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Bibliometric analysis and career mapping of the SFF scheme

Sub-report II to the SFF evaluation panel



Gunnar Sivertsen, Espen Solberg, Pål Børing, Solveig Hillesund and Fredrik Piro

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Preface

This report was commissioned by the Research Council of Norway (RCN) as part of the evaluation of the Norwegian Centres of Excellence scheme (SFF). The results of the quantitative analyses presented here are meant to serve as background information for the international scientific committee appointed to evaluate the scheme.

According to RCN's requirements, this report is based on quantitative analyses, notably bibliometrics and register-based career tracking. The report should be seen in conjunction with a parallel qualitative analysis of the impact of the SFF scheme on the Norwegian research system (Borlaug et al. 2019). Both reports deal with many of the same questions, but with different data and approaches.

The members of the project team behind this report were Gunnar Sivertsen (project leader and author of chapter 2), Espen Solberg, Pål Børing and Solveig Hillesund (responsible for chapter 3) and Fredrik Piro (responsible for chapter 4).

The team would like to thank our colleagues Hebe Gunnes, Kaja Wendt and Bjørn Magne Olsen for their help in extracting and cleaning data for the career tracking analysis. We also thank Inge Ramberg for carrying out the web-based study of the international visibility of SFF1 (presented in Annex 1).

Finally, we thank the Norwegian Research Council for initiating the project and financing the study.

Oslo, 2 December 2019

Sveinung Skule
Director

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Deputy Head of Research

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Summary

In 2002, the Norwegian scheme of Centres of Excellence (SFF) was established to promote quality in Norwegian research. Parts of the background was a series of disappointing evaluations of Norwegian research, pointing at low ambitions, varying quality and few contributions to the international research frontier. The establishment of SFF was a concrete answer to these challenges.

Through highly competitive calls, the scheme has allowed for flexible and long-term funding for a period of 10 years. Since its inception, four generations of SFF centres have seen the light, including 44 centres and more than 4300 researchers¹, postdocs and PhD fellows have been affiliated with the centres. The centres vary in size, are found in different fields – some highly interdisciplinary – and are hosted by different types of institutions.

The scheme is currently being evaluated, and this report is one of the sub-reports commissioned by the Research Council of Norway (RCN) in order to inform the international scientific committee responsible for the evaluation. This particular sub-report describes a register-based analysis, focusing on bibliometrics and the impact of the SFF scheme on participants' career development (career mapping). The report should be read in context with the second sub-report on the impacts of the SFF scheme on the Norwegian research system (Borlaug et al, 2019).

Main findings

At the outset, the measurable outputs of the scheme are quite significant. The total SFF-funding invested from RCN amounts to approximately 1 per cent of total public allocations to R&D in Norway from 2004 to 2017. This report shows that during the same period SFF-researchers have been involved in

- 21,5 per cent of Norwegian scientific articles, published in Web of Science
- 27,5 per cent of Norway's total highly cited articles (10% most cited)
- 31,4 per cent of Norway's top cited articles (1% most cited)
- 45 per cent of Norwegian ERC-grants (during the period 2007-2018)

¹ This number relates to the first lists provided by RCN. The complete list used as a starting point for the career analyses included 4604 unique names.

Arguably, these findings indicate significant contributions to Norway's participation and visibility in the international research frontier. At the same time, this report reveals several aspects that modify and put these results in perspective:

Firstly, the measurable results are rather skewed, as often 2-3 centres in each generation account for a large share of both publications, citations and ERC-grants. Secondly, where this is possible to observe, we see that many of the researchers involved in SFFs also were high performing researchers before they entered the centres. Thirdly, the centres in question are often international consortia and include many researchers whose actual involvement in the centres is partial or marginal. A fourth point is that a relatively large share of SFF-researchers seem to stay in temporary positions long after their engagement in the centres. This rather surprising finding may have several explanations, but it raises questions concerning the scheme's ability to secure long term stable researcher careers in the Norwegian system.

In the following, we summarize some of the main findings and conclusions from each chapter. These point are also summarized at the end of each chapter.

Bibliometric analyses

Given the strong emphasis on academic quality of the SFF-scheme, analyses of the scientific publications related to the centres represent an important part of the study. Our bibliometric analyses are based on 37,000 scientific articles related to the first three generations of SFF. Although bibliometric methods have several well-known limitations, our findings shed light on several questions raised in the evaluation of the SFF scheme:

- *To what extent do the centres produce ground-breaking research?*

Some SFFs in each of the three generations, particularly in the first and third generations, have relatively large proportions of highly cited and top cited articles. The relatively high number of top cited articles emanating from the SFF *might* indicate ground-breaking results, but this needs to be validated by experts in the field.

