to research and development, which allows for completion of both long-term and short-term plans. The duration also gives some degree of freedom within the innovation process to change the focus area in the face of challenges and unforeseen obstacles.

However, it is also mentioned that a long program duration is a challenge for industry partners, whereby changes in leadership and revenue can impact participation over an 8-year period. This is confirmed by the survey results, as the majority of respondents who believed the SFI should be shorter, were industry partners. Only 6 pct. of research partners believed that the SFI should be shortened, while 21 pct. of industry partners believed it should.

Furthermore, it should be mentioned that though the program period is 8 years, multiple partners continue into other SFI's later, as mention in section 3, ensuring a degree of continuity in research beyond the 8 year program period.

FIGURE 5.4
In your opinion, should the duration of the SFI centre be:



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: n=185

Overall, we conclude that the SFI scheme and its participants provide a good environment for high quality collaboration and continuity in research.
Some areas which are identified as a challenge include ensuring researchers' innovation perspective and securing partner engagement and commitment from the start of the scheme.

6 Differences in centre characteristics and goal attainment

6.1 Results from cluster analysis

In order to thoroughly identify and assess patterns in structures and performance of the SFI centres, we have conducted a cluster analysis of the SFI centres. The clustering approach has the advantage that it makes it possible to characterise patterns within the SFI centres across generations by dividing them into segments. Within each segment SFI centres should be alike across generations. Given that SFI-III is only 2 years into the scheme the results regarding SFI-III should be interpreted with caution. The generation is still included in the analysis in an attempt to capture the early characteristics of the centres in the generation. A detailed description of the methodology and the full set of features included in the cluster analysis can be found in appendix I.

The SFI centres can be divided into clusters on two dimensions:

1. **Structural clusters**, which group centres based on characteristics, and
2. **Performance clusters**, which group centres based on outcomes.

Based on the cross between these clusters we are able to analyse if there is a pattern in characteristics among centres which is correlated with certain results or outcomes.

6.1.1 Structural clusters

In this section we characterize the structural clusters by using 14 different characteristics to identify similarities across the centres. These include variables on partners, PhDs and postdocs, number of sectors and counties partners are located in, as well as financing variables in both in-kind and cash from hosts, RCN, and research- and business partners respectively (see appendix I for a full list of variables). The 8 most important characteristics which highlight the differences within the clusters are summarized in figure 6.1. We find that the SFI centres can be divided into 4 structural clusters, which capture the structural types across SFI generations:

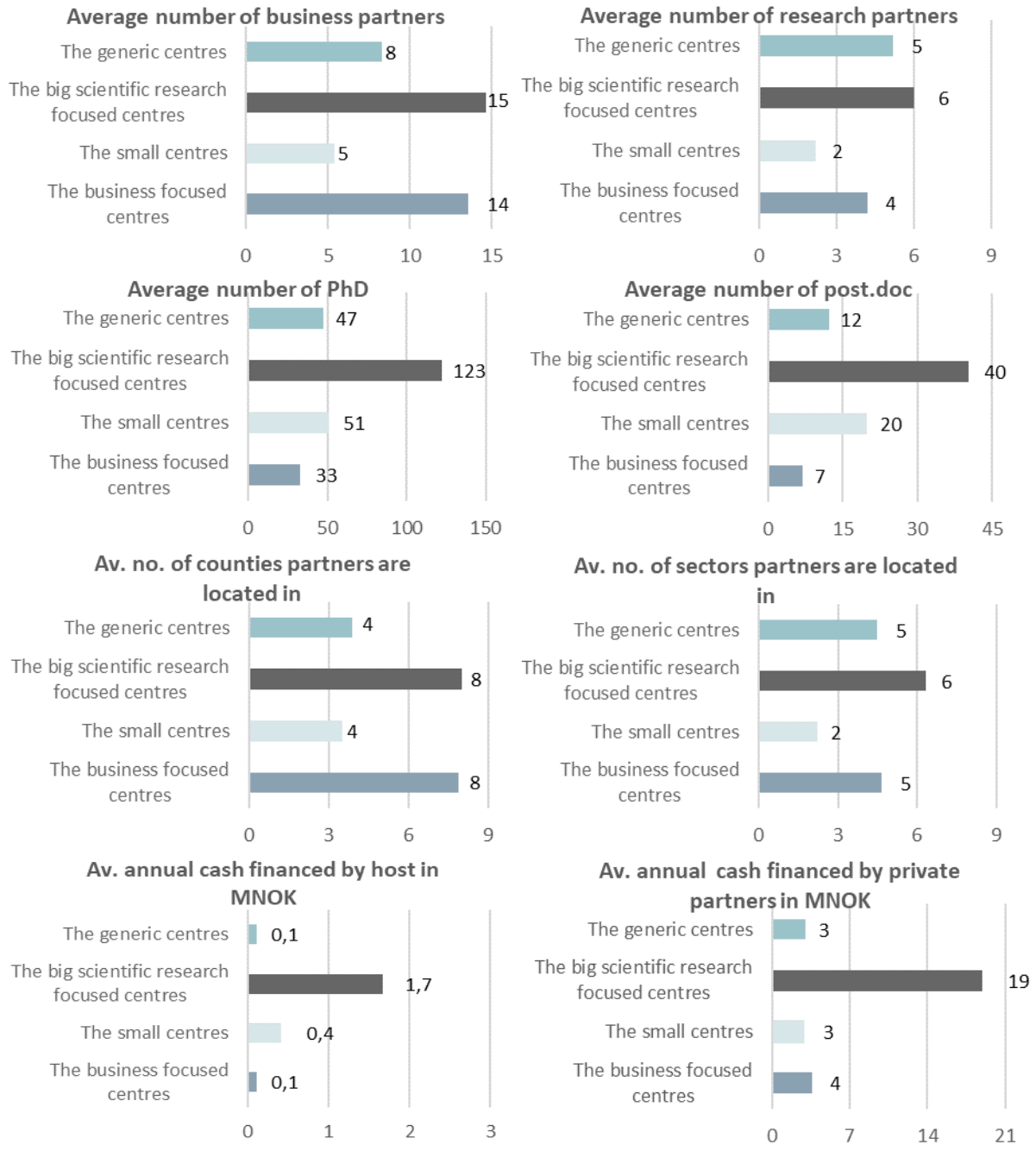
The generic centres: This group of centres is characterised by a relatively high variance in sectors represented as well as many research partners. However, the centres appear to have few PhD students and postdocs affiliated, as well as a low amount of cash contributions from partners compared to the other centres. Overall this group scores average on most of the characteristics. This is a cluster with 10 centres.

The big scientific research focused centres: This cluster contains large centres with a focus on academic results. These centres contain partners from many sectors, and which are more geographically dispersed compared to the other clusters. However, this group also consists of centres with many research partners and a large number of scientific personnel, measured by postdocs and PhD students. This is distinct for this cluster. Measured in cash contributions this is a group of centres that succeeds in attracting cash funding from the host organization as well as private partners. This is the only cluster where there is a significant contribution of cash. This is the smallest cluster with only 3 centres.

The small centres: This cluster has a small number of research and business partners. Furthermore, the numbers of sectors and counties represented is limited. The contributions from the business partners to these centres in terms of cash or in-kind is low. Furthermore, the hosts primarily contribute in-kind rather than in-cash. The opposite is true for the research partners, which contribute primarily in cash. This may be due to the fact that in a small research environment, one chooses to concentrate the researchers in one place and the other partners thus help to finance this. Taking their limited size into account, these centres have an academic profile with a fair number of research personnel. This is a cluster with 10 centres.

The business focused centres: These centres have a large number of business partners. At the same time, they have an average level of research partners and a low level of scientific personnel involved. Their partners are dispersed among a number sectors and are geographically dispersed as well. The majority of the centres in this cluster come from SFI-III, while SFI-I and SFI-II are more represented in the other clusters. This indicates a structural change over the three generations, with

FIGURE 6.1
Infographics structural cluster



Source: Self-evaluation reports by centre leaders and The Research Council of Norway.
Note: All financing variables are in per MONK in 2016 prices. Figure 6.1 only illustrates the financing variables, that were most important for the cluster analysis. Further variables include financing by: Host, RCN, Research- and Business partners in both in-kind and cash respectively.

the newest generation having a more direct focus on company participation than previously. This is the largest cluster with 15 centres.

6.1.2 Performance clusters

For the formation of the performance clusters 17 outcomes are used, including variables on scientific publications, disseminations, patents, license contracts and innovation measures. (see appendix I for a full list of variables). The 10 most important outcomes are summarized in figure 6.2, showing the annual outputs per MNOK invested in the given centre. The first row of outputs pertains to academic publications, while the second row pertains to other dissemination measures. The third row shows patents and license contracts, while the fourth and fifth row show four measures of innovation and commercial output. We find that the SFI centres can be divided into 4 structural clusters with respect to performance:

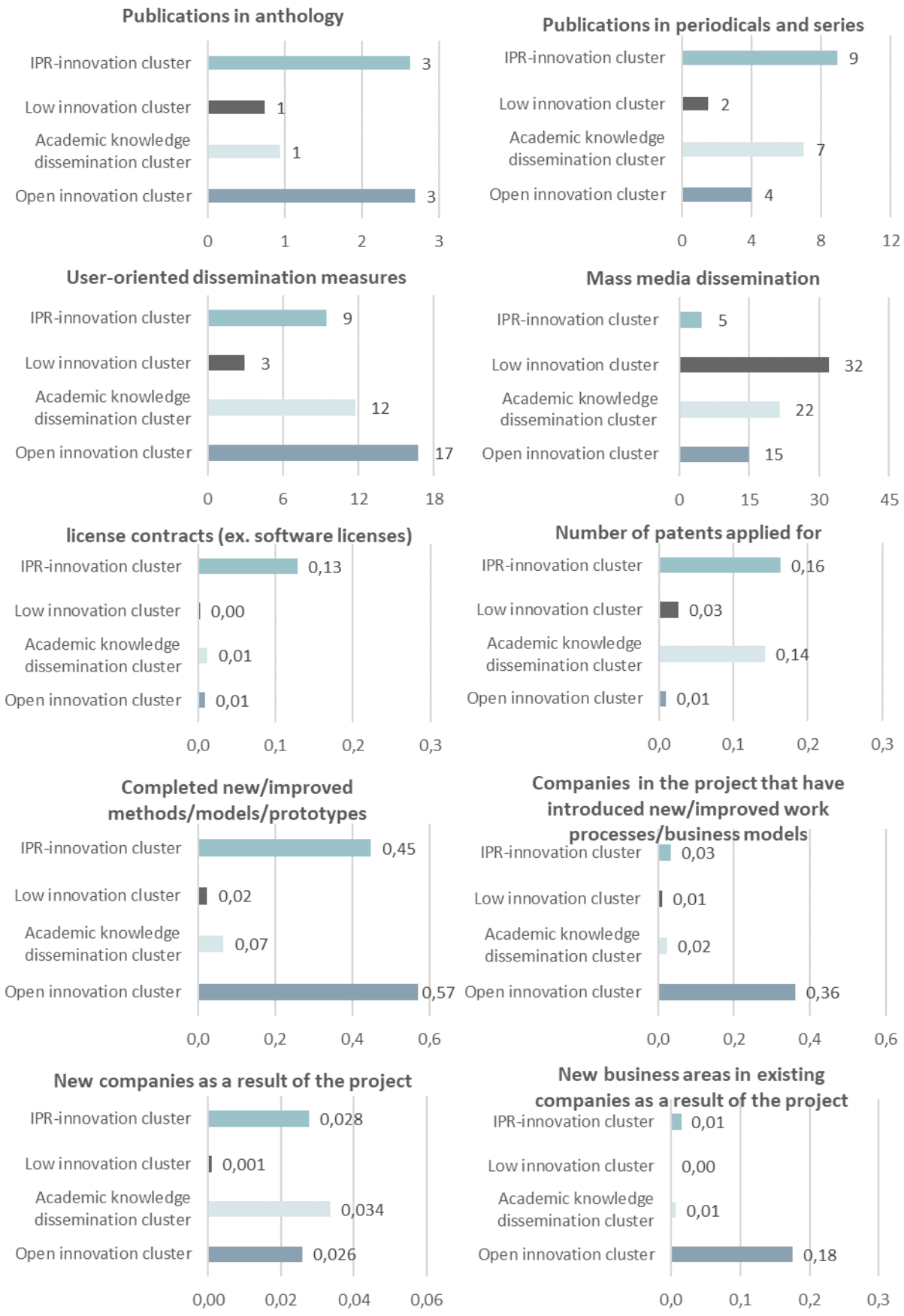
IPR-innovation cluster: This cluster performs well in terms of all outputs that have protected IP/knowledge. On the academic side this is e.g. publications in monographs, anthologies and periodicals. On the commercial side, this is particularly completed innovations (new or improved methods, models or prototypes), where this group performs very well. This group distinguishes itself when it comes to new license contracts and patents, outperforming all other clusters. However, this cluster performs poorly in terms of new business areas and creating new or improved business models for companies in the scheme. These centres have a low score when it comes to wider dissemination of the results targeted the public and mass media. This cluster consists of 3 SFI-I centres.

Low innovation cluster: The outputs from this group of centres is on the lowest level compared to the other clusters. It scores relatively lower on all indicators besides mass media dissemination. All SFI-III centres (17) are placed in this cluster. This is naturally due to their short duration. On the longer run we expect them to migrate to other clusters. We further find 5 SFI-I and 4 SFI-II centres in this group, totaling 9 out of 21 SFI-I & II centres scoring low in terms of innovation outputs.

Academic knowledge dissemination cluster: This cluster performs very well on all adademic performance measures. This is especially true when it comes to publications in periodicals and series, but also with respect to reports, lectures etc. and dissemination. In terms of non-academic performance measures, this cluster manages to perform well only in terms of patents and new companies created. However, the cluster performs poorly on all other innovation outcomes with respect to creating value for businesses involved in the scheme, hereunder new products, business areas, and business models/ processes. This suggests that for the centres in this cluster, though commericial results are limited, the method for commericialization is patenting and creating spin-offs or new companies.

Open innovation cluster: This cluster is performing at a high output level compared to the other groups. Generally, the knowledge dissemination outputs are at a high level, especially the user-oriented measures. However, this cluster stands out when it comes to outputs measured as innovation outputs in companies, performing well in terms of new business areas, products, technologies, business models etc. However, the focus is not on IPR given that the licenses and patent applications are almost non-existing. As such, these centres have a clear emphasis on outputs where knowledge is shared.

FIGURE 6.2
Infographics performance clusters



Source: Self-evaluation reports by centre leaders and The Research Council of Norway.
Note: All figures are average annual output per MNOK in 2016 prices.

6.1.3 Relationship between structural and performance clusters

In order to analyse the characteristics that have an influence on performance, we plot each center according to which structural cluster and performance cluster they belong to. These are shown in figure 6.3.A. Though all generations are plotted, centres belonging to SFI-III are marked with dotted lines, in order to focus primarily on the trends for SFI-I and SFI-II centres. As such, though all SFI-III centres currently belong to the low innovation cluster, centres may follow earlier generations in the same cluster into other performance clusters once it has reached maturity.

Starting with generic centres, only one has managed so far to have business oriented innovations (IPR and Open innovation clusters) and one is located in the academic performance cluser. The majority, however, are centered in the low innovation performance cluster.

At the same time, none of the centres in the big research oriented clusters manage to be part of any of the business oriented clusters, measured on output. Though there are not many centres in this cluster, they are all located in the academic performance cluster. As such, research focused centres, with a high number of academic staff and research partners, as well as a high cash contribution, primarily succeed in terms of academic performance.

Similarly, we find that none of the centres in the business cluster belong to the academic performance cluster. These are evenly spread among the low innovation and open innovation performance clusters. As such, centres with a business aim, naturally see success in terms of innovation and business outcomes, and not so much in terms of academic outcomes.

The largest within-group-variation is found for the small centres which have been dispersed amongst the four different output clusters. However, if only the low innovation cluser is seen as a low performance cluster, the majority of centres (excluding SFI-III) perform well- either in terms of academic or innovation output.

The “low innovation cluster” reflects to some extent that there will be a time lag for centres of this scope and size, given that all SFI-III and many SFI-II belong to this cluster. A such, low innovation centres are primarily those which have not concluded their 8-year term. The relationship between time and total outputs is illustrated in figure 6.3.B, whereby all types out outputs from the centres are summed. The figure also shows that within SFI-I and SFI-II there are centres having much poorer performance than the others with the same time span. Therefore, we have mapped the centres on the two cluster dimensions at the same time.

As such, though there are only a few centres in the academic research-driven centres and the business-focused centres, these are more likely to generate results which pertain to respectively research and innovation outcomes. This speaks to a result overall that it is difficualt to succeed at generating both academic and commercial outputs. The performance of the generic clusters is yet to be shown when SFI-III matures, as earlier generations have been spread in performance. IPR innovation performance has thus far only been seen from generic centres or small centres, while open innovation has been primarily seen from small centres and business focused centres.