There are also large variations within each generation with regard to citation impact. Although each generation as a group performs clearly above their host institutions as well as the Norwegian average, a few centres are even performing below the Norwegian average. This means that some centres in each generation are probably producing ground-breaking research. The probability is higher for SFFs than for Norwegian research in general.

- *To what extent are the researchers at SFF centres internationally recognised and competitive?*

High numbers of top cited and highly cited articles are also indications of international recognition. We find that the high-performing SFFs publish relatively large proportions of their articles in collaboration with top and leading universities abroad, and that high shares of their articles are published in the most prestigious journals.

A tentative answer to the second question is therefore: Most SFFs in each generation have international collaboration and publishing profiles indicating that the researchers are indeed internationally recognized and competitive. In this respect, researchers at some SFFs in each generation clearly stand out from Norwegian researchers in general as well as from a comparable group of receivers of other highly competitive funds (FRIPRO).

- *Has the SFF scheme helped to enhance scientific quality, and if so, how?*

Again, there are large variations among the centres in each generation. The trends are generally positive for those with high performance and for each generation in general. The positive trends concur with similar trends for Norwegian research in general, perhaps indicating that the SFFs have contributed positively to their Norwegian research environments.

Hence, the SFFs seem to have helped the enhancement of scientific quality in Norwegian research. Bibliometrics usually cannot tell *how* such possible improvements happen, but we see a clear indication from the increased collaboration with leading and top universities abroad.

- *What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?*

International collaboration has been increasing steadily in the period studied here, both from a Norwegian and an international perspective. The SFFs stand out from the general Norwegian pattern with a rapid increase since 2009 in the share of articles with top universities (mainly in the USA). This trend reaches a peak around 2013.

We can therefore conclude that the SFFs have indeed steered the general Norwegian international collaboration pattern in the direction of the world's most influential institutions in research. At the same time, the national and local collaboration patterns remain stable, indicating that the SFFs are not moving away from close collaborations with their local research environments.

Career tracking

Attracting and developing future research talents has been another main purpose of the SFF-scheme, ever since the first generation of centres in 2002. Two questions raised in the terms of reference are of particular importance for this part of the analysis:

- *What impact has the scheme had on recruitment to Norwegian research?*

The gender balance of SFF staff is generally in line with the balance in the Norwegian research system, although with moderate variations between the four generations of SFFs. In terms of age, we find that SFFs have recruited a significantly higher share of young researchers (below 35) than the overall Norwegian research system did in the same time period. PhD-fellows and postdocs are also more frequent in the SFFs than elsewhere in the system, which confirms the role of SFFs as a means to recruit future researchers to the Norwegian research system. At the same time, we find that young SFF researchers are more likely to pursue careers outside Norway or outside the core research system compared with older and more established colleagues.

The disciplinary profile of the SFF staff largely reflects the thematic profile of the SFFs, with a stronghold in mathematics/natural sciences as well as medicine in all four generations of SFF. Social sciences make up a significant share in SFF4, while technology was quite important in SFF1. Humanities appears with a relatively low proportion of staff through all four generations.

For the three selected years of comparison, we see that around half of all SFF researchers had completed a PhD before their first year of employment in the centre. Given that recruiting future researchers is one of the main objectives of the scheme, the share of completed PhDs in the first year of employment must be considered relatively high. This indicates that a PhD constitutes more of a “minimum qualification” than elsewhere in the system, and that for the SFFs, the postdoc position may be considered an equally important recruitment position.

As expected, researchers with a Norwegian doctorate degree are more likely to pursue careers in the Norwegian system compared to those who entered SFFs with foreign degrees. Nevertheless, we find that a substantial number of researchers with foreign degrees choose to stay in the Norwegian research system. By 2017, more than half of the researchers who started their SFF-careers with a foreign degree are still active researchers in the Norwegian research system. This indicates that the SFF-scheme has been able to recruit and maintain foreign researchers in the Norwegian research system.

- *What impact does the SFF scheme have on the career of students and other employees of the centres?*

Among those who have started their careers as PhD-fellows at SFFs, we find that 90 per cent of PhD-fellows from SFF1 have completed their degrees by 2017. The completion rates are also above 80 per cent for all SFF-related PhD-fellows who started their PhD prior to 2015. Compared to general PhD completion patterns in Norway, this indicates a rather high rate of completion.

In terms of sectoral mobility, we find that most SFF researchers pursue careers within the same sector as the one they were in when they started their career as SFF researchers. However, although the SFFs are primarily academically oriented and hosted by universities, the majority of those who switch sectors seem to move towards careers in the research institute sector. We assume that the prospects of finding full time research positions as well as permanent positions are important factors behind this sectoral mobility.