FIGURE 6.3
Figure A: Overview of SFI representation in structural and performance clusters

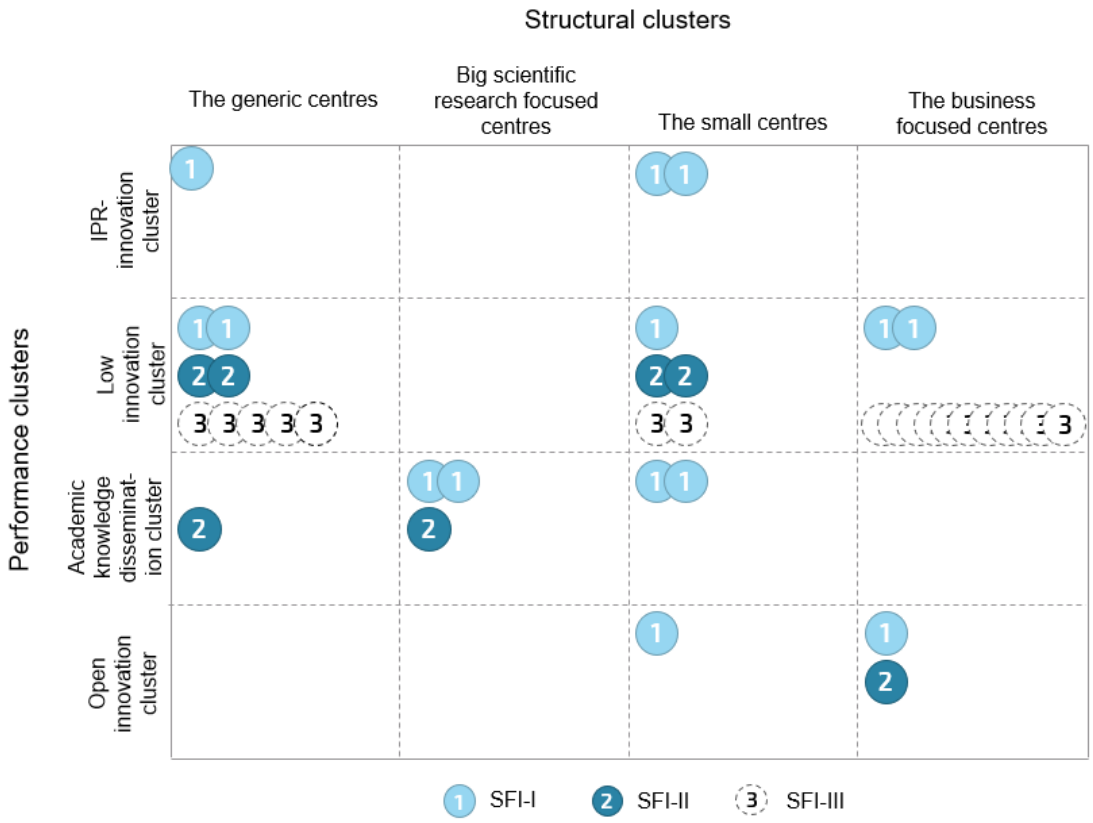
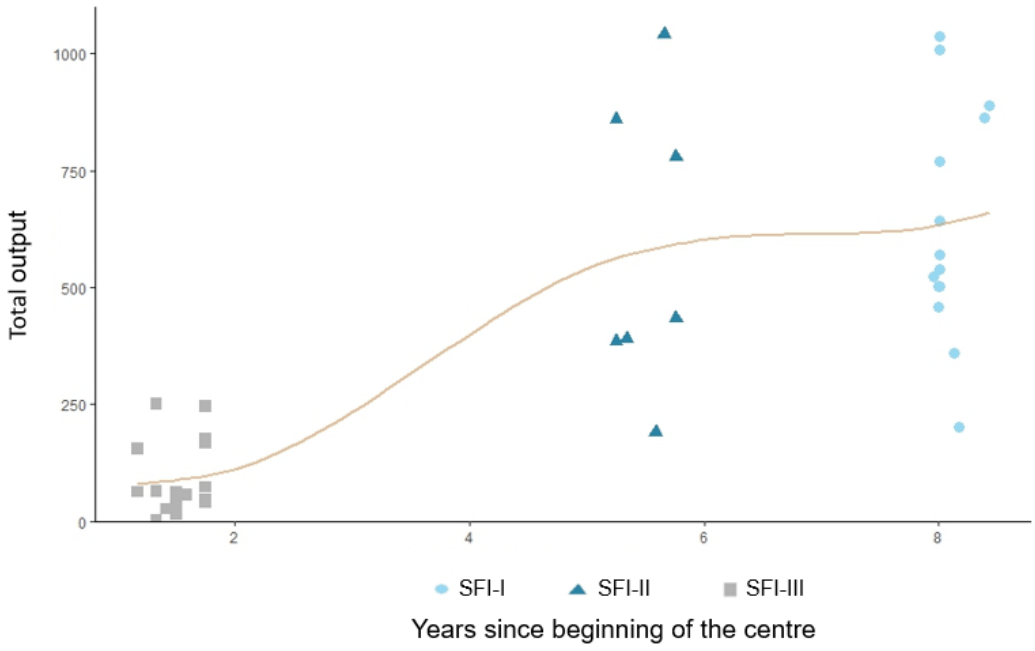


Figure B: Time-lag and variation in number of outputs by centre and generation



Source: Self-evaluation reports by centre leaders and The Research Council of Norway.
Note: Output in figure 6.3.B refers to the sum of publications, disseminations, innovation and commercialized results.

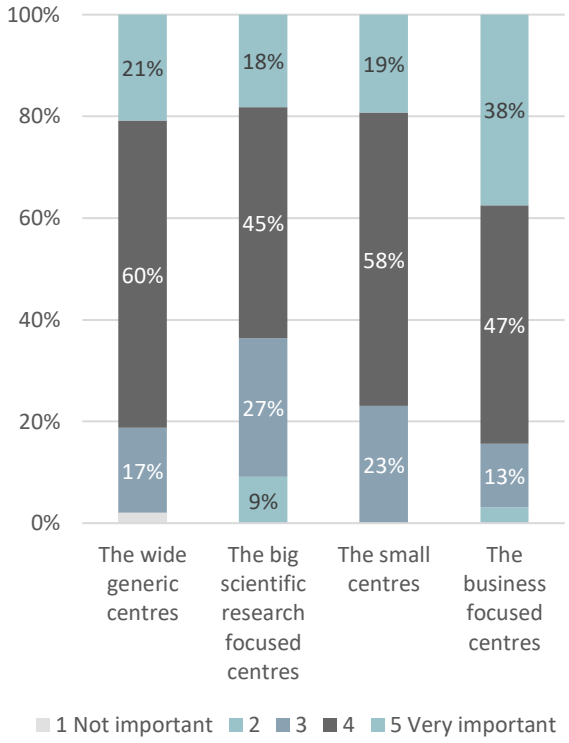
6.2 Survey results

In order to further undertand and nuance the results, we here draw upon insights in the survey, segmented into the structural clusters. Given that the survey has been segmented into smaller groups, there are few respondents and the results should be interpreted with caution. For some questions, we find that there are only small differences, while others have too few responses to adequately conclude.

In the structural clusters, there is a clear difference between how the private partners in the big research clusters see their own role compared to all other clusters. The private partners in this cluster having answered the questions are much less likely to answer that they are engaged in the centre taking part in research, publishing articles with researchers, take active part in specific projects, co-operate with researchers in the project and collaborate with companies in the project.

Despite a large financial contribution from the private partners in the big research clusters, the private partners appear not to be engaged in the activities in the centres. This is shown in figure 6.4., whereby the big research cluster to a lesser extent values the activity level of the participating companies, with a larger share responding with low importance. The results could either explain or be a consequence of the fact that none of the centres in this cluster tend to have a business oriented innovation performance profile. There is only a limited number of responses from the research partners in this cluster. However, the answers from the research partners are in line with this conclusion, because only few say that they take active part in research projects and cooperate with private companies in the research projects. The results suggest that in the big research clusters the private funding is to some extend funding of research, and not participation. Conversely, looking to the big business focused centres, a much larger share place a high value on the activity levels of participating companies. This speaks to a higher collaboration with business, and desire for in-kind participation.

FIGURE 6.4
How important are high activity levels of participating companies?



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: n=181

The attitudes of the different performance clusters with respect to expectations for commercialization are shown in table 6.5. The main insight from this is that the partners in the open innovation clusters have much better faith in the ability to commercialize the innovations on the short term than the other three clusters. 86 pct. expect to commercialize the discoveries within the next two years.

The corresponding figure is only 22 pct. in the academic performance cluster and 38 pct. in the low innovation cluster. Summing expectations over the two-year and five-year period, an optimistic view is

clear from the low innovation cluster, with over three fourths of repsondents expecting to commericialize.

6.3 Overall findings

If these results are to be confirmed by the development of the SFI-III centres, the analysis suggests that good commercial results could especially be expected from clusters with a focus on active participation from companies and collaborations between the participants.

Across the findings in this analysis we have the following reflections:

- While time is an important factor for both commercial and scientific outputs within centres it is not a sufficient factor– there is a large variation in performance between centres within same generation and thereby lifespan. This implies that the focus within the centres varies with respect to the extent to which they prioritize commercialization and academic outputs.
- A structural change has happened over the three SFI generations, as the SFI-III centres primarily are represented in the business focused cluster.
- Centres being structured with a strong emphasis on research participants with respect to number of research partners, PhD students and postdocs generate academic outputs.
- Commercially oriented centres tend to be either focused on IPR or an open innovation output performance.
- There is not a cluster that excels in all variables describing both scientific publications and innovation. This implies again that each of the clusters have different priorities and focus areas with respect to generating outputs.
- Active participation of companies in specific projects and in research collaboration appears to be important for the ability to generate commercially oriented outputs, while cash contribution is neither necessary or sufficient in itself.

It is too early to assess the importance of the structural components for the output of SFI III. However, if they follow the parttern of the previous centres, the output performance will be either low on innovation or commercially oriented performance.

TABLE 6.5
Survey question: “Do you expect to commercialize and go to market with your innovation?”

	IPR-innovation cluster	Low innovation cluster	Academic knowledge dissemination cluster	Open innovation cluster
Yes, within the next 2 years	50%	38%	22%	86%
Yes, within the next 5 years	13%	38%	44%	14%
No	38%	24%	33%	0%

Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: n=137

6.4 Further qualitative insight on goal attainment

This section provides qualitative insight from the participants regarding factors which are important for goal attainment, to add further to the above analysis.

Figure 6.6.A displays results from the survey regarding whether the respondents believe that the centre they have been affiliated with has been a success. 89 pct. answer that it has been a success. Whether the respondents have commercialized or not is a crucial factor for this conclusion. 90 pct. of the respondents who have commercialized say it has been a success where only 55 pct. of the respondents who have not commercialized say the same. The answers do not differ significantly between the different SFI generations or if you segment responses into business partners and research partners. As mentioned in section 5 the most common answer to why the partners believe that their centre has been a success is the fact that the centres open up for collaboration between research and business partners, as well as collaboration within specific business areas.

Figure 6.6.B shows how partners rank the importance of listed factors for their SFI centre's goal attainment. The most important is geographical closeness of partners in the centre with 86 pct. reporting positive response (where positive response refers to answering 5 or 4 out of 5). Figure 2.6 showed the location of the business partners, suggesting that the partners and host institutions are very geographically dispersed within Norway.

The factor that scores second highest is in-cash payment of participating companies with 86 pct. positive response. This is particularly interesting, as the cluster analysis showed that high in-cash contributions were mainly found in the big scientific research focused centres, for which goal attainment mainly was met through publications.

Third, a high percentage cite that competition among companies is harmful to success and goal attainment. This is seconded in interviews, citing that competition hampers the willingness to engage and commit to innovation.

Fourth, it seems that even partners suggest that a stronger monitoring progress can be conducive to goal attainment. The remaining elements pertain to the competencies and participation levels of partners and hosts, commented on in section 5. In particular it should be noticed that the research capabilities of the business sector and the ability of the research sector to maintain a market perspective are considered important. These are also mentioned frequently in interviews with centre leaders.

FIGURE 6.6

Firgure A: Has the SFI center or SFI centers you are affiliated with been a success?

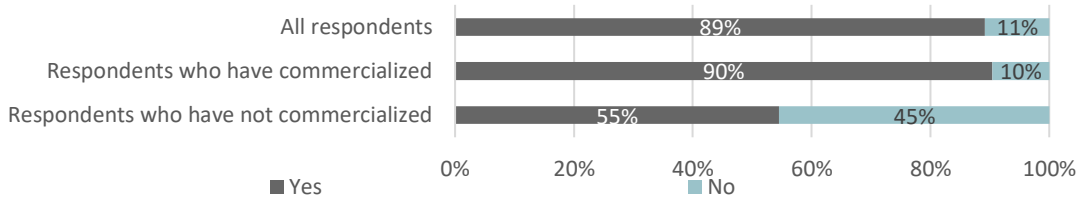
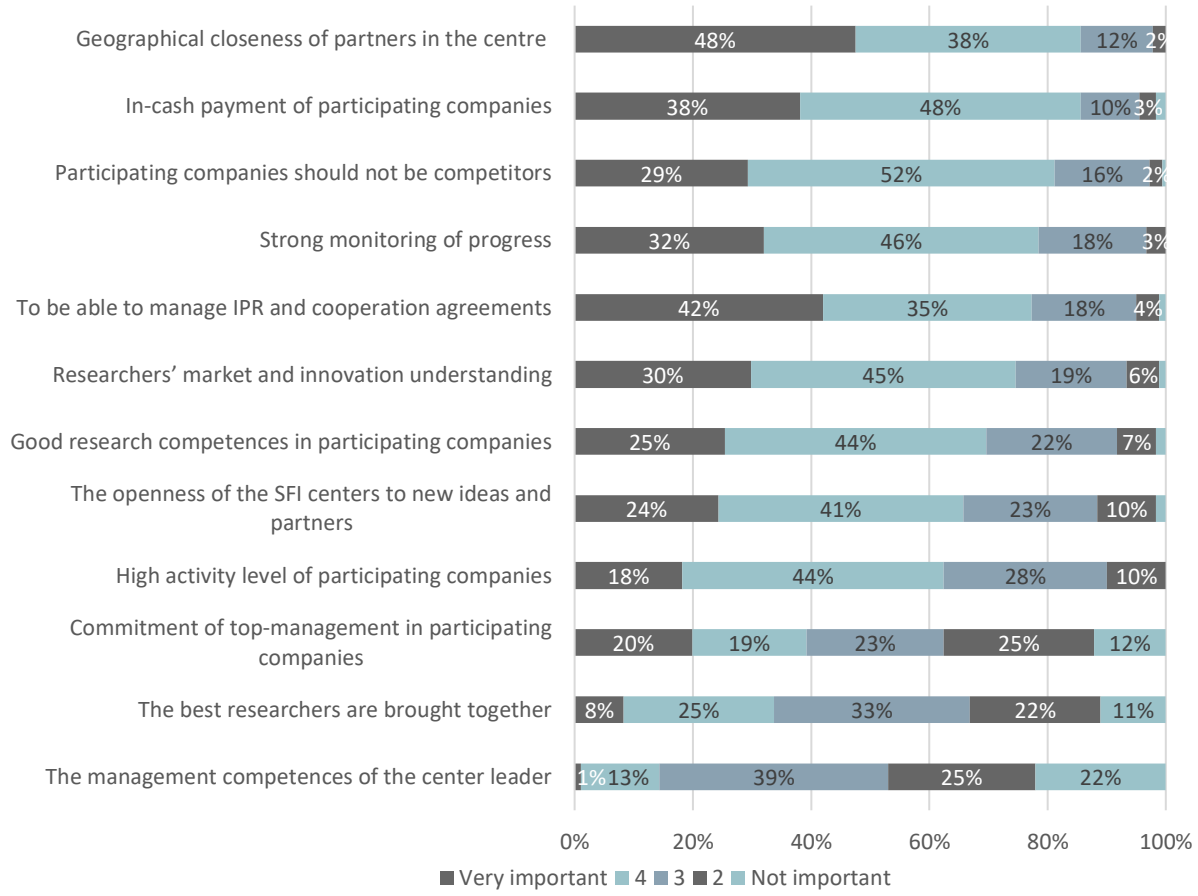


Figure B: How important are the following factors for your SFI centers goal attainment? (On a scale from 1 (Not important) to 5 (Very important))



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: Figure A: n=185. Figure B: n=181

7 International review of comparable schemes

To put the SFI centres in an international perspective, this chapter examines three comparable schemes for research driven innovation based on public-private partnership. The three schemes presented are Catapult (U.K.), COMET (Austria) and VINN Excellence (Sweden). Each scheme is presented separately and focuses on the schemes' purposes, how they have handled challenges, and key learnings. The material presented in this chapter are shorter versions of the full-length reviews of the international schemes which can be found in the Appendix II International reviews. The full-length reviews examine the history and objective of the program, placement of initiative in the national research and innovation agenda, structure and financing model, output and impact, challenges and how they are handled, public sector and services sector relevance, and perspective and learning from the initiative.

The purpose of the international review is to give inspiration to possible future governance changes, to provide insight into the constraints of the design of different schemes, and to provide insight into changes in the framework conditions and how countries have adapted and changed their schemes. All schemes are funded up to a maximum of 10 years.

The financing models of Catapult and VINN Excellence resembles each other in that they both are funded through a three-way split. However, the constitution of the agents differs between the two schemes. The private and public sector fund 1/3 each, while the last 1/3 is provided jointly by both sectors. The parts of the financing model where the private sector is involved in won competitively. VINN Excellence centres are funded through the university, the government and the industry, where each entity funds 1/3 of the total funding. Instead of a three-way split, the Austrian COMET centres are usually funded in a 50-50 split between the public and industry funding whereas 50 percent of the funding must be in cash. The 50 percent cash requirement is not a requirement for the Catapult or VINN Excellence centres and thus one of the main inspirations from the Austrian scheme. On the other hand, the Swedish VINN Excellence centres allow the public sector to finance the centres via in-kind. The VINN Excellence centres have an explicit focus to involve the public sector, which is not true for the Catapult or COMET centres.

The three schemes also differ in what kind of entity the centres form. While the Catapult and COMET centres are separate organizational entities and can be located anywhere in the countries, the Swedish VINN Excellence centres do not form separate legal entities and are situated at respective co-funding university. The Catapult centres form a legal entity called 'company limited by guarantee' while COMET centres form GmbHs, which are limited liability companies. The Catapults' legal form as companies limited by guarantee makes the centres independent in the sense that they are neither part of a governmental body, research organisation, or a company. This ensures that the intellectual property produced in the projects stays with the involved research organisations and companies for the specific projects.

One of the key learnings from the VINN Excellence centres are two initiatives, where one took place before the centres started and one was initiated during the programme. The initiators of VINN Excellence recognised the importance of the leadership of the centres from the previous generation of the Swedish competence centres and therefore offered the leaders of the new centres a preparatory leadership course before the VINN Excellence programmes started. During the programme it became obvious to the leaders of the VINN Excellence organisation that the centres experienced setbacks on establishing the centres internationally. To increase internationalization incentives for the centres an announcement was made three years into the programme with a budget

of 10 MSEK. While the effects of the initiatives are debatable, it shows the importance of agility.

Finally, beyond examining the three international schemes in Austria, Sweden and the U.K, this

TABLE 7.1
Summary of competence centres in Austria, Sweden and the U.K.

	Catapult	COMET	VINN Excellence	Other literature learnings
Country	U.K	Austria	Sweden	Performance metrics should be based on out-comes and impact 'Real time' follow-up on KPI's rather than after. No one-size-fits-all solution for the selection of KPIs'. Internationalization needs clear strategy, incentives and support structures. More authority and autonomy to centre directors Allow the centres to experiment with various structural models
Initiated	2011-2013	2006	2005	
Financing model	Generally: 1/3 business-funded (won competitively), 1/3 provided jointly by the public and private sector (won competitively), 1/3 core public funding 5-10 million £ centre/ year	Depends on centre type. Usually a 50-50-split public-industry funding (50% in cash). Scientific 5% (in-kind). New Comet Modules with 80% public funding to facilitate emerging research fields of high risk. 0,45 to 4 mio € centre/ year	1/3 university, 1/3 government, 1/3 industry Up to 21 mio SEK centre/ year (max 7 mio SEK from each entity per year)	
Duration	10 years	4 -10 years	10 years	
Public sector focus	No	No	Yes	
Service focus	No	No	Yes	
Business entity	The centres are separate legal entities, CLG (company ltd by guarantee)	The centres form GmbHs, limited liability companies	The centres are located at universities and do not form separate legal entities	
Important changes and acknowledged key learnings about strengths	• Clear criteria • Independence • Physical (neutral) • Flexible IPR • Technology facility • Connect SMEs and large companies	• GmbH (for flexibility and independence) • Financing model ensures commitment • Addresses challenges of fixed duration vs sustainability, and cooperation vs. competition	• Public sector in-kind financing allowed • Special funds for SMEs • Centre collaboration days • Global link grants • Leadership course • Competition between centres for the first 5 years	

Reference: This table is a summary of the full-length reviews of the international competence centres, which can be found in Appendix II.

chapter will also present key learnings from other international reviews of research and innovation centres in Europe and the U.S. Table 7.1 shows a summary of the international competence centres reviewed in this report.

7.1 Catapult

7.1.1 Background

In 2010, physicist and entrepreneur Hermann Hauser published the report 'The Current and Future Role of Technology and Innovation Centres in the UK' (Hauser 2010), which was commissioned by the UK government. The report, commonly called the 'Hauser Report', suggested that the UK should learn from other countries' innovation networks and outlined a plan on how the country could establish its own technology and innovation centres (UK Parliament 2011). Initially, the UK's innovation centre programme was supposed to follow Germany's model of Fraunhofer institutes. In the same year, the Government decided to spend over £200 million over four years to establish six innovation centres, and commissioned the Technology Strategy Board (TSB, now called Innovate UK), UK's national innovation agency, to develop a strategy and implementation plan for the new centres (Hepburn & Wolfe 2014, 11). The innovation centre programme corresponded to the UK government's general aim to support business innovation and growth, and it is strongly related to the main objectives of TSB's strategic plan 'Concept to Commercialization' for the period between 2011 and 2015. The first seven so-called Catapults opened between 2011 and 2013.