The latter point relates to the observation that doctorate holders with an SFF-background seem to have more difficulties in obtaining permanent academic positions in the Norwegian Higher education sector after they complete their PhDs. In fact, PhD holders from SFFs seem less likely to obtain such positions than Norwegian doctorate holders in general. These difficulties are particularly pronounced in the old universities, and among researchers within humanities and to some extent natural sciences/mathematics. It is likely that these findings reflect a combination of i) a scarcity of permanent positions in certain parts of Norwegian academia; ii) strong competition within the research areas where SFFs operate, driven in part by the success the SFFs have had in recruiting talented researchers; and iii) high academic ambitions among young SFF-researchers in general, and a corresponding willingness to endure temporary employment while waiting for “the right position”.

Among SFF researchers with careers outside the core Norwegian research system, we find that the largest share pursue careers in the business enterprise sector. More than 200 of the 720 researchers we investigated are traced with an occupation in this sector. As expected, careers in the Norwegian business enterprise sector is by far the most common pathway among Norwegian researchers who have left the core Norwegian research system. More surprisingly, we find that SFF-researchers registered with a non-Norwegian nationality or residence at their time in SFF are slightly more likely to have found jobs in the Norwegian business enterprise sector than abroad.

Participation in EU-programmes

While the SFF-scheme constitutes a competitive grant in itself, there is reason to expect that researchers involved in the centres also are able to attract additional grants, both during and after the period they have been involved in the centres.

Hence, this report also includes a study of SFF-researchers' ability to attract competitive grants from the EU Framework programmes in general and the European Research Council (ERC) in particular. Since the main focus of this analysis is the European Research Council (ERC), we only matched data from FP7 and Horizon 2020. These programmes cover the period from 2007 to present, which is relevant to see in relation to the duration of the SFF-scheme.

In total, we find that the 44 SFFs have been actively involved in EU-projects during the course of EUs 7th framework programme and Horizon 2020. More than 300 EU-projects can be connected to Principal investigators with an affiliation to SFFs. This number may also be underestimated as EU-projects where SFF-researchers participate as partners are not included in these analyses.

In general, we see that the SFFs contribute to counterbalance the total profile of Norway's EU participation. Firstly, while Norway generally fares well within programmes addressing societal challenges and less well within the excellence programmes, the SFFs display an opposite profile. In fact, we can observe that SFF researchers based in Norway contributes to nearly half of all Norwegian ERC-grants, which in turn indicates that the centres have been able to recruit and cooperate with a substantial number of research talents.

The SFF participation in EU-projects is however rather skewed. With the exception of SFF3 (where at least five centres appear to be quite active in EU-projects), we find that 2-3 centres stand for more than half of all EU-projects. These patterns reflect much of the same skewness identified in the bibliometric part of this study

Finally, there seems to be little evidence of a "boost" in EU projects after the researchers join an SFF. In fact, for the two SFF-generations where such comparisons are possible, we find that many of the researchers in question had already retrieved EU-funding before they joined the centre. Data on SFF-related EU-funding is therefore not sufficient to establish a causal relation between SFFs and increased EU funding. Instead, there is reason to conclude that the centres have been able to attract a large number of researchers with sufficient competencies and capacities to be successful in the competition for prestigious EU-grants and projects. Furthermore, given the high number of EU-projects related to SFFs, we can conclude that SFF researchers have made significant contributions to Norway's total performance in the Excellence pillar within EU-programmes.

1 Introduction

This section provides a brief background for the project and points to some general aspects concerning the data and approaches used in this study. For a broader presentation of the SFF-scheme and its role in the Norwegian research system, we refer to the sub-report I (Borlaug et al, 2019) issued in parallel with this sub-report.

1.1 Background

In 2002, the SFF scheme was established to promote quality in Norwegian research through supporting leading Norwegian research groups with the potential of contributing to the international research frontier. Flexible and long-term funding is granted for a period of 10 years through a highly competitive call. Since its inception, four generations of SFF centres have seen the light, including 44 centres and more than 4300 researchers², postdocs and PhD fellows have been affiliated with the centres. The centres vary in size, are found in different fields – some highly interdisciplinary – and are hosted by different types of institutions.

The scheme is currently being evaluated, and this report is one of the sub-reports commissioned by the Research Council of Norway (RCN) in order to inform the international scientific committee responsible for the evaluation.