While focusing on a wide range of sectors, the main objectives of all Catapults are to 'bridge the gap between academia and industry, research and commerce, providing a trusted, neutral space where new ideas can thrive and find their way to market' (Catapult Network 2017, 11). In addition, Catapults should connect small and medium sized firms (SMEs) with large leaders in their respective sector, support the growth of the sectors in general, and advance the UK's economy through turning innovation into economic value (Catapult Network 2017, 16–19, 26).

7.1.2 Changes made, public sector and services sector

In his 2014 review of the Catapult network, Hauser stated that Catapults are relevant to the public sector as they would support the achievement of key policy objectives. For example, they contribute to the renewable energy sector, help improve transport systems or facilitate the use of satellite data for a wide range of purposes (e.g. climate events prediction or for national security) (Hauser 2014, 20). In addition, according to our interviewees, Catapults indirectly serve the public sector as they support a better use of resources and would make the UK's industry more productive, efficient and innovative, and consequently also more competitive. When it comes to the services sector, all of the interviewees felt that Catapults would only be marginally or indirectly relevant, because Catapults' foci would not be on providing services.

The literature reviewed for this case study did not refer to any significant challenges Catapults have to face. Interviewees consulted raised both sector-specific as well as Catapult/innovation centre-related challenges. One of those general challenges – which does not seem to be specific to the Catapult programme – is ensuring that the split between different funding sources of the financing model stays in balance. It was also pointed out that it would be challenging to make and demonstrate impact, and related to that, to constantly adapt to changes in the specific sector. While our interviewees stated that in general there is a good balance between industry and academia at the Catapults, some stressed that keeping this balance is difficult in some cases. For example, an interviewee noted that while Catapults already helped reducing the gap between industry and academia, it is sometimes difficult to keep interests of both sides aligned. According to our

interviewees, two elements would be crucial to keep the risks of the mentioned challenges low. First, clear strategies and business plans would be crucial, and second, close communication both at Catapult level and with Innovate UK are necessary.

7.1.3 Key learnings

All of our interviewees emphasised that the funding model[8] of the Catapults are a particular strength of the programme. The three-way funding model ensures a balance between science and industry, strengthens public-private collaborations, and enables the Catapults to operate at a high level (including attracting good people, providing state-of-the-art facilities and equipment, etc.). Interviewees noted that keeping the three-way balance would be important for several reasons:

- First, the public funding ensures that Catapults can work with excellent facilities and world-class staff with relevant expertise;
- Second, public funding allows the Catapults to be neutral and more independent from commercial and R&D income;
- Third, the winning of collaborative applied R&D projects would support collaborations between research organisations and industry partners throughout the proposal and project processes;
- Fourth, business-funded R&D contracts would contribute to the Catapults' relevance to businesses; and
- Finally, projects of large scale would only be possible in larger collaborations and when sufficient funding is available.

A further strength of the Catapults is their legal form as 'companies ltd by guarantee' (CLGs), and that they are independent in a sense that they are neither part of a governmental body, research organisation, nor a company. In addition, our interviewees noted that Catapults benefit from being non-for-profit and physical centres. Particular the latter point would allow industry and scientific partners to interact at one (neutral) place and build relationships, and to make use of provided infrastructure and expertise. The legal form also ensures that Catapults are not holders of intellectual property produced in the context of their projects, but that the intellectual property would stay with the involved research organisations and companies. IPR arrangements differ from project to project and they also depend on the source of funding (i.e. public funding, collaborative applied R&D projects, and business-funded R&D contracts). In the case of publicly funded work, Catapults should ensure that IPR are made 'available to business appropriate licensing, spin out or other arrangements' (Catapult n.d.-b). For collaborative applied R&D projects, existing regimes for publicly funded collaborative research should be used. In the case of business-funded R&D contracts, IPR rights should be determined by contracts (Catapult n.d.-b).

7.2 COMET

7.2.1 Background

The Austrian research-based innovation centres programme *Competence Centres for Intelligent Technologies* (COMET) was founded in 2006 and is the successor of two programmes, *Kplus* (funded by the Austrian Federal Ministry for Research and Transport; today: Austrian Federal Ministry for Transport, Innovation and Technology) and *K_ind/K_net* (funded by the Austrian Federal Ministry of Economy), which were both introduced in 1998. *Kplus* and *K_ind/K_net* were founded as a response to perceived weak science-industry cooperations in Austria in the 1990s.

Based on an assessment of the two programmes, in 2006, COMET was introduced as a 'further

[8] One third of business-funded R&D contracts (won competitively), one third of collaborative applied R&D projects (won competitively, provided jointly by the public and private sector), and one third of core public funding.

development', which would not only merge the two parallel running programmes, but also integrate new elements. While the objective to strengthen science-industry cooperations continued, COMET also has an 'ambitious orientation towards excellence, the integration of international research know-how and developing and safeguarding the technology leadership of companies to strengthen Austria's position as a location for research' (Stahlecker et al. 2015, 34). As of today, the main objectives of the COMET programme are:

- 'Developing and focussing competencies through long-term research cooperation between science and industry at the highest level;
- Strengthening Austria as a business location […];
- Strengthening Austria as a research location […];
- Strengthening the competitiveness in both science and industry by driving internationalization […]; [and]
- Establishing and developing human resources' (BMVIT et al. 2016, 4).

7.2.2 Changes made, public sector and services sector

Both primary and secondary literature reviewed for this study did not provide any relevant information about COMET's relevance to the public sector and services sector. Only few partners of existing and former Centres or Projects are public sector organisations, and their focus seems to be rather technology- and industry-oriented than service-oriented. Similarly, our interviewees felt that the programme would not have a significant impact on neither of the two sectors. However, some of them assumed that programmes such as COMET would contribute to an increased collaboration between science and industry, which might have an implicit impact on the public sector and services sector. In addition, as some COMET Centres and Projects would address societally relevant topics (e.g. climate change, food quality, renewable energy), some interviewees found that the programme might have a further implicit relevance to the public sector.

The desk research conducted for this case study provided limited information about challenges at both Centre/Project and programme level. By contrast, interviewees would point out that the programme is very stable and will likely stay stable (also regarding public funding) – changing framework conditions were not mentioned as barriers.

7.2.3 Key learnings

Stahlecker (2015) identified lessons learned and success factors of the COMET programme, which include: 'High level of trust between science and industry, long-term commitment on the part of science […] [and] of industry, research manager at the centres, legal form of centres as GmbHs and physical entities, openness to international environment, research program as a "living" construct […] [e.g. possibility of adaptations], competitive components form the regular calls and the "predetermined breaking points", thematic openness' (Stahlecker 2015, 50).

Our interviewees further confirmed the importance of the Centres' organisation as GmbHs, which allows for a higher degree of flexibility than other organisational forms (e.g. subsidiaries of research organisations or companies, or non-university research organisations such as the Fraunhofer Centres in Germany). In addition, this legal organisation should ensure independence from participating scientific or industrial partners when it comes to the management of a Centre/Project, budget, research focus, intellectual property, etc.

Both literature reviewed, and interviewees consulted for this case study emphasised that COMET's financing model is a clear strength of the programme. Indeed, some interviewees highlighted challenges of the funding model, in particular when it comes to scientific partners' 5 per cent funding contribution, which would sometimes be difficult to

be provided in the case of very large Centres. However, interviewees find the contribution of scientific partners crucial, as they ensure a stronger commitment. Similarly, industry partners' financial share (of which at least 50 per cent need to be provided in cash in the case of Centres) contributes to a sustainable engagement throughout the lifetime of a Centre/Project. Public funding ensures that the Centre/Project/Module can operate in general, and that high-quality research can be undertaken. In addition, adequate public funding enables research on high risk topics, the development and focusing of competencies and expertise, as well as the achievement of COMET's overall objectives such as stronger internationalization, enhancing Austria's competitiveness, and consequently contributing to the country's overall economic growth.

7.3 VINN Excellence

7.3.1 Background

Historically, the contact between Swedish scientists and other parts of the society have been weak and the investments made by universities in industry-related research low. To solve the market failure resulting in insufficient production of knowledge relevant to industry the first generation of Competence Research Centres (CRC) was launched at eight Swedish universities in 1995 by VINNOVA (a government agency focused on innovations) (Stern et al. 2013). The first generation of CRCs provided a ten-year investment in 28 CRCs and due to the CRCs being well received both domestically and in a European context VINNOVA initiated a second generation of CRCs called VINN Excellence Centres in 2005 (Lidgard and Lundberg 2010). The first and second generation of CRCs share the core objectives, thus the second generation of CRCs is viewed as the second phase of the competence centre program (Stern et al. 2013).

19 VINN Excellence Centres from nine universities were selected to be funded for up to ten years. The Centres were to create new internationally competitive concentrations of competencies in which enterprises, public partners, universities, and research groups aim to provide needs-driven and multidisciplinary research and ensure that the newly generated knowledge and technology result in new products, processes, and services. The goal of the program was to promote sustainable growth in Sweden (Call for proposal VINN Excellence Centres 2004). One of the differences compared to the first generation of CRCs is that the VINN Excellence Centres' partners from the public sector were to be more involved and the Centres were to be more visible in public (Stern et a. 2013).

In 2015 VINNOVA announced they will finance a new program, the Competence Centre Program, which is set to start in 2017. The new program is based on the CRC program from 1995 and the VINN Excellence Centre program. One of the goals for the new program is to get the centres to cooperate with the surrounding research and innovation environment rather than constitute isolated entities, as has been the case in the previous programs (VINNOVA Call for proposal Competence Centre 2017).

7.3.2 Changes made, public sector and services sector

One of the desired differences between the first generation of CRCs and the VINN Excellence centres was to increase the involvement of partners from the public sector. Historically, the main part of the partners involved in the centres have belonged to the engineering and the manufacturing industry. The engineering and manufacturing industries have large and important roles in the Swedish industry landscape and rely on applied research, which have made it natural for these industries to become highly involved in the centres; both financially and strategically. The public sector plays a minor role in both industries. The role of the public sector is, however, larger in other kinds of industries such as the life science sector and transport sector. To involve the public sector an exception to the co-finance

restriction has been granted: The public sector is allowed to contribute to the centres through in-kind payments.

Collaboration has been an on-going struggle for the VINN Excellence centres. Both collaboration within the centres, between centres, and with the industry. According to the leader of the VINN Excellence centres it was not clear on their part how centres should collaborate when the program was initiated. To help improve the collaboration between centres VINNOVA started to arrange "centre days" where the leaders of the centres met and could share experiences.

The interviewees also mentioned internationalization as one of the challenges for the centres. Large international corporations are often included as partners of the centres. However, to get regular collaborations with the international partners have turned out to be hard for the centres. Even regarding internationalization, the legal agreements seem to be the challenge. The researchers often start new international projects outside of the centre instead of waiting for the project to be cleared within the centre. In 2008, VINNOVA invited actors within the research and innovation community (not only VINN Excellence centres) to apply for grants to help the centres on their way of becoming more international. The announcement was called "Strategies for global links for strong research and innovation milieus" and the goal was to establish a process to become more integrated internationally within its field of research. The budget of the announcement was set to 10 MSEK (VINNOVA 2008). According to the interviewees, VINNOVA is not satisfied with the results of the announcement but since the final evaluation of the program has not been carried through yet, a solution to the problem has not been presented yet.

Finally, a last challenge recognized by VINNOVA was the importance of the leaders of the centres. The importance of the leaders came clear for VINNOVA after the first generation of CRCs, which lead VINNOVA to initiate a leadership course called "Leadership Mandate Programme – The art of becoming a better centre director" in 2008. The course, consisting of six two-day workshops, was optional and addressed the role of the leader in numerous ways. A total of 70 leaders, not only leaders of VINN Excellence centres, participated. (VINNOVA 2010)

7.3.3 Key learnings

One of the struggles of VINNOVA's first and second generation of CRCs have been to keep the centres from developing into isolated entities. Including new partners have called for substantial legal processes which have resulted in the centres developing into closed centres. Since most of the researchers also work outside of the centres, they have simply started projects outside of the centres when the legal processes have stalled their projects. A difference between the second and third generation CRCs is that the centres can construct their own legal agreements, instead of using VINNOVA's. However, most of the centres have kept to VINNOVA's agreements, sometimes slightly modified.

Closely related to the aforementioned challenges regarding researchers starting projects outside of the centres due to legal agreements slowing down the processes in the centres, is the challenge of keeping the quality of the research in the centres on a high level. The best researchers do not need to tie themselves to a centre or specific partner. They will be able to do their research anyway. Rather, the legal agreements between the centres and the partners need to be flexible to be able to create high-quality research and hence appeal to the best researcher. If new collaborations require substantial legal processes the best researchers will simply start new projects outside of the centres and the centres will risk becoming isolated entities excluded from top level research.

Finally, to put pressure on the centres to not procrastinate projects, the setup of the third generation CRCs has been updated. The third generation CRC program is still planned for a ten-year period, but the ten years are divided into two terms. Eight centres are granted funding for five years. When the five-year period ends the centres will be evaluated, and two of the centres will be cut from the program. The idea is to hinder centres from becoming slow starters. Out of the eight new centres, the two worst centres will be cut no matter how successful they might be. It will all come down to how they are performing relatively to the other centres. By creating the competition between the centres VINNOVA believe the centres will not waste time in the beginning of the ten-year term, but rather get going directly from the start. The new setup does not imply that the centres are immune to being shut down within the first five years. As for previous generations, the centres will be evaluated throughout the program and can be shut down within the first five years if performing badly.

7.4 Key learnings from reviewed literature

To broaden the spectrum of the international review, this subchapter highlights key learnings from two studies which examines competence centres from Austria, Belgium, Czech Republic, Germany, Estonia, Ireland, Luxembourg, The Netherlands, Norway, Sweden, and the U.S. The two reports are the TAFTIE report (Report of the TAFTIE Task Force on Competence Centre Programmes CompAct, 2016) and the prepublication of the 2017 review of the U.S. Engineering Research Center Program (ERC). Among the European competence centres reviewed in the TAFTIE report are the Catapult, COMET, and VINN Excellence centres, while the report on the ERCs solely focusses on the ERCs in the U.S. The following learnings and recommendations are meant to give inspiration and new ideas to the continuing work with the SFI centres.

Performance metrics

- Performance metrics should be based on outcomes and impacts, rather than based on outputs (ERC)
- 'Real time' follow-up on KPI in order to know whether the competence centres are on track (TAFTIE)
- There are no one-size-fits-all solution for the selection of KPI. It depends on the type of competence centre (TAFTIE)
- Three core questions to have in mind when devising KPI:

    1) 'Timeliness: Is the monitoring system delivering results when they are needed?
    2) Comparability: can the information of individual centres be compared across centres, with similar programmes, other funding mechanisms.
    3) Feasibility: what burden does a monitoring system pose on its constituents?' (TAFTIE)

- Instead of using extensive reporting requirements; use software tools to capture outcomes and minimize bureaucracy. (ERC)

Internationalization

- A clear strategy with clear objectives is needed to succeed with the internationalization of a competence centre. Adequate incentives and support structures may support successful internationalization. (TAFTIE)

Size and structure of the centres

- Allow the centres to experiment with various structural models, such as university-based centres, national laboratory-based centres, independent institutes, public-private partnerships, and industry consortia, instead of one common structural model. (ERC)

- More authority and autonomy given to the centre directors, rather than compelling the centre directors to answer to numerous boards and site visit recommendations. (ERC)
- Larger competence centres are typically organized as independent entities, and generally need more time for constitution and establishment processes. (TAFTIE)
- Most competence centres programmes are managed at the level of the national government. (TAFTIE)

8 SFI scheme limitations for public and services innovation

In this chapter of the evaluation report we ask the important question if there are limitations in the design of the SFI scheme that are inhibitory for the establishment of SFI centres targeted at the public sector and services sector?

We seek to answer the question through document studies, the international review of schemes in Austria, Sweden and the UK as well as interview with partners in the SFI centres and stakeholders around the SFI scheme.

It is important to note that this evaluation is not an assessment in any way of single SFI centres, but we have nevertheless focussed some attention on obtaining learning from the centres with experience regarding public sector innovation and commercial service innovation. The centres are:

C3 – Centre for Connected Care (SFI-III)
CSI - Center for Service Innovation (SFI-II)

On the basis of the analysis, the following challenges of service innovation and public sector innovation, which the SFI scheme does not handle, are identified:

8.1 Public sector innovation challenges

- SFI scheme is generally not targeted at public sector innovation
- Incentives are lagging and interest is low
- Financing barriers – no public resources in public sector organisations to use on innovation projects in an external centre
- Not possible to have in-kind payment from public sector partners
- Substantial obstacles in legislative systems
- Skills and attitudes of civil servants
- Old rules and routines not removed but co-exist
- Political support is often short term and varies over time
- Long term commitment is difficult to achieve
- It has to be as cheap as possible to be legitimate to society and tax payers
- Researchers are not as engaged in public innovation issues
- Public innovation is often about changes that requires organizational changes
- Public innovation requires triple-helix public-private partnership with research. It is more complicated as there are often more partners and all partners have different motives and thus incentives have to be different
- No profit motives
- Extremely dependent on security, quality, trust and certainty.
- It has to rest much on user interaction to be successful and relevant
- Metrics for assessing public sector performance have to be different from the ones used in the SFI scheme
- Many risks concerned with implementing large-scale innovations in complex and politically sensitive arenas

8.2 Services sector innovation challenges

- SFI scheme is generally not targeted at service sector innovation
- SFI-scheme is very technology and product oriented – whereas service innovation is about organisational and cultural changes, new guidelines, improved satisfaction of the user or customer, etc.
- Norwegian companies are generally very product oriented
- Service companies are very short sighted and show little interest in research-based innovation
- Service innovation projects are often short-termed
- Norway has lacked research volume and quality It is coming but is still very concentrated
- Service innovation often requires cultural and organizational change

- Successful innovation (identified in research or in one regional marketplace) may not translate well in other places where cultural norms for a positive user experience vary
- It has to rest much on user interaction to be successful and relevant
- Metrics for assessing service innovation performance have to be different from the ones used in the SFI scheme
- Organisations should be more than willing to accept risk and failures as a part of their innovation plans. Because service-based initiatives and testing often takes place in the actual marketplace where the customer experience occurs, instead of in a lab.
- Innovation is hindered by security challenges. Financial services are particularly challenged by the need to secure their applications and data, and for many this is hindering their efforts to innovate.

9 Changing conditions, challenges and future demands

9.1 Changing framework conditions

A highly relevant but also rather broad question for the evaluation concerns the impact of changes in framework conditions and in the national and international research and innovation landscape for the SFI scheme.

We have approached the question through the following steps, followed by analysis. Each step has delivered inspiration and substance to the next.

First, we have carried out desk research to identify the key trends and changes being discussed and described in academic literature, government reports and other relevant literature. Second, we arranged the first of two evaluation workshop with a broad spectrum of around 25 knowledgeable SFI-participants and other key stakeholders.

Third, we have posed the evaluation questions through a large number interviews with almost all SFI centre leaders and some of the participating companies. The answers they gave were presented to and discussed with the reference group.

This led to more nuanced and targeted questions about trend and changes regarding framework conditions which we enclosed in a survey questionnaire that went out to almost all participants in the three generations of SFI centres (almost 500 persons).

Finally, the results from the questionnaire was tested, discussed and being nuanced at a final evaluation workshop with almost the same persons participating as in the first workshop.

The questions asked through these steps are:

- What are the strongest trends, nationally and internationally, that will influence the SFI centres over the next 10 years?
- What are the biggest uncertainties in these trends?
- What are the particular strategic dilemmas facing the SFI scheme and the SFI centres?
- What changes in framework conditions in the research and innovation landscape, nationally and internationally, may affect your centre and the SFI scheme in the future?
- What conditions are important for achieving goals?
- What are the main barriers for your goal attainment?

Below we present the results of the sum of analytical activities to answer the overall question.

Great many tendencies have been mentioned as important by the participants in interviews and the workshop sessions. Below, we show the great variety of trends identified as important and certain by the participants:

- Food needs globally
- Renewable energy
- Circular economy
- Increasing short term focus
- Higher speed of change
- Disruptive systems
- Falling oil prices
- Majority of Norwegian industry not profitable
- Growing demand for new business areas to develop
- Demand for R&D in new areas with competitive advantage
- Increased need for inter-disciplinary research
- Smart transportation
- Energy mix- green shift sustainability
- Digitalisation, ICT, big data, pervasive
- Unlimited health care needs
- Changing life models
- Global talent hunting
- Increased demand for economic impact of R&D
- Spending up for defence R&D

- Less EU – more nation state
- Loss of competitive advantage
- Asia on the rise
- Personalised medicine
- Demographic changes
- Need for R&D in alternative use of oil and gas

We have tested and discussed the above identified trends through interviews and the survey questionnaire. This has led to the identification of the following five changes in external framework conditions which have been highlighted by the respondents as having the biggest impact on the future of the SFI centres and the SFI scheme.

9.1.1 Falling oil prices challenges SFI centres

The drop in oil prices has made parts of Norwegian industry unprofitable. It has also started a process of a slowly decreasing oil and gas sector. The question is how fast it will decrease. The changes challenges the SFI centres related to oil and energy as the partners in these centres find it difficult to think long term and plan ahead and therefore has difficulty committing.

9.1.2 Climate changes and renewable energy

In the last few years, climate changes are generally recognised as a fact of life and there is an increasing demand for renewable energy. This is also recognized by governments in all advanced economies, including the Norwegian government which is looking for Norwegian growth in new areas, e.g. with policies to push sales of electric cars and help avert climate change abroad. The changes also challenge Norwegian research and industry to cooperate to create Norwegian areas of strength which cam support the green shift of the economy. It should, however, be noted that RCN alreay has initiated the Scheme for Centres for Environment-friendly Energy Research (FME) with the aim to establish centres which conduct concentrated, focused and long-term research of high international calibre in order to solve specific environmental challenges.

9.1.3 Circular economy in the centre

Talks and ideas about a circular economy has moved from the grassroots and periphery to the centre of political attention. Governments in all advanced economies are now putting forward packages to support the transition to a circular economy. It is generally believed that by maintaining the value of products and materials for as long as possible, and minimising waste and resource use new innovation, growth and job creation will be realised.

This will also be an important tendency for the Norwegian SFI scheme to contain and support. The question is how research can be supported and how it can lead to investments and new business opportunities and what obstacles needs to be removed.

9.1.4 Digitalization will disrupt the economy

Digitalisation will continue to disrupt industries and sectors in the economy. All business processes are converted from “analog to digital” and the boundaries between “physical and virtual” are becoming increasingly blurred. Governments, organisations and companies are all struggling to respond. The digital economy begins and ends with the customer. Customers are more empowered, so companies need to become more customer-centric. Nowhere is that more true than in R&D. It has to be as near to real time as possible – to changing customer demands. Software development is not an add-on – it is integral to all R&D processes, which requires increasing collaboration in the supply chains in all areas. The question is how the SFI scheme can support the development of new business models in the era of strong digitalisation which will surely disrupt sectors and industries.

In the questionnaire survey, we asked the companies participating in the SFI scheme if they believed that digital technologies would disrupt their industry. 45 pct. believed that would happen to a great extent. When asked if their own product innovation would have the same effect, only 18 pct. replied

confirmatively. Also, we see that very few companies use the SFI centre to get help with commercialization.

It is similarly interesting to note that almost 40 pct. of both the research partners and industry partners in the SFI centres argue that the SFI scheme should set the agenda for the next industrial (digital and disruptive) revolution. We will return to the other changes suggested to the scheme below.

9.1.5 Recruiting the best talent is now global

A final tendency that many participant have mentioned concerns the global recruitment of talented researchers and R&D personnel to the universities, research institutes and companies connected to the SFI centres. It is mentioned as a general tendency that there is a global competition for talent and that it has become harder to attract and recruit the most talented researchers.

For the same reasons many of both the research and industry partners argue that it is important that the host institutions help to establish career tracks for the talented researchers that are attracted to the SFI centres. A more flexible exchange of R&D personnel between the research and industry partners is also seen as important. Most importantly for the future priorities of the SFI scheme, we see that international recruitment and access to personnel are one of the primary strengths of the SFI centres according to both industry and research partners. More than 40 pct. of the research partners argue that their SFI centre contribute to their internationalization to a great extent by helping to recruit foreign PhD candidates and/or master students. The same share of industry partners argue that their SFI centre contribute to their internationalization by giving improved access to competent personnel and knowledge institutions.

9.2 Changes in the research and innovation landscape

When asked about changes in the research and innovation landscape, nationally and internationally, that will impact the SFI scheme and the SFI centres, the following three changing tendencies are highlighted as the most important.

9.2.1 EU funding is not seen as attractive

There is tendency among the participants in the SFI scheme to see EU funding as different from national funding schemes, and the application processes as more complicated, burdensome and bureaucratic, and with much lower success rate. We hear the argument among the participants that they have no big incentive to apply for EU funding since the funding opportunities in Norway are so good. This might also be the reason why EU funding is given such a low priority by both industry and researchers in the SFI centres. However, this is despite the fact that shows that research shows that the researchers with the most external funding also tend to receive significant EU funding. They also tend to be the researchers with the most patents and collaboration with industry. The big question is then, how should the SFI scheme deal with this tendency and challenge which affect the centres internationalization efforts.

9.2.2 Open access challenges research

The open access movement, where research papers are made freely available online, rather than published in journals has grown rapidly in recent years. It challenges the research system because the open access journals are less established than subscription journals and many are not being tracked for impact factors. For researchers (especially young researchers), research groups and research centres that are highly dependent on publication records as they are judged on the impact factors of the journals in which they publish, this is a

real challenge. The question is how it should be dealt with in the context of the SFI scheme?

9.2.3 Defence R&D spending will increase

With the demands by the US government that the European partners in NATO should increases their contributions to two percent of GDP, participants in the workshop has also made the prediction that European countries' defence R&D will see a big rise in coming years. The questions is how this will affect the European and Norwegian research and innovation systems. The participants argue that it could have a knock-on effect on the entire research system as research funding will not increase but will have to be transferred from other areas to this new area. The question is then also, if Norway should have a SFI in the area of defence R&D?

9.3 Challenges to the SFI scheme

The challenges identified through the workshop, the interviews and the survey are reported below. Again, it should be noted that we have gone from a great variety of challenges identified by the participants to a shortlist that have received the biggest attention by the participants and are seen as most relevant by the evaluator considering the quantitative data, the results of the cluster analysis and survey of the impact factors that matters as well as the extent to which they can in fact be handled in the context of the SFI scheme.

On this basis the shortlisted challenges are:

The participating companies are not research competent and active enough in the SFI centres. This is a real challenge since the competence and active participation of companies in specific projects and in research collaboration is one of the strong driving forces for the centres ability to generate commercially oriented outputs on the basis of excellent research.

Many of the partners agree that their willingness to engage in long term partnerships increase when a share of payment to the centres is in-cash. The point is highlighted in many of the interviews. It has been acknowledged at the workshops, and in the survey, it is seen as the second most important impact factor for the SFI centres goal attainment by more than 80 pct. of the participants. However, the message is also that it is important to find the right balance between in-cash and in-kind payments for the private partners.

The level of research-industry co-publications is not as high as could be expected

It is at approximately 12 pct. as we reported in the chapter on the SFI scheme's contribution to active collaboration. Compared to other schemes evaluated in Denmark and Sweden this is below average. One could argue that it should be higher given the objective of the scheme to support research-industry collaboration. The challenge is complemented by the fact that the large bulk of publications with industry co-authorship are concentrated on a few of the participating companies.

The **participating researchers do not have sufficient innovation and market understanding**. In the opinion of the business partners researchers lack knowledge of market mechanisms and are generally not thinking or acting like innovators.

Many SFI centres are slow starters. It has been brought up again and again in the interviews that it takes a long time – up to two years for the SFI centres to get really operational, active and producing results. The reasons given for the slow starters are several, i.e. that it takes time to commit all the partners and formalise the cooperation with a consortia agreement. This is especially the case when there are international companies with a foreign head office in the consortia. It is also mentioned in several of the interviews that for some of the partners they have not really considered the kind of commitment

they had signed on to before the application went through. The challenge with slow starting centres is not unique to Norway. It is well known in the other schemes in Sweden and Austria that we have analysed.

Internationalisation has low priority in the centres. There are several indications of this challenge and it is confirmed in the interviews. The bibliometrics shows that international co-publication is below average. We also see in the survey that EU-projects and EU-funding seemingly has rather low priority. One explanation given in the workshop is that there are already enough funding possibilities and there is therefore not really an incentive for internationalisation. It is rather seen as a burden making the business of the centres more complicated and bureaucratic.

The SFI scheme reports on many innovations and commercialisations and the survey among the industry partners shows that a lot of the innovations are in fact new to industry or market. However, **only 14 pct. of the companies confirm that their innovations are due to their involvement in the SFI centres**.

Public innovation and services innovation is not sufficiently supported by SFI scheme. The interviews send the clear message that the SFI scheme should contain a number of other measures to be able to really support public sector innovation and innovation in the commercial service sector. The challenges and constraints are not the same, but one thing they have in common is the need to focus much more on the customer or user in the research and innovation processes. Also, the performance metrics for the SFI scheme should also be targeted at reporting public innovation and service innovation which is also about organisational and cultural changes, new guidelines, the improved satisfaction of the user or customer and many other conditions that are different.

Finally, it is an overall challenge for the SFI scheme to **achieve a good balance between developing excellent research and producing innovations that are really new and can change industries** and markets.

The results of the quantitative analysis suggest that the centres that are composed with a strong emphasis on excellent research are more focused on generating academic results whereas more commercially oriented centres tend to focus on commercialization based on IPR or on open innovation output performance.
One issue raised by the participants in the workshop concerns a vague formulation of the two goals of research vs innovation. The view is that the goals could be formulated more strongly to better guide the participants.

9.4 Future ambitions and suggestions for changes in the SFI scheme

During the evaluation process we have noted a great deal of ambitions and suggestions for changes in the SFI scheme. We have aimed to link these to the trends and challenges identified and described above. In figure 9.1, the results from the survey are reported on the shortlist of suggestions.

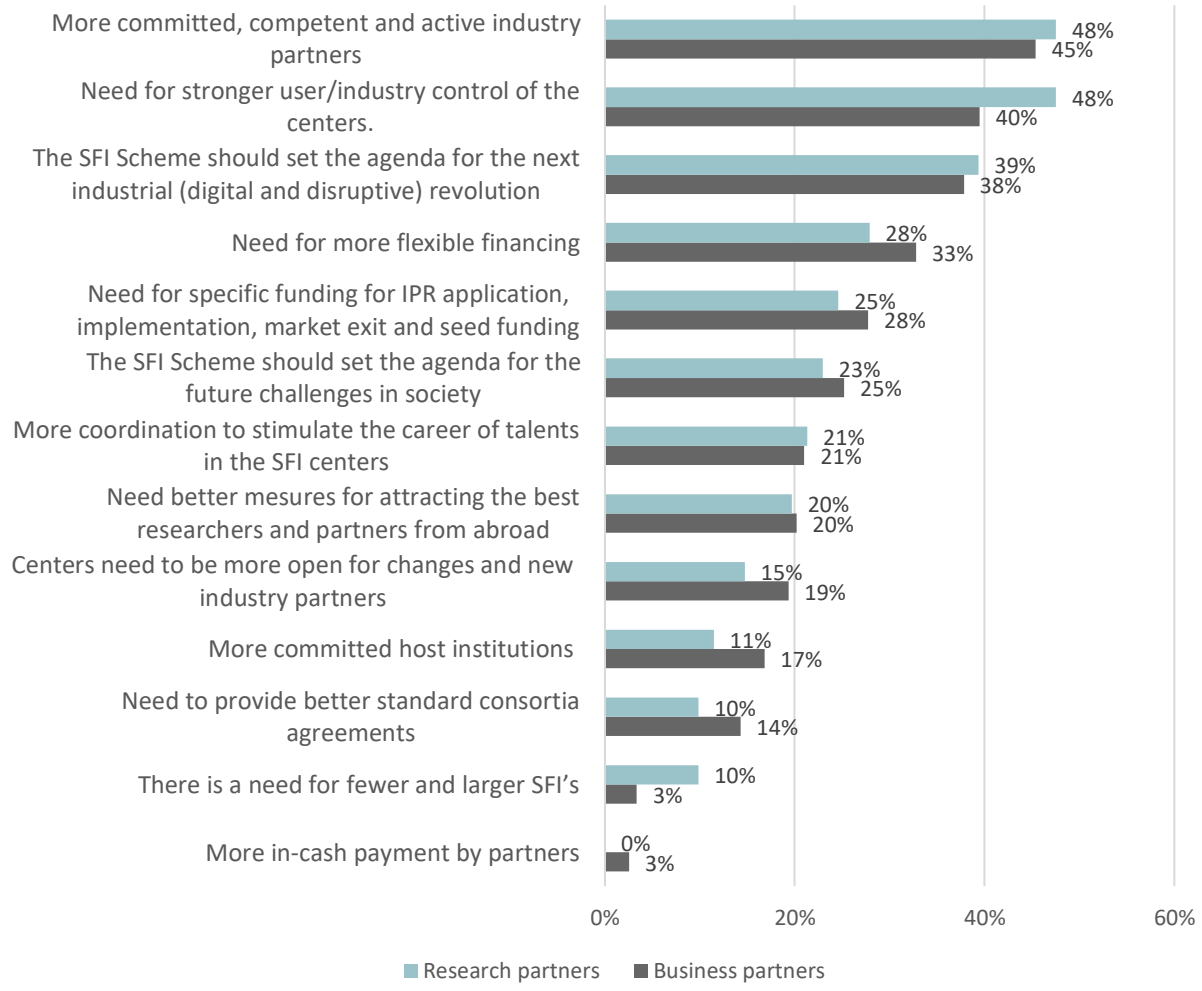
Through further discussions in the evaluation workshop and continued analysis of the challenges, the answers and the supporting quantitative data, we have arrived at the following list of ambitions and suggestions for changes that are proposed to increase the effectiveness and goal attainment of the SFI scheme.

9.4.1 Future ambitions for the SFI scheme

The following five new or stronger future ambitions for the SFI scheme are proposed on the basis of the evaluation:

- More **committed, competent and active industry partners** in the SFI centres. This will also support the ambition of stronger user/industry control of the centres.
- The SFI scheme should **set the agenda for the next industrial (digital and disruptive) revolution.**
- Participants in the centres must have a much **stronger focus on commercialising research results**.
- SFI centres need to give much **higher priority to internationalization** in all its forms – from attracting EU funding, international co-publication to recruiting researchers and students abroad.

FIGURE 9.1
What changes are needed in the SFI scheme according to the research and business partners?



Source: DAMVAD Analytics Survey for Partners in SFI centres, 2017.
Note: Question: What changes are in your opinion needed in the SFI scheme? Private partners n=119, research partners n=61

- **Public innovation and services innovation** needs to be supported more and by other measures – and its performance should be measured by other metrics.
- **SFI centres need a faster start**. The centres need to be operational from day 1. This is also about the function of the consortia agreements, the partners' commitment and how to organise an application process which will result in the best selection of SFI candidates.

9.4.2 Proposed changes in the SFI scheme

What are the measures that will help realise the proposed future ambitions for the SFI scheme? On the basis of interviews, survey results, international outlook to comparable schemes in Austria, UK and Sweden and the final workshop, we have arrived at the following proposed changes in support measures for the SFI scheme.

Start with business model and support implementation

To be able to better set the agenda for the next industrial agenda and solve future challenges in society, the SFI centres should start with business model innovation rather than business as usual. To ensure that this will happen, it should be built in as an expectation to the participants already in the application process.

To become more oriented towards commercialisation there needs to be a parallel focus on how to support implementation of research results at the level of the industry partners and further into the direct go-to-market activities of the partners. It will require special and flexible IPR support. It should be considered if the TTO's at the host institutions can have a more formalised role to help the push for more commercial results that are introduced to the market.

A stronger focus on providing support for implementation of research results, innovation and commercialisation is extremely important but it should not come at the cost of excellent and experimenting research. Research and innovation are two sides of the same coin. Therefore the goals of the SFI scheme regarding the relationship between research and innovation must be formulated very clearly hence leaving no doubt of what is expected of the centres and the partners. From the interviews and the discussions at the workshops there are seemingly some differences in the participants understandings and interpretations of the objectives of the scheme.

It should be well-known and stated clearly what the SFI scheme is not about, and how it differs from other RCN schemes, such as FORNY Scheme, SkatteFunn, FME, SFF or the BIA Scheme.

According to the objective of the SFI scheme, all research conducted by the centre, including research funded by the partners, is to be longterm in nature and is expected to provide a basis for innovation and value creation.

The SFI centres are selected on the basis of not only their scientific merit but also their potential for innovation and value creation. It is the hence the overall objective of the SFI scheme to enhance the ability of the business sector to innovate.

According to the objectives, the centres' research results and competence shall furnish a platform for innovation and value creation among user partners. User partners shall participate in the centres' governance, funding and research, and must have significant innovation activities of their own as well as the ability to take advantage of advanced research when developing their activities.

Finally, according to the objective of the SFI scheme, it is primarily the companies participating

in a centre that are expected to exploit the results of research.

However, this does not mean that the research partners and RCN are without responsibilities for implementation of research result, innovation and commercialisation. The respondents in the survey clearly confirm that the participating researchers do not have sufficient innovation and market understanding. Therefore, it should also be a future priority for the SFI scheme to encourage career researchers to think and act more like innovators. The goal is to ensure that the researchers achieve a better understanding and appreciation of market mechanisms.

Finally, what falls outside the core areas of the business can be commercialized differently, for example through research-based start-ups. The Norwegian Research Council has a role in facilitating how the SFI tool can be linked with other instruments such as the FORNY Scheme, SkatteFunn, FME, SFF or the BIA Scheme, which previous evaluations have documented as possible step stones to and from the SFI centres in the partners research and innovation processes.

Strong industrial focus in application process

The SFI scheme needs stronger industrial focus, in the sense of more committed, competent and active industry partners. This can be realised without jeopardising the objective of creating research-based innovation. There needs to be a stricter screening of the industrial partners in the application process to ensure that the industry partner is really committed and will be active as stated with their in-kind contributions. The screening should also ensure that the application is acknowledged and preferably involves both the C-level and the leading R&D personell in the participating companies.