This particular sub-report describes a register-based analysis, focusing on bibliometrics and the impact of the SFF scheme on participants' career development (career mapping). The analysis should be read in context with the second sub-report which focuses on the impacts of the SFF scheme on the Norwegian research system (Borlaug et al, 2019). These two sub-reports are complementary in scope and partly in methodology, but also overlapping as they shed light on many of the same research questions with different data and methods.

While this report is based on register data, the other sub-report relies mainly on qualitative evidence, including judgements from SFF-researchers and other stakeholders.

² This number relates to the first lists provided by RCN. The complete list used as a starting point for the career analyses included 4604 unique names.

1.2 Research questions

According to the terms of reference for this project, this register-based study should seek to answer the following research questions:

- *To what extent do the centres produce groundbreaking research?*
- *To what extent are the researchers at SFF centres internationally recognised and competitive?*
- *Has the SFF scheme helped to enhance scientific quality, and if so, how?*
- *What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?*
- *What impact has the scheme had on researcher training and recruitment? (career mapping)*
- *What impact does the SFF scheme have on the careers of students and other employees of the centres?*
- *What impact has the scheme had on recruitment to Norwegian research?*

While all these questions are underpinning the studies described in this report, it is important to note that data sometimes prove to be insufficient to answer all aspects of such broad questions. At the same time, the data may serve to reveal other aspects that are equally relevant for understanding the effects of the SFF scheme. The report is therefore not entirely restricted to the questions raised above.

1.3 Main approach and data coverage

At the outset, it is important to bear in mind the following aspects regarding the scope, approach and data coverage for this study.

Firstly, the evaluation of the SFF scheme is primarily an evaluation of the entire *scheme*, and not the individual 41 centres. This means that individual centres are rarely mentioned in our analyses. Instead, we focus on the four generations of SFFs and different groups or cohorts of researchers involved in the centres. As a result, our findings and observations are often presented on a more general and aggregate level than what would be the case if the evaluation had focused on individual centres.

Secondly, the time dimension represents a challenge as the SFF-scheme has been in operation for nearly two decades and with different centres active at different

points in time. Hence, the window for conducting quantitative ex-post analyses of the scheme is limited and differs between the four generations of SFFs.

The figure below illustrates this general challenge, notably the limited time for analysing the effects of activities related to SFF3 and SFF4, as these are respectively ongoing and in an early phase. The approaches used to handle these challenges will be further described in each chapter.

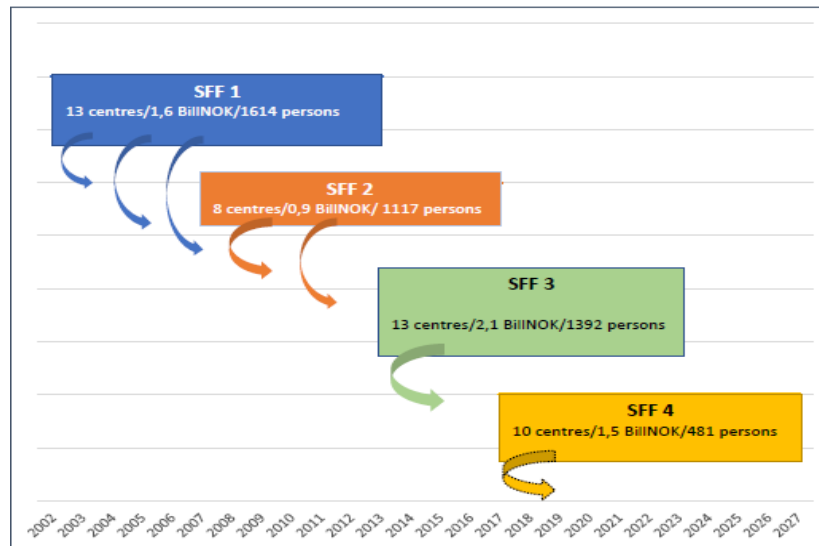


Figure: Overview of SFF generations:

Thirdly, both our bibliometric data and registries use persons as the unit of analysis, more precisely all researchers that have been involved in the centres. This means that our findings rely on person-based information which is sometimes incomplete or missing. In these cases, our analyses will have to limit certain aspects to the groups for which we have available data, even though all researchers involved in SFFs may be equally relevant in principle. Furthermore, the total number of SFF researchers differs somehow between the chapters because the full list of SFF-personnel has been cleaned and reorganised for different purposes:

- In chapter 2 the list of persons was cleaned and linked to publication data resulting in a total number of 3,384 scientists related to the first three generations of SFF.
- In chapter 3 the starting point was the full list of all SFF personnel reported by RCN, amounting to 4604 unique persons
- In chapter 4 the list was linked to ECORDA-data, based on a list with app. 4300 SFF researchers.