One challenge is that only few of the industry partners conduct research themselves. This is one of the reasons that some companies are not as actively involved in the research at the centres. Rather, the innovation of many of the companies is based on experience, not research. It is important then to ensure that if the companies do not conduct research, they need to have sufficient competence to implement the research from their SFI centre. In many companies, this competence is lacking according to respondents in both the interviews, the survey and the workshops. To ensure more research competent companies in the future, it should therefore be considered whether the companies that are to participate in an SFI must document research skills or make visible measures to obtain this competence. A requirement could be that all industry partners should have at least one business PhD student attached during the period of cooperation.

The industrial focus of the SFI scheme would also benefit from requirements of in-cash payment by the participating companies. The current private funding requirement is 25 pct. (including both in-kind and cash). It should be considered if the requirement should be linked to cash contribution only. As figure 9.1 shows, it is not a popular proposed change among neither business partners or research partners. Almost none are in favour of higher cash contributions. That should be taken into consideration in moving forward with this suggestion. It will meet opposition and it will require a change in understanding among the partners. It may have to be implemented stepwise, and it is important to ensure that it will not exclude smaller companies. It should also be noted that, it is not a matter of only cash, or only in-kind, but rather the optimal share of each that has to be considered. The magnitude can be discussed, but the point is that the partners must contribute with both. The SFI scheme can look to the COMET Scheme in Austria for inspiration as to how the split for financing can be handled. Cash

contributions have the further impact that they allow the centres to do more innovation related activities.

Several partners also mention flexible financing as a way forward to allow for more industry involvement. This could be through annual fees or different types of private memberships.

Finally, it is noted that the industrial focus can also be strengthened by having a larger share of industrial PhDs connected to the centres. This will ensure more mobility and knowledge translation from industry to research and vice versa, which many of the industry partners benefit from.

It is recommended that the judging panel in RCN has interviews both with centre leaders and one of the industry partners as part of the application process. The interviews should be followed by meetings with the centres three months after funding has been granted, to ensure that the centres get a head-start and know what is expected of them.

Competition between centres and clear termination procedures

To push the centres to a faster start and to facilitate more fundamentally disruptive innovation, some elements of competition can be introduced to the SFI scheme, in two ways. First, there can be a competition process after the first 3 years where the centres are reviewed and evaluated. The top-80 pct. of the centres with the best results can then continue while the latter 20 pct. will have one year to terminate their activities. The model is inspired from a new measure recently introduced to the Swedish VINN Excellence Scheme. Furthermore, the SFI scheme can introduce a common pot that SFI centres can bid into and compete for to allow for further additional innovation activities.

Though the aims of the competition should be clear, as stated above, it is important to carefully observe that the more competitive environment does not just encourage to more incremental research and innovation at the cost of intellectual experimentation and breakthrough innovations.[9] We believe that this is not a major risk, if the goals and ambitions of the SFI scheme are clearly defined and formulated to all centres.

It is equally important that the metrics for measuring performance are broadly and clearly defined, and applied in a flexible way. We, discuss and make more detailed recommendations for the performance metrics below. However, it is important at this place to note that there might be a tension between a) service/public sector SFI centres and classical SFI centres needing very different performance measures and b) competition between centres. A judging panel will need to make an apples and oranges comparison to judge which SFI centres are doing best, as they will have to compare service/public sector and classical SFI centres.

In addition, it is recommended that RCN develops clearer procedures that can be activated when it is decided that a centre should terminate its activities before time. When many centres are supported, there will always be a centre that functions less well. If it proves too difficuelt to get this centre to perform, the difficult but necessary decision of closure has to be made. The challenge is then also how to move forward with the termination. The RCN needs clear procedures for that. Also, it needs to be formulated clearly to the centres at initiation that closure before

[9] The study by Pierre Azoulay Joshua Graff Zivin and Gustavo Manso (2008) "Incentives and Creativity: Evidence from the Academic Life Sciences" tests the hypothesis that freedom to experiment, tolerance for early failure, long time horizons to evaluate results, and detailed feedback on performance stimulate creativity and innovation in scientific research.

the eight years is a possibility if they are not performing well.

Criteria and incentives for internationalization

To make the SFI centres further prioritise internationalisation in all its forms, it is necessary to impose stricter criteria and to build in international supporting economic incentives into the SFI scheme.

The scheme should favour research that is conducted in close cooperation between Norwegian and international research communities and companies. This is best achievet if proposals for centres involves academic partners from abroad as well as international companies as partners, hence these are important criteria to apply if more internationalisation should be achieved. Applications should also be judged with an eye on the centre leaders experience with international cooperation and the centre's potential to become a key player in international cooperation, such as within the EU.

A stronger focus should be imposed on attracting EU Horizon 2020 funding. One of the challenges is here also that not only is seemingly easier for the researchers to attract Norwegian funding.

The SFI scheme has to establish more incentives to reward the centres that internationalize. Also, several new performance criteria could be introduced to support the development, e.g. number of applications and success rate of applications, SFI lead in applications, international co-authorship, international recruitment of PhDs and international market introductions, international industry partners, etc.

Improving the metrics for assessing the performance of the SFI centres?

The stronger ambitions highlighted above can be supported by a stronger annual monitoring of progress and flexible but clearer performance metrics. It concerns the above-mentioned internationalization indicators, but even more so the indicators used to measure innovation and commercialization in the SFI centres. The existing way of self-reporting on innovation and commercialisation has been accused by several participants to be imprecise and not comparable. Several other challenges have been mentioned by the participants, e.g. that: Innovations both inside and outside the scheme are registered with the same source.

A large number of suggestions for revised performance metrics have been made by participants in the evaluation workshops, which complement the ones mentioned above regarding internationalization, public innovation and service innovation, e.g. spin-outs, implemented results, successful pilots, prototypes, PhDs, industrial PhDs, Postdocs and master students over time, new business models, new innovation methods, etc.

Finally, it is important to note that the same performance metrics do not fit all. Some should for instance focus more on reporting on public sector innovation and service innovation indicators, which is more about organisational and cultural changes, new guidelines, improved user and customer satisfaction etc.

To have precise metrics is important and probably more important than most stakeholders acknowledge. It is important because it is used as a guide for both participants and in evaluations. A very relevant example is here how to measure research and innovation to be able to balance the two and to support the goal attainment of the SFI centres. We need to know and the participants need to acknowledge what research topics they think can be refined to create innovations within a fairly short period of time (e.g. in the next 5 years) and what research topics can be expanded within 10 years. Measuring and valuing both in the same way is not

relevant because basic or fundamental research will not create innovation results in the near future. For the centres with fundamental research, it then also has the implications that they need to be more careful ensuring that the industrial partners can anchor it to make it valuable.

How better to support public innovation and service innovation

Public innovation and services innovation needs to be supported better and by other measures than exists today in the SFI scheme. This is generally acknowledged as important by all the respondents in the interviews and surveys. The analysis process has contributed with some ideas about what to do differently in the attempt to better support public innovation.

Public innovation

First of all, there needs to be an incentive for public sector organisations to identify and engage in the processes and structures that can support and accelerate innovation.

Then there is the challenge of attracting public financing to establish research based innovation centres. This is a challenge due the budgetary constraining rules for most public sector organisations. In the VINN Excellence Scheme in Sweden this challenge has been attempted solved by allowing the public sector to contribute with in-kind financing.

For public sector innovation to succeed it has more than other areas to be based on a platform of security, quality, trust and certainty. It also has to rest on user interaction. Finally, public sector innovation also requires triple helix with both public and private partnership with research. This makes it more complicated as you combine actors that are driven by different interests and need different incentives.

Service innovation

The challenges mentioned in the interviews when it comes to supporting service innovation through the SFI scheme concerns that the service companies are more short-sighted and less interested in research-based innovation. Also there is no tradition for research, hence the volume and quality has been low. It is slowly changing but the research environment is still rather concentrated. The participants understand the SFI scheme as very technology and product oriented in contrast to the service sector, which is targeted more at new guidelines, culture, organisational changes, users and employees. Also, as mentioned the current performance metrics do not report on service innovation.

The participants in the workshop and interviews suggest several ways forward, including:

h) More flexible start with a test period for the partners before they commit long term.
i) More focus on the translation of research to innovations
j) More flexible centres which are allowed to change centre focus and research areas
k) Use the centre to build the capacity needed
l) More focus on business models and integrated supply chains.
m) The following sectors are mentioned as mature service innovation areas: Financial sector, logistics, retail, tourism and media.
n) Following subject areas are mentioned as highly relevant in connection to service innovation: Digitalization/ big data, business models, employee vs robots, online shopping and block chain.

FIGURE 9.2
An overview of future ambitions and suggested changes in support measures for the SFI scheme

Support measures / **Ambitions**	Start with business model and support implementation	Strong industrial focus in application process	Competition between centres and clear termination procedures	Criteria and incentives for internationalisation	Improving metrics for assessing the performance of SFI centres?	Specific measures supporting public and service innovation
Committed, competent and active industry partners		X			X	
Setting the agenda for the next industrial disruptive revolution	X		X		X	
Stronger focus on commercialising research results	X	X			X	
Higher priority to internationalization				X	X	
Support to public innovation and services innovation	X				X	X
SFI centres need a faster start			X			

Source: DAMVAD Analytics 2017.

Appendix I Methodology

In the following, we describe in more detail the various methods applied in the evaluation.

Survey questionnaire

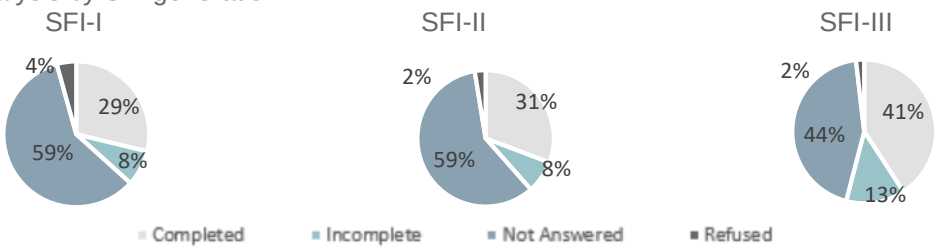
We have conducted a survey in the attempt to investigate the characteristics and quality of the output as well as goal attainment in the centres and changing conditions, challenges and future demands for the SFI scheme.

The survey was conducted in the programme Enalyzer and it was launched to partners within the individual SFI centres where contact information was available. In total the survey was launched to 491 partners in the period 18-09-2017 to 05-10-2017. Within this period 3 reminders were sent to secure a high response rate. Given the relatively high response rate at 36 pct. completed responses and 11 pct. incomplete responses the results presented in the analysis is regarded as representative for the whole population.

The analysis is based on 176 completed replies (36 pct.). 53 (11 pct.) incomplete replies, 249 (51 pct.) not answered and 13 (2 pct.) refused replies. The overall response analysis grouped by SFI generation is showed in the figure below.

Further we have 225 respondents who have answered the question: "*What type of institution is your main occupation?"* 152 (68 pct.) have answered *"Private sector"* where 118 have completed the survey. This category is in the report being referred to as private partners. 73 (32 pct.) have answered that their main occupation is within either a university, research institute, hospital trust, or public organisation. This category is in the report being referred to as research partners

Response analysis by SFI generation



Source: Conducted survey responded by centre partners

When splitting on whether the respondents have answered that they have commercialized or not the split was made on behalf of the question: *"Do you expect to commercialize and go to market with your innovation?"*. In this split we have 194 replies. 98 complete and 6 incomplete (54 pct.) responses from the partners who have answered that they expect to commercialize (corresponding to the answers: *"Yes, we expect to commercialise our discoveries within the next 2 years"* or *"Yes, we expect to commercialise our discoveries within the next 5 years")*. We have 27 complete and 6 incomplete responses (17 pct.) from the partners who have answered that they do not expect to commercialize (corresponding to the answers: *"None of our innovation results have reached a commerciable state or are expected to do so").* Lastly, 57 answers that they don't know. (29 pct.)

Document studies

This methodological element involves collecting and analysing relevant available literature given by the SFI scheme and other relevant written sources.

The purpose of this source of data has primarily been to ensure that the evaluation of the SFI scheme builds on all knowledge available in previous analyses and evaluations. Furthermore, the review of previous literature has aimed to collect relevant information that can contribute to building a knowledge base for the evaluation, including information on, e.g. the intention of the SFI scheme, goals and organization. Lastly, this element seeks to collect knowledge about existing quality indicators and effects of the SFI scheme illustrated in previous reports relevant to the evaluation.

Review of international comparable research and innovation centers

To put the SFI centres in an international perspective, we provide context through examination of three comparable schemes for research driven innovation based on public-private partnership. The three schemes presented are Catapult (U.K.), COMET (Austria) and VINN Excellence (Sweden). Each scheme is presented separately and focuses on the schemes' purposes, how they have handled challenges, and key learnings. The reviews examine the history and objective of the program, placement of initiative in the national research and innovation agenda, structure and financing model, output and impact, challenges and how they are handled, public sector and services sector relevance, and perspective and learning from the initiative.

The purpose of the international review is to give inspiration to possible future governance changes, to provide insight into the constraints of the design of different schemes, to provide insight into changes in the framework conditions and how countries have adapted as well as changed their schemes

The reviews were conducted based on document studies from evaluations of the aforementioned schemes and qualitative interviews with key individuals related to the individual schemes.

Qualitative interviews

A large number of interviews have been conducted with key persons affiliated with the SFI centers. This involves project participants, involved research institutions (universities, health institutions, research

institutes), as well as companies. In addition, interviews have been conducted with key stakeholders with knowledge and insight on the research and innovation policy agenda.

The interview element plays a central role in the evaluation, and as such contributes to the majority of the evaluation questions in the review. The interviews help provide a holistic understanding of the key aspects of the scheme, while also answering questions raised by the Research Council of Norway. Furthermore, interview responses help to test and validate results that are found through other sources.

Collection of company information about participating companies from *Brønnøysundregistrene*.
The Brønnøysund Register Centre has provided detailed information about participating companies containing data about number of employees, revenue, industry, organization type and geographical location. The information about organization type of a given company is key to identifying business partners, which are defined as private limited companies throughout the report.

Workshops
Two workshops have been held throughout the process. The first workshop took place the 14th of June in Oslo, hosted by The Norwegian Research Council. The workshop was planned and facilitated by leading staff from the Evaluation Team consisting of DAMVAD Analytics, Rand Europe and University of Cambridge (CSaP). A total of 26 participants from companies, policy institutions, SFI centres, foundations in Sweden and Denmark as well as the Research Council of Norway offered their insight in the workshop.

The purpose of the workshop was to get the participants views on the key factors affecting the development of the SFI centres and the key aspects of performance for further examination. In addition, the workshop provided suggestions as to how the SFI scheme and the strategies of the centres could be improved to better meet the challenges of the future. This workshop allowed the evaluation team to focus in on key elements for further examination.

The second workshop took place on 23rd of November 2017 in Oslo. It was again hosted by The Norwegian Research Council. 20 participants from companies, policy institutions, SFI centres, a foundation in Sweden as well as the Research Council of Norway offered their insight in the workshop.

The purpose of the workshop was to get the participants views and comments on the tentative key results and recommendations for the SFI scheme. In addition, the workshop provided suggestions as to how to increase goal attainment for centres across the SFI scheme within four specific sectors: public sector, emerging sector, commercial service sector and established research and industry sectors, with a focus on how to continue to disrupt the industry. The insights from the workshop provided numerous perspectives on the key results that have been included in the final report in regards to recommendations to the future of the SFI Programme.

Bibliometric analysis

The bibliometric analysis is intended to assess the quality of the scientific output of the SFI centres. The main source to publication data is interim reports and annual reports from the SFI centres. From these publications, we were able to identify a total of 3.557 (93 pct.) peer reviewed publications (counting books, book chapters and journal articles) in Scopus.

The scientific output from the SFI centres are measured along the following dimension:

Research volume and focus measuring the number of publications per SFI centre and generation as well as the research fields. The research focus of SFI and the individual centres are identified by utilizing that Scopus classifies each journal and its publication at two levels. The most aggregated level being the subject areas (overall research fields) and at the most disaggregated level the subject terms (individual research topics). The subject areas classification scheme assigns the publications to at least one of 27 overarching research fields like medicine, engineering or computer science. For each of the subject areas Scopus has subdivided the research within e.g. computer science (the subject area) into the second level of classification, subject terms, being e.g. Artificial Intelligence or Software. As most journals covers more than one research field, Scopus can assign up to five different subject terms per journal. For the simplicity of the evaluation we report at the level of subject areas solely.

National, International and Industry co-publication: By examining the organisational affiliations of authors to publications affiliated with the SFI centres, we investigate the degree to which other Norwegian organisations, in the university and university college sector, as well as the research institute sector and industry, collaborate on concrete, joint research tasks as reflected in joint publications. By classifying the organisational affiliations to be either national or international we identify which articles have been published in collaboration with international research institutions or companies. Based on this information, we calculate an indicator for the degree of international collaboration.

Scientific impact refers to the impact of an article on the scientific community. In the current analysis, impact is measured by a single indicator, derived from the number of citations for publications authored by researchers affiliated with the SFI centres. More precisely, we estimate impact based on the Field normalized mean citation Score.

The Field normalized mean citation Score used in the analysis is state-of-the-art when it comes to citation analysis. The indicator considers differences in publication patterns for different scientific fields, publication types, and publication year. Finally, as an extra precaution to avoid overestimating the citation counts, we exclude self-citations, i.e. authors citing their own work. The calculation of the normalized mean citation score is based on the period from 2007 to 2016, and is performed only for volumes of publications that exceed 50 in the said period for a given SFI generation or research field. Finally, we calculate the normalized mean citation score relative to two different benchmarks: the Nordic countries, and the EU28.

Clustering approach

In the quantitative attempt to characterise SFI centres across generations we aimed at dividing them into segments. Within each segment SFI centres should be alike across generations. Our approach was "people like me" or better known as clustering. The attempt with the clustering was to establish easily communicable arch types.

Unsupervised learning
When one wants to learn from *un*labelled data she turns to *un*supervised learning opposed to supervised learning which deals with labelled data. Labels could be the gender of persons or in this context the structure of the SFI centres. In the sense of innovational and structural labels, these did not exist on beforehand, thus this project deals with unlabelled data.

Cluster analysis
When dealing with the task of searching data for a structure of "natural" groupings, one turn to the algorithms of unsupervised learning called cluster analysis. Among the algorithms one will find hierarchical clustering, mixture models and k-means. For the clustering of SFI centres, k-means was chosen, and this section will briefly review the theory behind the algorithm.

Cluster analysis is a "primitive" technique in that sense, that no assumptions are made concerning the number of groups or the group structure on beforehand. It all depends of the specific case and data available. When doing clustering, the algorithm requires a measure of similarity between pairs of observations and that similarity measure is often chosen to be the (Euclidean) distance.

For the formation of the innovation clusters 17 features were used, and 14 features for the structural clusters. The features for the innovation clusters include; Publications in anthologies; publications in periodicals and series; publications in monographs; User-oriented dissemination measures - reports, notes, articles, lectures at meetings/conferences; Mass media dissemination (newspapers, radio, TV etc.); Public Dissemination Scientific publications (articles / books etc.); R&D results - Completed new/improved methods/models/prototypes; Companies in the project that have introduced new/improved work processes/business models; Companies that have introduced new/improved methods/technology; Companies outside the project that have introduced new/improved methods/models/technology; Commercial results with project contributions - Completed new/improved products; Commercial results with project contributions - Completed new/improved processes; Commercial results with project contributions - Completed new/improved services; license contracts (ex. software licenses); Number of patents applied for; New companies as a result of the project and New business areas in existing companies as a result of the project

The features for the structural clusters include; Average number of business partners and research partners; Average number of PhDs, post.doc and project managers; Average number of counties and sectors partners are located in as well as financing variables in both in-kind and cash from host, RCN, research- and business partners respectively.

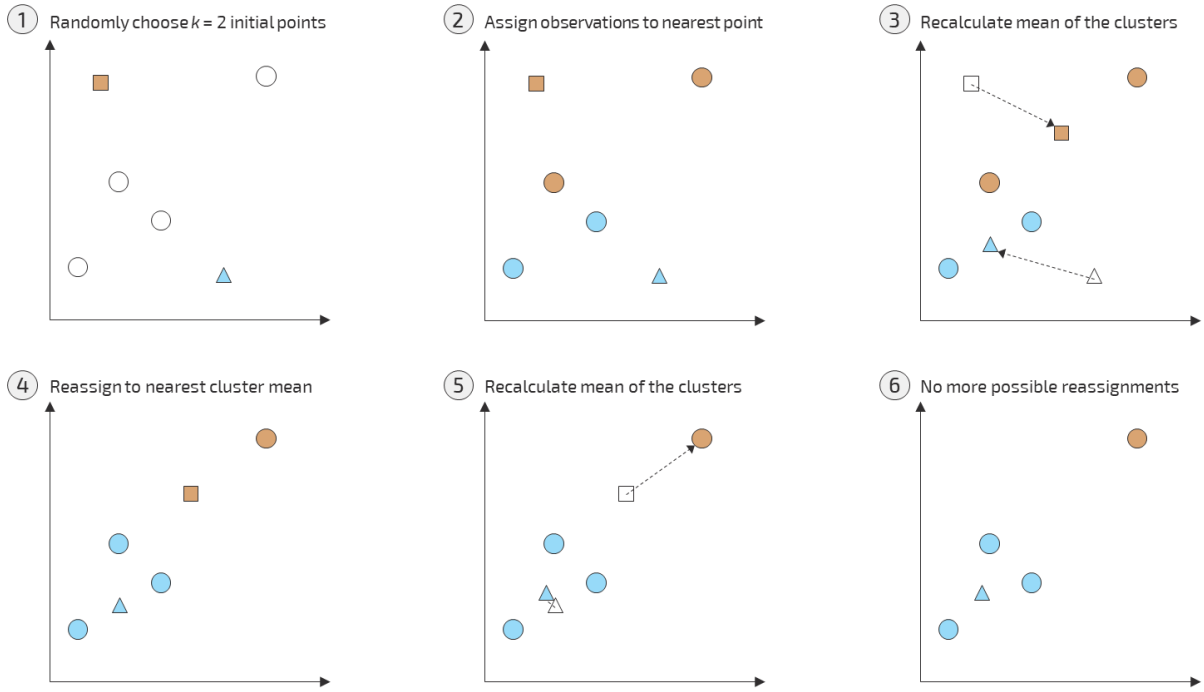
This correspond to a #17- and #14-dimensional coordinate system, respectively. One can imagine, that every SFI centre is plotted into the coordinate system and the similarity between the SFI centres are measured taken *all* of the #17 and #14 features into account, respectively.

k-means

k-means are designed to group observations into a collection of *k* clusters. The number of clusters (*k*) is not known a priori but must be determined as part of the clustering process. The way one decides the number of clusters (*k*), is to perform several initial cluster analyses for various number of clusters and determine the trade-off between less within-clusters-variation and number of clusters. Often one choses between one cluster (all the SFI centres in the same cluster) and up to #38 clusters (every SFI centre is its own cluster).

When the number of clusters (*k*) has been decided the algorithm is:

1. Randomly choose *k* initial points in the coordinate system (these are potentially empty clusters, but definitional a cluster none the less).
2. For each observation, assign the observation to the cluster whose mean is the nearest.
3. Recalculate the mean of the clusters.
4. Repeat step 2 and 3 until no more reassignments take place.



Outcome

In the project we performed two cluster analyses. One with focus on innovational features and another one with structural focus. For both analyses the optimal number of clusters was four. That way we were able to segment the SFI centres into different innovation and structural types across SFI generations.

Appendix II International reviews

Below we present the detailed results of the three international reviews of comparable schemes in UK (Catapult), Austria (COMET) and Sweden (VINN Excellence)

Catapult (United Kingdom)

History and objective of the programme

In 2010, physicist and entrepreneur Hermann Hauser published the report 'The Current and Future Role of Technology and Innovation Centres in the UK' (Hauser 2010), which was commissioned by the UK government. The report, commonly called the 'Hauser Report', suggested that the UK should learn from other countries' innovation networks and outlined a plan on how the country could establish its own technology and innovation centres (UK Parliament 2011). Initially, the UK's innovation centre programme was supposed to follow Germany's model of Fraunhofer institutes. In the same year, the Government decided to spend over £200 million over four years to establish six innovation centres, and commissioned the Technology Strategy Board (TSB, now called Innovate UK), UK's national innovation agency, to develop a strategy and implementation plan for the new centres (Hepburn & Wolfe 2014, 11). The innovation centre programme corresponded to the UK government's general aim to support business innovation and growth, and it is strongly related to the main objectives of TSB's strategic plan 'Concept to Commercialisation' for the period between 2011 and 2015.

The programme opened the first seven so-called Catapults between 2011 and 2013, with the High Value Manufacturing Catapult being the first one (High Value Manufacturing Catapult 2012, 1). From 2015 to 2016, three further Catapults followed, and the newest Catapult (Compound Semiconductor Application Catapult) shall open soon. In June 2017, Innovate UK published its decision to merge the Precision Medicine Catapult into the Medicines Discovery Catapult, which opened in 2015 and 2016 (Innovate UK 2017). According to an interviewee we consulted for this case study, this decision was based on the finding that the sectors of the two Catapults strongly overlap.

As of August 2017, most of the Catapults and their centres are located in England; the Offshore Renewable Energy Catapult has two locations in Scotland, Northern Ireland hosts a regional Digital Catapult centre, and the Compound Semiconductor Applications Catapult will open in South Wales. Table 1 provides an overview of the current ten Catapults, their sectors, and locations.

Table 1: Overview of Catapults

Catapult	Sector	Location(s)	Launch date
High Value Manufacturing Catapult	High value manufacturing, creation of products, production processes and services	• Strathclyde, Scotland (AFRC) • Wilton, North East England (CPI) • Rotherham, Yorkshire and the Humber (AMRC, NAMRC) • Coventry, West Midlands (WMG) • Ansty, West Midlands (MTC) • Bristol, South West England (NCC)	2011

Cell and Gene Therapy Catapult	Development and improvement of cell and gene therapy	• London • Stevenage, East of England	2012
Offshore Renewable Catapult	Offshore renewable energy (knowledge areas: blades, drive trains, electrical infrastructure, operations & maintenance, wave & tidal, foundations & substructures)	• Glasgow, Scotland • Levenmouth, Scotland • Blyth, North East England	2012
Digital Catapult	Development of practical application of digital innovation and culture	• London Regional centres: • North East & Tees Valley, North East England • Belfast, Northern Ireland • Bradford, Yorkshire and the Humber • Brighton, South East England	2013
Future Cities Catapult	Advancement of urban innovation	• London	2013
Satellite Applications Catapult	Satellite technologies, space sector	• Harwell, South East England Regional centres: • North East England • Scotland • South West • South Coast • East Midlands	2013
Transport Systems Catapult	Development of intelligent and integrated transport systems, smart and connected transport	• Milton Keynes, South East England	2013
Energy Systems Catapult	Transformation of global energy systems; electricity, heat and combustible gases	• Birmingham, West Midlands	2015
Precision Medicine Catapult[10]	*Development, delivery and commercialisation of precision medicine*	• *Cambridge, East of England*	*2015*
Medicines Discovery Catapult	Support of and enabling commercial drug discovery	• Alderley Edge, North West England	2016
Compound Semiconductor Application Catapult	Development of compound semiconductor materials, typologies and devices	• Cardiff, South Wales	tbc

Sources: Catapult (2016), Catapult Network (2017) and individual Catapults' websites

[10] The Precision Medicine Catapult will be merged with the Medicines Discovery Catapult in 2017 (Innovate UK 2017).

While focusing on a wide range of sectors, the main objectives of all the Catapults are to 'bridge the gap between academia and industry, research and commerce, providing a trusted, neutral space where new ideas can thrive and find their way to market' (Catapult Network 2017, 11). In addition, Catapults should connect small and medium sized firms (SMEs) with large leaders in their respective sector, support the growth of the sectors in general, and advance the UK's economy through turning innovation into economic value (Catapult Network 2017, 16–19, 26).

Placement of initiative in the national research and innovation agenda

In 2011, the Technology Strategy Board assumed that Catapult Centres would become an essential element in the country's innovation landscape (Technology Strategy Board 2011, 9). This objective was further stressed in the UK's National Innovation Plans of 2011 and of 2014 (Department for Business, Innovation & Skills 2011, 2014). In the 2011 plan, the UK Government described the Catapults as an 'elite national network of technology and innovation centres (…) [which] will provide comprehensive access to specialist capability and expertise, to transform innovative ideas and technologies rapidly into valuable products, processes and systems' (Department for Business, Innovation & Skills 2011, 26). In 2010, the UK government promised to spend over £200 million between 2011 and 2015 on the Catapults (Department for Business, Innovation & Skills 2011, 30).

The UK's most recent innovation plan of 2014 also highlighted the importance of the Catapult programme, naming it one of the major achievements of the government. The document also announced the introduction of new Catapults in addition to the seven initial ones, and promised to continue to intensively invest in the Catapult Network (Department for Business, Innovation & Skills 2014, 8, 52, 57–8).

As of August 2017, the UK's newest innovation plan is still under development. A green paper published by the UK government in January 2017 indicates that – similar to the previous plans – the Catapults will continue to play an essential role in the new strategy (HM Government 2017, 121). This indication was confirmed by several of our interviewees. In addition, the new innovation strategy seems to have strong focus on industry in general, as it is branded as an 'industrial strategy'.

Structure and financing model

Commissioned by the UK government in 2010, Innovate UK is responsible for establishing Catapults and the provision of their public funding. In general, each Catapult is supposed to centre on a specific technology area, and to provide equipment and knowledge to firms, which should enable them to advance their own research and development activities (Danby 2016, 7). Catapults are created based on five main criteria questions:

- Are the potential global markets which could be accessed through the centre predicted to be worth billions of pounds per annum?
- Does the UK have world-leading research capability in the area?
- Does UK business have the ability to exploit the technology and make use of increased investment to capture a significant share of the value chain and embed the activity in the UK?

- Can a proposed centre in this area enable the UK to attract and anchor the knowledge-intensive activities of globally mobile companies and secure sustainable wealth creation for the UK?
- Is a proposed centre closely aligned with, and essential to achieve, national strategic priorities?' (Technology Strategy Board 2011, 10)

The legal form of Catapults is a 'company ltd by guarantee' (CLG), and they are thus separate legal entities from Innovate UK, which are managed by their own boards and executive management (Catapult n.d.-a). Catapults are further not-for-profit, independent as well as physical centres, which 'operate in the middle levels of technology readiness and provide services that address market failures, enable capital investment by firms, and are meant to pay off over longer timescales. Each centre offers a space with the facilities and expertise to enable businesses and researchers to collaboratively solve problems and develop products on a commercial scale' (Kroll 2016, 13).

Catapults are funded for a period of five years; after this period, a formal evaluation will take place which assesses the Catapults against their set objectives and aims, and provides improvement recommendations. As part of this evaluation, Catapults will also present their strategic plan for the next five years and based on this plan, Innovate UK will decide on the required public funding for the upcoming five-year period.
Catapults are funded through three sources (throughout the lifetime of a Catapult, the share of the three sources may vary, though ideally they are equal):

- One third from business-funded R&D contracts (won competitively),
- One third from collaborative applied R&D projects (won competitively, provided jointly by the public and private sector), and
- One third from core public funding.

The core public funding provided by the UK government should ensure a 'long-term investment in infrastructure, expertise and skills development' (Catapult, n.d.-a). It should thus cover procurements such as large devices, technologies, and other equipment; operational costs of the centres; as well as Catapults' human resources. In addition, it should support the creation of links between industry and academia. In 2011, the annual amount of core public funding should be £5–10 million (Technology Strategy Board 2011, 11); in 2014, Innovate UK's average investment in a Catapult was £10 million per year (Kroll 2016, 14).

Output and impact

As the Catapult network only started recently, both literature reviewed as well as interviewees consulted for this case study suggested that it would be too early to identify the impact of the Catapults. However, some interviewees referred to some early indications that Catapults would have an impact on economic growth. In a review of the Catapult network in 2014, Hermann Hauser also noted that impacts would not be visible yet. However, he suggested that there is early evidence that the Catapults do perform well, and already have or are likely to have an impact. For example, some Catapults would 'have made significant investments; attracted and recruited high quality staff that provide in-house expertise to business; and engaged extensively in R&D activities with academia and business' (Hauser 2014, 24). In addition, public-private collaborations enabled through the Catapult network would have led to the creation of new jobs and

the number of international industry partners working with Catapults could be seen as an indicator for the programme's success (Hughes 2015, vii).

In 2017, a two-part formal evaluation of the seven initial Catapults started. The first part of the evaluation, which took place in the first half of 2017, included self-reporting of the Catapults on their work during the past five years as well as the provision of a strategy, aims and financial requirements for the next five years. The reporting on the previous five years and the forward outlook for the next five years was assessed by a panel of independent national and international experts coming from both academia and business. Panel members further made two-day onsite visits at the Catapults, where they spoke with staff, customers and key stakeholders (e.g. interviews, round tables), and received presentations on the work and future aims of the Catapults.

The reviewers will develop recommendations based on their evaluation work, which will be used by Innovate UK to decide on the future funding and plans of the Catapults. As of August 2017, the reports of this evaluation were not yet finalised, and our interviewees assumed that they would not be publicly available. However, interviewees indicated that the assessments were overall positive.
The second part of Innovate UK's evaluation of the Catapult network is an economic impact analysis, which on the one hand will assess the work of the Catapults in the previous five years, as well as track their impact until 2020.

Innovate UK also continuously monitors Key Performance Indicators (KPIs) of each Catapult. KPIs are identified by the Catapults and agreed on with Innovate UK. They can include indicators such as GBP value acquired, capital expenditure, number of private sector industrial clients, number of projects with private sector clients, etc. (Warwick Economics & Development 2015, 10).
In a recent report (Catapult Network 2017, 9–10), the Catapult network published numbers on the Catapults' output, which include (2015–2016 data):

- Operation of £850 million of world class facilities;
- 636 academic collaborations;
- 2,473 industry collaborations;
- Support of 2,851 SMEs;
- Work in 24 countries;
- Training of 900 apprentices in one year;
- Engagement with 4,700 fast growing technology businesses in one year; and
- Support of £1 billion valuation of VR companies.

Challenges and how they are handled

The literature reviewed for this case study did not refer to any significant challenges Catapults have to face. Interviewees consulted for this case study raised both sector-specific as well as Catapult/innovation centre-related challenges. One of those general challenges – which does not seem to be specific to the Catapult programme – is ensuring that the split between different funding sources of the financing model stays in

balance. It was also pointed out that it would be challenging to demonstrate impact, and related to that, to constantly adapt to changes in the specific sector. While our interviewees stated that in general there is a good balance between industry and academia at the Catapults, some stressed that keeping this balance is difficult in some cases. For example, an interviewee noted that while Catapults already helped reducing the gap between industry and academia, it is sometimes difficult to keep interests of both sides aligned. According to our interviewees, two elements would be crucial to keep the risks of the mentioned challenges low. First, clear strategies and business plans would be crucial, and second, close communication both at Catapult level and with Innovate UK are necessary.

A final – UK-specific – challenge that will become relevant in the near future is related to the UK's withdrawal from the European Union. As collaborative applied R&D projects, which constitute a third of the Catapults' funding, are often EU funded (e.g. Horizon 2020), the outcomes of the withdrawal negotiations might have an impact on the Catapults' current financing model.

Public sector and services sector relevance

In his 2014 review of the Catapult network, Hauser stated that Catapults are relevant to the public sector as they would support the achievement of key policy objectives. For example, they contribute to the renewable energy sector, help improve transport systems or facilitate the use of satellite data for a wide range of purposes (e.g. climate events prediction or for national security) (Hauser 2014, 20). In addition, according to our interviewees, Catapults indirectly serve the public sector as they support a better use of resources and would make the UK's industry more productive, efficient and innovative, and consequently also more competitive. When it comes to the services sector, all of our interviewees felt that Catapults would only be marginally or indirectly relevant, because Catapults' foci would not be on providing services; an exception would be the Digital Catapult and the Future Cities, which would sometimes indirectly add to this sector.

Perspectives and learning from the initiative

Although the Catapult programme only started a few years ago, and it might be too early to outline clear impacts of the Catapults or 'lessons learned', several strengths of the programme can already be identified at this stage. In general – and this is not specific to the Catapult programme – the importance of research-based innovation centres was stressed in all of our interviews, as they would not only foster collaboration between science and industry, but such collaborations would also help to prevent market failures and contribute to a country's economic growth. Interviewees also emphasised that in general, they assume that economic impacts of collaborations would be significantly higher than that of the work of a single company. It was also highlighted in our interviewees that Catapults might become even more important as drivers of economic growth after the UK's withdrawal from the European Union.

All of our interviewees emphasised that the funding model of the Catapults are a particular strength of the programme. The three-way funding model (see section 0) ensures a balance between science and industry, strengthens public-private collaborations, and enables the Catapults to operate at a high level (including attracting good people, providing state-of-the-art facilities and equipment, etc.). Interviewees noted that keeping the three-way balance would be important for several reasons:

- First, the public funding ensures that Catapults can work with excellent facilities and world-class staff with relevant expertise;
- Second, public funding allows the Catapults to be neutral and more independent from commercial and R&D income;
- Third, the winning of collaborative applied R&D projects would support collaborations between research organisations and industry partners throughout the proposal and project processes;
- Fourth, business-funded R&D contracts would contribute to the Catapults' relevance to businesses; and
- Finally, projects of large scale would only be possible in larger collaborations and when sufficient funding is available.

A further strength of the Catapults is their legal form as 'companies limited by guarantee' (CLGs), and that they are independent in a sense that they are neither part of a governmental body, research organisation, nor a company. In addition, our interviewees noted that Catapults benefit from being not-for-profit and physical centres. In particular the latter point allows industry and scientific partners to interact at one (neutral) place and build relationships, and to make use of provided infrastructure and expertise. The legal form also ensures that Catapults are not holders of intellectual property produced in the context of their projects, but that the intellectual property would stay with the involved research organisations and companies. The Catapult programme provides a general framework on intellectual property rights (IPR) on their website. IPR arrangements differ from project to project and they also depend on the source of funding (i.e. public funding, collaborative applied R&D projects, and business-funded R&D contracts). In the case of publicly funded work, Catapults should ensure that IPR are made 'available to business appropriate licensing, spin out or other arrangements' (Catapult n.d.-b). For collaborative applied R&D projects, existing regimes for publicly funded collaborative research should be used. In the case of business-funded R&D contracts, IPR rights should be determined by contracts (Catapult n.d.-b).

Interviewees also emphasised that clear selection criteria for establishing new research-based innovation centres will be an important success factor going forward. In particular, they thought that the presence of a potential market as well as existing world-leading research and industry capabilities in the respective area would be essential (see Catapult criteria questions 1, 2 and 3 in section 0).

While the Catapult programme only started in the early 2010s, interviewees referred to a high international interest in the Catapult model and regular requests for onsite visits and insights into how the model works. According to two interviewees, this international interest could be anecdotal evidence that the programme performs well.

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- Representative of Innovate UK: Interview on 3 August 2017
- Representative of the Digital Catapult: Interview on 21 July 2017
- Representative of the High Value Manufacturing Catapult: Interview on 2 August 2017
- Representative of the Cell and Gene Therapy Catapult: Interview on 16 August 2017

COMET – Competence Centres for Intelligent Technologies (Austria)

History and objective of the programme

The Austrian research-based innovation centres programme *Competence Centres for Intelligent Technologies* (COMET) was founded in 2006 and is the successor of two programmes, *Kplus* (funded by the Austrian Federal Ministry for Research and Transport; today: Austrian Federal Ministry for Transport, Innovation and Technology) and *K_ind/K_net* (funded by the Austrian Federal Ministry of Economy), which were both introduced in 1998. *Kplus* and *K_ind/K_net* were founded as a response to perceived weak science-industry cooperations in Austria in the 1990s.

Based on an assessment of the two programmes, in 2006, COMET was introduced as a 'further development', which would not only merge the two parallel running programmes, but also integrate new elements. While the objective to strengthen science-industry cooperations continued, COMET also has an 'ambitious orientation towards excellence, the integration of international research know-how and developing and safeguarding the technology leadership of companies to strengthen Austria's position as a location for research' (Stahlecker et al. 2015, 34). As of today, the main objectives of the COMET programme are:

- Developing and focussing competences through long-term research cooperation between science and industry at the highest level;
- Strengthening Austria as a business location […];
- Strengthening Austria as a research location […];
- Strengthening the competitiveness in both science and industry by driving internationalisation […]; [and]
- Establishing and developing human resources' (BMVIT et al. 2016, 4).

Placement of initiative in the national research and innovation agenda

Public research funding in Austria is primarily organised by two main funding bodies, the Austrian Science Fund (Der Wissenschaftsfonds, FWF) and the Austrian Research Promotion Agency (Österreichische Forschungsförderungsgesellschaft, FFG). An additional third pillar for public research funding, the Austria Wirtschaftsservice Gesellschaft (AWS), only plays a minor role compared to the FWF and the FFG. While the FWF manages funding for basic research and AWS for enterprise-related funding, the FFG is in charge of funding for applied and industry-related research, and among them the COMET programme. FFG's most recent annual report shows that COMET received 10.24% of all of FFG's funding in 2016 (overall funding provided by the FFG: € 453,886,959; COMET: € 46,465,820). The average funding for a COMET Centre or Project is significantly higher than the average funding for any other project or programme line managed by the FFG, although only 1.01 per cent of all FFG projects are COMET Centres or Projects (FFG 2016a, 11).

According to Austria's most recent RTI Strategy (2011), programmes supporting public-private collaborations such as COMET are particularly important for Austria's innovation landscape. The strategy also emphasises the Federal Government's support for the programme's further development (Republic Österreich

2011, 29). While Austria has other programmes and initiatives supporting industry-science cooperation (Christian Doppler Research Association and its laboratories (CDG)), Ludwig Boltzmann Gesellschaft (LBG) and the institutes of the Austrian Cooperative Research (ACR)), COMET is considered unique because it focuses on collaborations of multiple partners. By contrast, other initiatives often have bilateral partnerships and are less flexible, as some of our interviewees pointed out. Interviewees did not comment on whether this was an advantage or disadvantage, only that COMET's multilateral cooperation were a unique feature and distinguished the programme from other national programmes.

All of the interviewees consulted for this case study highlighted that COMET plays a significant role in Austria's national research and innovation landscape. First, they pointed out the already mentioned funding volume, which is significantly higher than funding for other programmes. Second, interviewees emphasised the stability the funding structure provides: It is financed by two federal ministries, the Ministry for Transport, Innovation and Technology (BMVIT) and the Ministry of Science, Research and Economy. In addition, the regional governments of the federal states ('Bundesländer') hosting Centres or Projects co-finance the programme. Third, interviewees highlighted COMET's function as a 'translator' or bridge between science and industry. Finally, according to an interviewee, the programme is thought to contribute to Austria's good and relatively stable positions in international innovation rankings.

Structure and financing model

COMET is divided into three programme lines: COMET Centres (K1 and K2 Centres), COMET Projects, and, since 2016, COMET Modules[11] (BMVIT et al. 2016, 7–9). While there have only been minor changes at the programme level since its introduction in 2006, in 2016, the programme was renewed based on the results of two impact analyses of the programme (Geyer et al. 2013; Dinges et al. 2015) as well as on the outcomes of ongoing monitoring of the Centres and Projects. The renewal included two major changes, the phasing out and discontinuation of the K2 Centres[12] and the introduction of COMET Modules. According to our interviews, there were two main reasons for discontinuing the K2 Centre programme line. First, while they receive significantly more funding than K1 Centres (until 2016 ca. three times as much as K1 Centres), their output is only twice as big as that of K1 centres. Second, most K2 Centres did not fulfil the programme's requirements, in particular regarding the strong research focus (mainly measured through number of publications, including joint publications (Austrian Research Promotion Agency 2016, 7)) and internationalisation (measured by number of international partners and involved international researchers, number and scale of international R&D projects, involvement in international committees, etc. (Austrian Research Promotion Agency 2016, 8)). Our interviewees pointed out that the introduction of COMET Modules will enable the strengthening of strategic research (which was the main idea of the K2 programmes initially). They will also receive a significantly higher share of public funding (80 per cent of Modules' overall funding, while public funding only constitutes 35 to 55 per cent in the case of Centres and Projects; see Table 2). The Modules' high share of public funding should facilitate the establishment of new emerging research fields of high risk (BMVIT et al. 2016, 7).

[11] COMET Modules were officially introduced in 2016. However, the first call for applications will be in 2018.
[12] K2 Centres will not be phased out immediately, but there will be two further calls before its discontinuation (as of 2016).

In general, all COMET programme lines are open regarding research fields and topics covered. However, each of them needs to have a clearly defined topic that is jointly defined by science and industry. In addition, the topics should not 'simply constitute a conglomeration of individual projects, but [create] substantial added value as a result of cooperation and joint strategic orientation' (BMVIT et al. 2016, 7). As of 2015, almost half of all Centres and Projects were in the field of production, 20 per cent in life sciences, 15 per cent in ICT, 10 per cent in mobility, and 6 per cent in the area of energy and natural resources.

COMET Centres are organised as 'Gesellschaft mit beschränkter Haftung' (GmbH, meaning that a Centre's owner has only limited liability when it comes to a centre's potential debts). This legal company form also means that they are not subsidiaries of the hosting university/research institution or company, but they are their own organisational entities. Both industry and scientific partners are shareholders of the Centres. As of 2015, 54 per cent of K1 Centres were hosted by scientific partners, 31 per cent by industry partners, and 15 per cent by other partners. In comparison, 63 per cent of K2 Centres were hosted by scientific partners, 17 per cent by industry partners and 20 per cent by other partners ('others' not specified) (Stahlecker 2015, 41, 44).

COMET Projects, Centres, and Modules differ regarding their duration, funding structure, and required scientific/industry partner contribution (see Table 2), and also when in their main objectives. The main goal of COMET Projects is to conduct high-quality research through public-private collaborations with a medium-term perspective (BMVIT et al. 2016, 9). K1 Centres should aim to 'develop and focus competences' through excellent joint research with a medium to long term perspective, high level research at an international level, and also stimulate new research ideas (BMVIT et al. 2016, 9). K2 Centres should both focus existing competences and develop new ones with a strong international collaborative focus, and should further define new emerging research fields. With this in mind, the main difference to K1 Centres is that they conduct research of particularly high risk (BMVIT et al. 2016, 10). Similar to K2 Centres, COMET Modules focus on the establishment of new emerging research fields and are defined by research of high risk. However, their duration and funding structure significantly differs from K2 Centres (see Table 2).

COMET Centres, Projects, and Modules are funded through three sources: public funding, scientific partner contributions, and industry partner contributions. Two thirds of the public funding is provided by the two ministries BMVIT and BMWFW, and one third by the regional government of the hosting federal state (Taftie, Austrian Institute of Technology & Joanneum Research 2016, 25). Depending on the programme line, public funding constitutes 35 to 80 per cent of the overall budget of a Centre, Project, or Module. Scientific partners are required to contribute 5 per cent (all programme lines), and industry partners need to provide 15 to 45 per cent (see Table 2).

Table 2: Overview of COMET programme lines (2016–2020)

Programme Line	Projects	K1 Centres	K2 Centres	Modules
Duration	3–4 years	8 years (4+4 years)	8 years (4+4 years) (until 2016: 10 years (5+5 years))	4 years

Max. federal funding	EUR 0.45 m/year	EUR 1.7 m/year	EUR 4 m/year (until 2016: EUR 5 m)	EUR 0.5 m/year
Public funding (state and 'Bundesländer' funding)	35–45%	40–55%	40–55%	80%
Scientific partner funding contribution	Min. 5%	Min. 5%	Min. 5%	Min. 5%
Industry partner funding contribution	Min. 45% (until 2016: 50%)	Min. 40% (until 2016: 45%)	Min. 40%	Min. 15%
Number of scientific and industry partners	Min. 1 scientific and 3 industry partners	Min. 1 scientific and 5 industry partners	Min. 1 scientific and 5 industry partners	Min. 1 scientific and 3 industry partners
Number of planned new projects/centres 2016–2020	Approximately 20	Approximately 15	Max. 5	Approximately 20

Sources: BMVIT et al. (2016, 7–11); Stahlecker (2015, 40)

Organisations interested in founding a COMET Centre, Project, or Module can respond to regular calls by the FFG (published on their website). Existing Centres and Projects can reapply to any subsequent calls and continue their activities if successful. While Projects are not evaluated during their lifetime, both K1 and K2 Centres undergo a mid-term evaluation after four years. In the case of a negative evaluation of a Centre, a phasing-out period of one year for K1 Centres and 1.5 years for K2 Centres starts. Such a phasing-out period should enable Centres to resume their planned research activities and to conclude them in an appropriate manner. However, phasing-out funding is limited to a maximum of 50 per cent of the average annual funding during the last funding period (mean value). Centres that do not aim to respond to a COMET call may also apply for phasing out (BMVIT et al. 2016, 13; Stahlecker 2015, 41–2). As the first call for Modules will be in 2018, detailed information on possible reapplications, evaluations, or reviews has not been announced yet.

Output and impact

The achievement of COMET's objectives and impacts (both at the programme and individual Centre/Project/Module level) are regularly assessed by quantitative and qualitative indicators using a specifically developed evaluation concept. At individual Centre, Project, and Module level there are four types of evaluations: ex-ante evaluations, reviews, mid-term evaluations, and ex-post evaluations (Austrian Research Promotion Agency 2016, 5) (see Table 1).

Table 3: Evaluations of COMET Projects, Centres and Modules

	Ex-ante evaluation	Review	Mid-term evaluation	Ex-post evaluation
Date	Prior to start	Mid-term of Projects and Modules	Last year of first funding period of centres (4th year)	After the end of term
Object of evaluation	• Applications for projects and modules	• Projects • Modules	• Centres (objectives, results of first funding	• Centres • Modules • Projects

	• For the first funding period of a centre		period, research plan for second funding period)	
Evaluators and reviewers	• FFG: internal experts • FWF and CDG: external experts	• FFG • External reviewers, if required	• External reviewers • FFG	• FFG • External reviewers, if required
Consequences	Go or no-go decision	Recommendations	Stop or go decision (stop: phasing-out period)	–

Source: Austrian Research Promotion Agency (2016, 5)

The main objectives of the reviews and evaluations at Centre/Project/Module level are to analyse both the quality of research activities undertaken, if and how previously set targets have been achieved, as well as to find out whether previous recommendations for improvements have been considered (Stahlecker 2015, 46). The methods for the evaluation are not specified in the evaluation concept, which only mentions the consideration and use of both qualitative and quantitative indicators. As we learned through our interviews, for mid-term evaluations, a committee of international peers, which would mostly also include two members of the initial panels for the ex-ante evaluations, would assess the Centres. Centres have to submit a report covering their output and impacts, which will be reviewed by the committee. In addition, the reviewers will make on-site visits to learn more about the Centre's impacts and outputs. Finally, the peers will give recommendations; based on the reviews it will be decided whether a Centre will continue or discontinue. The recommendations are based on for example:

- Review of whether aims regarding numbers of publications, numbers of patents, etc. indicated in the initial proposals were met;
- Work presented during the on-site visits; or
- Evaluation of the costs of the Centres (and how the Centres' outputs and impacts are related to the costs) as well as the how they performed regarding the success and progress presented in the proposal.

The COMET programme is also regularly evaluated through an impact analysis, building mainly on quantitative indicators aggregated from Centres' and Projects' data,[13] which are measured against previously set target values. These indicators include: numbers of publications and patents; follow-up projects of industry partners as well as the implementation of new products, processes and procedures; additional external funding acquired from research promotion funds and contracts with companies; intensity and quality of cooperation using network analysis; composition of employees (also considering gender mainstreaming); number of PhD and Master's theses; or indicators to assess the degree of internationalisation (Austrian Research Promotion Agency, 2016, 7–8). To date, two programme impact analyses have been conducted (last assessment: 2015, see Dinges et al. 2015; next assessment: 2020) (BMVIT et al. 2016, 16). The most

[13] As Modules were only introduced in 2016 and the first call for applications will be in 2018, they have not yet been included in any impact analyses.

recent impact analysis was based on data generated through an online survey with scientific and industry partners, interviews, input-output modelling, and an analysis of EUPRO database[14] data to collect information about international cooperation of Centres (Dinges et al. 2015, 17). While K1 Centres and Projects were to a great extent positively evaluated in this analysis, it was highlighted that K2 Centres do not have more outputs (e.g. publications, patents) than K1 Centres, although their funding is significantly higher (Dinges et al. 2015, 24). Interviewees stated that the critical assessment of K2 Centres influenced the decision to discontinue this programme line.

Dinges et al.'s (2015) survey and interviews conducted for the impact analysis also provided insights into how industry and scientific partners assess the impact of Centres and Projects, and how they have benefitted from the public-private collaborations in terms of output. For example, 87 per cent of all interviewed industry partners noted that they have introduced a product or service innovation within five years, and 65 per cent of the interviewees related those to the COMET programme. According to the interviewed scientific partners, COMET (and especially Centres) would particularly strengthen knowledge transfer and long-term public-private cooperation. A minor critique mentioned by scientific partners is that COMET would not necessarily equip PhD students for future professions in industry or provide job opportunities. Yet they emphasised that being involved in a Centre/Project/Module would provide PhD students the opportunity to find out if they want to pursue a career in industry (Dinges 2015, 68–69).

In addition to reviews and evaluations at Centre/Project/Module level, continuous monitoring is conducted to assess whether funds have been used appropriately. Monitoring is based on data obtained from the funded Centres, Projects, and Modules (Austrian Research Promotion Agency, 2016, 3). The last monitoring report was published in 2016 and covers the years 2014 and 2015 (FFG 2016b, 2016c). It showed that in the monitoring period, all Centres have reached their target values or over-accomplished them. In the case of the Projects, it widely varied if they have reached or not reached their target values (e.g. regarding patents and licenses, Master's and PhD theses, academic publications).

Challenges and how they are handled

The desk research conducted for this case study provided limited information about challenges at both Centre/Project and programme level. By contrast, interviewees pointed out that the programme is very stable and will likely stay stable (also regarding public funding) – changing framework conditions were not mentioned as barriers. Information on Modules were rather limited since they haven't started yet and interviewees did not make any assumptions regarding this issue. In addition, interviewees expect that the programme will remain stable in the near future.

A review conducted by Stahlecker (2015, 50–51) highlighted two main challenges from the viewpoint of the programme owners: (1) Fixed duration vs. sustainability, and (2) cooperation vs. competition. With regards to the first mentioned, Stahlecker notes that the funders would not aim to make Centres permanent research

[14] The EUPRO database, maintained by the Austrian Institute of Technology (AIT), contains information on research programmes funded by the European Commission's Framework Programmes (FPs). For more details, see: http://risis.eu/data/eupro-dataset/

organisations, and therefore they prefer the fixed limited funding periods. However, while many of the Centres are well-established, large, and institutionalised organisations, it is unlikely that they would survive without COMET funding. With regards to cooperation vs. competition, it is pointed out that in many cases both the scientific and industry partners would rather focus on their own core tasks than on the overall goals of the Centres. In addition, industry partners often have to work with competitors, which may impact their readiness to cooperate. However, as interviewees pointed out that Centres usually have far more industry partners than required, readiness to cooperate seems to be a rather minor challenge.

In our interviews for this case study, several general and specific challenges at Centre/Project level were highlighted. In general, it was emphasised that there would not be any significant challenges at the programme level, but that they rather relate to the individual Centres or Projects. A main challenge identified is the difficulty to ensure collaboration between several partners at the same. In general, this should be guaranteed through the predefined minimum number of industry and scientific partners (see Table 2). However, while on paper there might be collaboration between several partners, some of the joint work would happen at a bilateral level only. According to our interviewees, there are two main approaches to reduce the risk of such bilateral cooperation: First, the rigorous review of applications to calls should prevent uneven partnerships, and second, the FFG's continuous monitoring of Centres' and Projects' work (based on Centres' and Projects' regular reporting to the FFG) enables fast reactions in such cases.

An interviewee also pointed out the challenges related to changes at the programme level, which would hamper managerial work at Centre and Project level. Such changes include increasing bureaucracy and administrative burdens as well as an increased amount of reporting on the ongoing work to the funders. However, interviewees also stressed that a certain amount of reporting is necessary to ensure that public money is spent properly according to the Centres' and Projects' plans and COMET's overall objectives. In addition, interviewees from the ministries as well as the FFG noted that the programme tries to keep the amount of reporting balanced.

Public sector and services sector relevance

Both primary and secondary literature reviewed for this study did not provide any relevant information about COMET's relevance to the public sector and services sector. Only a few partners of existing and former Centres or Projects are public sector organisations, and their focus seems to be rather technology- and industry-oriented than service-oriented. Similarly, our interviewees felt that the programme would not have a significant impact on neither of the two sectors. However, some of them assumed that programmes such as COMET would contribute to an increased collaboration between science and industry, which might have an implicit impact on the public sector and services sector. In addition, as some COMET Centres and Projects would address societally relevant topics (e.g. climate change, food quality, renewable energy), some interviewees suggested that the programme might have a further implicit relevance to the public sector.

Perspectives and learning from the initiative

In his review study on the COMET programme, Stahlecker (2015) identified lessons learned and success factors of the COMET programme, which include:

- 'High level of trust between science and industry,
- long-term commitment on the part of science […] [and] of industry,
- research manager at the centres,
- legal form of centers as GmbHs and physical entities,
- openness to international environment,
- research program as a "living" construct […] [e.g. possibility of adaptations],
- competitive components form the regular calls and the "predetermined breaking points",
- thematic openness' (Stahlecker 2015, 50).

Based on the challenges identified in section 0, a further learning point can be taken from the high level of bureaucracy and administrative burden that is perceived at Centre/Project level. Our analysis in this case study indicates that a balance between necessary reporting and keeping track of progress at Centre/Project/Module level is relevant to the success of a research-based innovation centre programme. In addition, ongoing monitoring and evaluation would ensure initiating timely countermeasures in risky situations. However, this must be moderated by an awareness that too much bureaucracy can lead to inefficiencies and less time do the research and innovation work. In addition, an interviewee highlighted that too much bureaucracy could discourage potential partners to participate in a COMET collaboration.

Both our interviews and literature on the COMET programme showed that good communication and communication strategies between funders and Centres/Projects/Modules in general as well as between partners at Centre/Project/Module level are essential. With regards to the desired cooperation between industry and scientific partners, this is particularly crucial according to our interviewees, because it enables an active and successful cooperation. In addition, communication is important to guarantee a balance between research and industry.

Our interviewees further confirmed the importance of the Centres' organisation as GmbHs, which allows for a higher degree of flexibility than other organisational forms (e.g. subsidiaries of research organisations or companies, or non-university research organisations such as the Fraunhofer Centres in Germany). In addition, this legal organisation should ensure independence from participating scientific or industrial partners when it comes to the management of a Centre/Project, budget, research focus, intellectual property, etc.

As pointed out in section 0, the fixed time period for COMET Centres is often seen as a barrier for sustainability. By contrast, our interviewees highlighted that defined funding durations would also be a driver for sustainability, as continuous efforts to reach the goals of the Centre as well as the programme need to be taken. In addition, the fixed funding period would ensure that Centres permanently 'renew' themselves and react to developments in their sectors, which in turn would reduce the risk of market failures.

Both the literature reviewed and interviewees consulted for this case study emphasised that COMET's financing model is a clear strength of the programme. But, some interviewees highlighted challenges of the funding model, in particular when it comes to the scientific partners' 5 per cent funding contribution, which would sometimes be difficult to provide in the case of very large Centres. However, interviewees find the contribution of scientific partners crucial, as they ensure a stronger commitment. Similarly, industry partners' financial share (of which at least 50 per cent needs to be provided in cash in the case of Centres) contributes to a sustainable engagement throughout the lifetime of a Centre/Project. Public funding ensures that the Centre/Project/Module can operate in general, and that high-quality research can be undertaken. In addition, adequate public funding enables research on high risk topics (particularly the new programme line Module and K2 Centres), the development and focussing of competences and expertise, as well as the achievement of COMET's overall objectives such as stronger internationalisation, enhancing Austria's competitiveness, and consequently contributing to the country's overall economic growth.

A final strength of COMET is related to the overall aim of research-based innovation centres, to foster public-private collaborations. In the case of COMET, cooperation is not only required when it comes to the research conducted in the context of the Centres/Projects/Modules, but joint work should also happen in the Centres'/Projects'/Modules' management and everyday business (which should, as mentioned above, also be ensured through Centres' legal form as GmbHs). In addition, it is essential that scientific and industry partners already work together in preparing their applications. Proposals need to clearly define several collaborative aspects, such as for example identifying the relevance of the science-industry collaboration in the specific research area, detailed research and funding plans, participating scientific and industry partners and their particular roles, etc. Several interviewees emphasised that such elements would play an essential role in the review of applications, as they would a priori ensure a balance between science and industry.

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Interviews

- Representative of the Austrian Federal Ministry of Science, Research and Economy (BMWFW): Interview on 14 July 2017
- Representative of the K1 Centre 'alpS – Climate Change Solutions': Written interview on 17 July 2017
- Representative of the Austrian Research Promotion Agency (FFG): Interview on 2 August 2017
- Representative of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT): Interview on 4 August 2017

VINN Excellence Centres (Sweden)

History and objective of the programme

The predecessor to VINNOVA, NUTEK (National Board for Technical and Industrial Development), launched the first generation of Competence Research Centres (CRC) in 1995 at eight Swedish universities, which made Sweden one of the first countries in Europe to support that kind of competence centre (Lidgard and Lundberg 2010). Traditionally the contact between Swedish scientists and other parts of the society were weak and the investments made by universities in industry-related research were low. The CRCs were meant to solve the market failure resulting in insufficient production of knowledge relevant to industry (Stern et al. 2013). The first generation of CRCs provided a ten-year investment in 28 CRCs and due to the CRCs being well received both domestically and in a European context VINNOVA initiated a second generation of CRCs called VINN Excellence Centres in 2005 (Lidgard and Lundberg 2010). The first and second generation of CRCs share the core objectives, thus the second generation of CRCs is viewed as the second phase of the competence centre program (Stern et al. 2013).

19 new VINN Excellence Centres from nine universities were selected to be funded for up to ten years.**Error! Reference source not found.** The Centres were to create new internationally competitive concentrations of competencies in which enterprises, public partners, universities, and research groups aim to provide needs-driven and multidisciplinary research and ensure that the newly generated knowledge and technology result in new products, processes, and services. The goal of the program was to promote sustainable growth in Sweden (Call for proposal VINN Excellence Centres 2004). One of the differences compared to the first generation of CRCs the VINN Excellence Centres' partners from the public sector were to be more involved and the Centres were to be more visible in public (Stern et a. 2013). In 2015 VINNOVA announced they will finance a new program, the Competence Centre Program, which is set to start in 2017. The new program is based on the CRC program from 1995 and the VINN Excellence Centre program. One of the goals for the new program is to get the centres to cooperate with the surrounding research and innovation environment rather than constitute isolated entities, as has been the case in the previous programs (VINNOVA Call for proposal Competence Centre 2017

Overview of the 19 VINN Excellence Centre programs

VINN Exellence Center	Sector	University
SuMo Biomaterials	Biotechnology	Chalmers University of Technology
Chase - Chalmers Antenna Systems Excellence centre	Information and Communications Technology, CleanTech	Chalmers University of Technology
GigaHertz Centrum	Information and Communications Technology, CleanTech	Chalmers University of Technology
Wingquist Laboratory Excellence Centre for Efficient Product Realization	Product Realisation	Chalmers University of Technology
SAMOT - Service and Market Oriented Transport Research Group	Transportation, CleanTech	Karlstad University
FunMat - Functional Nanoscale Materials	Materials	Linköping University
HELIX - Managing Mobility for Learning, Health and Innovation	Organisation and Manangement	Linköping University
Faste Laboratory - Centre for Functional Product Innovation	Product Realisation	Luleå University of Technology
Antidiabetic Food Centre	Biotechnology	Lund University
Next Generation Innovative Logistics – NGIL	Transportation, CleanTech	Lund University
ProNova VINN Excellence Centre for Protein Technology	Biotechnology	Royal Institute of Technology
iPack Centre - Ubiquitous Intelligence in Paper and Packaging	Information and Communications Technology, Biotechnology, CleanTech	Royal Institute of Technology
HERO-M - Hierarchic Engineering of Industrial Materials	Materials	Royal Institute of Technology

BiMac Innovation	Materials, CleanTech	Royal Institute of Technology
Centre for Sustainable Communications	Services, CleanTech	Royal Institute of Technology
Centre for ECO2 Vehicle Design	Transportation, CleanTech	Royal Institute of Technology
Mobile Life Centre	Services, CleanTech	Stockholm University
BIOMATCELL - Biomaterials and Cell Therapy	Biotechnology, Materials	University of Gothenburg
Uppsala VINN Excellence Centre for Wireless Sensor Networks (WISENET)	Information and Communications Technology	Uppsala University

Source: VINNOVA 2017

Placement of initiative in the National Research and Innovation Agenda

In the spectrum of basic and applied research, VINNOVA, as a government agency focused on innovations, naturally leans strongly towards applied research. The same is true for the VINN Excellence Centres. The purpose of VINNOVA is "to promote sustainable growth by improving the conditions for innovation, as well as funding needs-driven research" (www.vinnova.se). The centres aim to stimulate cooperation between different partners, both within academia and industry, to generate new products, services, and strategies. The main idea is, that centres create knowledge and the industry uses the knowledge to create innovations to put in the market. Thus, the VINN Excellence centres can be seen as a hub where academia and the industry meet and cooperate.

This does not imply that no basic research is conducted within the centres. Depending on what kind of industry the centre belongs to, the level of basic research differs. Within some industries, such as life sciences, basic research is a large part of the core business. ICT and Biotechnology, is the two most common sectors for the VINN Excellence centres to operate within. **Error! Reference source not found.**Beyond biotechnology; clean technology, information and communications technology (ICT), materials, and transportation are the most common sectors for the centres to operate within. The balance between basic and applied research in the specific industry is thus naturally reflected on the centre. However, as an initiative in the Swedish national research and innovation agenda, the VINN Excellence centre program is considered a program for applied research. The centres should always have the industry's point of view in mind when starting new projects.

Structure and financing model

The intention of the VINNOVA VINN Excellence Centre program was to establish and finance 25 new centres for a maximum term of ten years, divided into four phases. The first call for proposals was made in 2003 while the last calls were made in 2004. Four centres were established in 2005 and another 15 were established in 2007 making it a total of 19 funded centres, instead of 25 as was initially intended. International evaluations of the centres were carried out before every new phase begun. After the third, and final, international evaluation in 2016, three of the centres[15] had been cut from receiving continued funding implying that 16 of the originally 19 VINN Excellence centre programs made it through the ten-year period.

The calls did not exclude any research areas or disciplines. However, VINNOVA expected the majority of Excellence Centres to act within VINNOVA's scope of practice: technology, working life, and transportation. VINNOVA also pointed out development of working life, biotechnology, information and communications technology, product development, services and IT-usage, and transportation as extra important areas for the calls.

The accepted centres were awarded funding for the ten-year term. According to the financing model; VINNOVA, the university, and the involved enterprises co-financed the centres during the entire ten-year term implying that each entity granted an equal amount, 1/3, of the total funding. The maximum amount VINNOVA granted per year was 7 million SEK, thus the maximum investment volume of the program per centre was 210 million SEK over the ten-year term. (Call for proposal VINN Excellence Centre 2003, 2004)

Output and impact

The outlines of the final evaluation of the VINN Excellence centres are being drawn as this report is written. Consequently, a final report on output or impact of the centres has not yet been published. In accordance to the structure and finance model the centres have been evaluated by international reviewers three times since the launch of the program in 2005, though the focus of the evaluations has been on recommendations rather than impact. However, in 2014 VINNOVA published a report in which output created in 2012 from the then active 18 VINN Excellence centres is presented. The report is based on the results of a survey that is sent to the centres from VINNOVA, as a part of the evaluations. The compiled results give an insight in what is being done at the centres.

In 2012, the centres improved or completed 158 products, services or processes and initiated three licenses. Four centres contributed to starting eight new companies and nine centres applied for or was granted 32 patents. Over 748 publications where made by the centres. Of the 748 publications 133 were cowritten by cooperating enterprises or public partners. Moreover, 52 doctoral dissertations and 21 licentiate theses were awarded in 2012.

[15] iPack, NGIL, and Wisenet.

75 employees from domestic and international companies participated in different leading positions within the centres and eleven projects between the universities and companies laid outside of the Centre agreement and were totally or partially financed by the private sector partner in 2012. 33 researchers originally from the Centres were employed by the private sector partner during 2012. Finally, 56 foreign guest professors were active at the centres and 24 EU projects were connected to the centres. To conclude, the 2014 VINNOVA report shows that the centres produced a variety of different output in 2012. (Carlsson, Lundberg 2012)

Challenges and how they are handled

During the ten-year term, three international reviews have been conducted: The first one after 1.5 years, the second review after 4.5 years, and the last one after 7.5 years. The evaluation teams have consisted of both international experts and generalists. The international reviews of the centres have functioned as guidance for the centres in their continued effort as centres. Challenges recognized as common for all centres by the leaders of the VINN Excellence centre program and the international reviewers have been handled centrally by VINNOVA.

Collaboration has been an on-going struggle for the centres. Both collaboration within the centres, between centres, and with the industry. Many of the centres have become closed environments instead of using the centres as a hub where academia meets the industry and learning from other centres' experiences. According to the leader of the VINN Excellence centre program it was not clear on their part how centres should collaborate when the program was initiated. To help improve the collaboration between centres VINNOVA started to arrange "centre days" where the leaders of the centres met and could share experiences.

One of the obstacles for increasing collaboration between academia and the industry, and between different businesses within projects, are the legal agreements. The researchers at the centres have experienced hardship when they have wished to collaborate with partners outside of the centres. Before the centres' ten-year terms began they signed legal agreements, constructed by VINNOVA, with their intended partners. However, as the centres developed, new collaboration opportunities came forward but since the potential new partners were not included in the original agreements, they had to be accepted as partners by the university board. The hinder created by the legal processes lead researchers to engage in new projects outside of the centre with the new partners, instead of the new partners subscribing to the VINN Excellence centre agreement. To solve for this, VINNOVA decided to allow the third generation CRCs to construct their own legal agreements instead of using the contract created by VINNOVA.

The interviewees also mentioned internationalization as one of the challenges for the centres. Large international corporations are often included as partners of the centres. However, to get regular collaborations with the international partners have turned out to be hard for the centres. Even regarding internationalization, the legal agreements seem to be the challenge. The researchers often start new international projects

outside of the centre instead of waiting for the project to be cleared within the centre. In 2008, VINNOVA invited actors within the research and innovation community (not only VINN Excellence centres) to apply for grants to help the centres on their way of becoming more international. The announcement was called "Strategies for global links for strong research and innovation milieus" and the goal was to establish a process to become more integrated internationally within its field of research. The budget of the announcement was set to 10 MSEK (VINNOVA 2008). According to the interviewees, VINNOVA is not satisfied with the results of the announcement but since the final evaluation of the program has not been carried through yet, a solution to the problem has not been presented yet.

Another challenge that was mentioned in the interviews was to increase the incentive for researchers to postpone publications in favour for patents and innovations. As has been the case for both the first and second generation of VINNOVA's CRCs, the researchers have instead been prone to favour publications over patents and innovations. Since the CRCs are supposed to create conditions for the industry to create innovations, it is important for the researchers to acknowledge the perspective of industry. The researchers have not been able to see patents and innovations as results of their research, and therefore focusing on producing publications. VINNOVA wants to change the mindset of the researchers but, as for the challenge with internationalization, no solution has been presented.

Finally, a last challenge recognized by VINNOVA was the importance of the leaders of the centres. The importance of the leaders came clear for VINNOVA after the first generation of CRCs, which lead VINNOVA to initiate a leadership course called "Leadership Mandate Programme – The art of becoming a better centre director" in 2008. The course, consisting of six two-day workshops, was optional and addressed the role of the leader in numerous ways. A total of 70 leaders, not only leaders of VINN Excellence centres, participated. (VINNOVA 2010)

Public sector and services sector relevance

As mentioned in section 1.1 on the history and objective of the VINN Excellence program, one of the desired differences between the first generation of CRCs and the VINN Excellence centres was to increase the involvement of partners from the public sector. Historically, the main part of the partners involved in the centres have belonged to the engineering and the manufacturing industry. The engineering and manufacturing industries have large and important roles in the Swedish industry landscape and rely on applied research, which have made it natural for these industries to become highly involved in the centres; both financially and strategically. The public sector plays a minor role in both industries. The role of the public sector is, however, larger in other kinds of industries.

Within the life science industry, the relationship with the health care sector is of high importance. Since a large part of the Swedish health care sector is part of the public sector, the public sector thus plays a significant role for the VINN Excellence centres focused on life science. The involvement of the public sector is not restricted to the life science industry, but the involvement of the public sector in VINN Excellence centres stands out within the life science area. Another example of an industry where the public sector

plays a relevant role is the transport sector. To involve the public sector an exception to the co-finance restriction has been granted: The public sector can contribute to the centres through in-kind payments.

The co-finance requirement is not only an obstacle for the potential public sector partners, but also for small and medium-sized enterprises (SMEs). As opposed to larger businesses, SMEs work with a stricter budget and shorter time horizons. It is more important for small businesses to be able to put a product or service on the market relatively soon after the project starts, since being a co-financer can imply a considerable risk. Hence, most of the industry partners collaborating with the VINN Excellence centres have been large businesses, rather than partners from the public sector or small businesses.

Perspectives and learning from the initiative

Every 2-3 years, before a new phase has begun, the activities of each centre have been evaluated by an international expert group. However, a concluding report has not yet been carried out, but the outlines of the final evaluation is being worked on as this report is being written. After the VINN Excellence centre program ended, VINNOVA initiated a new competence centre program called VINNOVA Competence Centre Program. The Competence Centre Program is the third generation of CRCs and learnings from the VINN Excellence centre program has naturally been considered. Since the final evaluative report has not yet been finished, the perspectives and learnings from the VINN Excellence centre program presented below are based on answers from the interviewees involved in the VINN Excellence centre program and documents regarding the VINNOVA Competence Centre Program. Increasing the participation of SMEs, allowing the centres to develop their own legal agreements with their partners, and creating competition between the centres right from the start are three key learnings from the VINN Excellence centre program.

VINNOVA believes small business have the largest possibility to experience substantial growth in the foreseeable future. One of the challenges in the VINN Excellence centre program was to get small and medium-sized enterprises (SMEs) to participate in the centres. The largest obstacle keeping SMEs from participating was identified as the requirement of co-financing. To encourage SMEs to participate, “special funds have been allocated for improving opportunities for SMEs to actively participate in the programme’s research”. Effectively, the initiative grants funding not only for the academic partners, but also for SMEs research efforts in the centre. (VINNOVA 2017)

One of the struggles of VINNOVA’s first and second generation of CRCs have been to keep the centres from developing into isolated entities. The centres have expressed difficulties engaging in new collaborations due to legal constraints, explained in section 1.5. In the beginning of the program the centres reached agreements, constructed by VINNOVA, with their intended partners. Including new partners have called for substantial legal processes which have resulted in the centres developing into closed centres. Since most of the researchers also work outside of the centres, they have simply started projects outside of the centres when the legal processes have stalled their projects. A difference between the second and third generation CRCs is that the centres are allowed to construct their own legal agreements, instead of using VINNOVA’s. However, most of the centres have kept to VINNOVA’s agreements, sometimes slightly modified.

Closely related to the aforementioned problem regarding researchers starting projects outside of the centres due to legal agreements slowing down the processes in the centres, is the challenge of keeping the quality of the research in the centres on a high level. The best researchers do not need to tie themselves to some centre or specific partners. They will be able to do their research anyway. Rather, the legal agreements between the centres and the partners need to be flexible to be able to create high-quality research and hence appeal to the best researcher. If new collaborations require substantial legal processes the best researchers will simply start new projects outside of the centres and the centres will risk becoming isolated entities excluded from top level research.

Finally, to put pressure on the centres to not procrastinate projects, the setup of the third generation CRCs has been updated. The third generation CRC program is still planned for a ten-year period, but the ten years are divided into two terms. Eight centres are granted funding for five years. When the five-year period ends the centres will be evaluated, and two of the centres will be cut from the program. The idea is to hinder centres from becoming slow starters. Out of the eight new centres, the two worst centres will be cut no matter how successful they might be. It will all come down to how they are performing relatively to the other centres. By creating the competition between the centres VINNOVA believe the centres will not waste time in the beginning of the ten-year term, but rather get going directly from the start. The new setup does not imply that the centres are immune to being shut down within the first five years. As for previous generations, the centres will be evaluated throughout the program and can be shut down within the first five years if performing badly.

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