A fourth aspect concerns two additional approaches and data sources which have been tested with more limited results:

- One approach consisted in exploring the R&D funding profile of SFF host departments according to their reported thematic profile over time. Due to inconsistencies in reporting and thematic categories the development over time proved to be difficult to analyse with the necessary precision. The main findings from this approach is instead briefly described in appendix 1.
- Another approach consisted in exploring the reputation and visibility of the centres by conducting searches for names of centres and centre leaders from SFF1 in relevant publications and media sources. While these findings were relevant for the study, the findings provided little ground for exploring this aspect further. This part of the study is therefore briefly described in appendix 2.

1.4 Report structure

This report is primarily organised around three main approaches and data sources. These are described in separate chapters as follows:

- Chapter 2 describes the bibliometric study of the scientific publications related to the SFFs
- Chapter 3 presents the findings from the register-based analyses of careers and profile of SFF researchers
- Chapter 4 describes the participation and success of SFF researchers in the EU framework programmes
- Appendix 1 and 2 briefly presents findings from the two additional approaches described above
- Main findings and conclusions are presented at the end of each chapter and summarised in the executive summary.
- Since methodological aspects and data sources are closely linked to each approach, the descriptions of data are presented in the introductory part of each chapter.

2 Bibliometric analysis

2.1 Introduction

Given the strong emphasis on academic quality of the SFF-scheme, analyses of the scientific publications related to the centres represent an important part of the empirical material for the evaluation of the scheme. This chapter presents the findings from a bibliometric study of 37,000 scientific articles related to the first three generations of SFF.

2.1.1 Aims

Four specific questions have been identified in advance by the RCN as particularly relevant to be addressed partly with the help of bibliometric analysis:

- *To what extent do the centres produce ground-breaking research?*
- *To what extent are the researchers at SFF centres internationally recognised and competitive?*
- *Has the SFF scheme helped to enhance scientific quality, and if so, how?*
- *What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?*

The aim of this chapter is to answer these questions – to the extent that they can be enlightened by bibliometric methods.

Bibliometric methods have some strengths and limitations that need to be taken into consideration. In relation to the four questions, we have been asked to discuss relevant operational definitions of ‘ground-breaking research’ and ‘scientific quality’. We start by approaching this important discussion with a particular focus on citation indicators. We then present our solutions with regard to data sources, delineations and time series, and methods and indicators.

2.1.2 Operational definitions and solutions

'Scientific quality' and 'ground-breaking research' are concepts that reflect some of the main policy aims of the SFF scheme. While 'scientific quality' has often been discussed in relation to bibliometric indicators and their interpretation, 'ground-breaking research' has not. It seems clear, however, that *citation indicators* would be most relevant type of bibliometric indicators in relation to the two concepts. We start with the relation between 'scientific quality' and citation indicators.

In the Centre for Research Quality and Policy Impact Studies (R-QUEST), the concept of scientific quality is regarded as multi-dimensional (originality; scientific impact; societal impact; solidity and research integrity) and context-dependent (field and purpose of research; context and purpose of the evaluation). This was also underlined in a recent report to the Ministry of Higher Education and Science in Denmark in which these aspects of scientific quality are shortly explained and illustrated (Gornitzka et al., 2019, p. 59-61). When connecting this framework for understanding scientific quality to the literature on bibliometric methods, we will find that:

- Citations are regarded as expressing scientific impact, but not the other dimensions of scientific quality (originality; societal impact; solidity and research integrity)
- The validity of citations as a measurement of scientific impact also depends on the context (e.g. less valid in evaluations for recruitment of young teaching personnel in the humanities)

Limitations with regard to context are discussed in Sivertsen (2016A; 2016b). Limitations with regard to dimensions have recently been covered in a review of the international bibliometric literature from R-Quest (Aksnes et al., 2019):

We conclude that citations reflect—with important limitations—aspects related to scientific impact and relevance, but there is no evidence that citations reflect other key dimensions of research quality. There is no obvious road to better handle the tension between administrative needs for simple measures and more easy evaluation methods and researchers' request for fair and comprehensive assessments of scientific quality. Citation-based indicators cannot provide sufficiently nuanced or robust measures of quality when used in isolation.

Given these limitations, we still think that for the purpose of the SFF evaluation as well as its level of analysis – SFFs as a national funding instrument rather than an evaluation of the individual centres – it is possible to apply robust citation analysis as the main bibliometric tool to come closest to the questions given for the bibliometric part of the tender. However, three important limitations should be mentioned:

- SFFs representing research in the humanities and the social sciences will need special attention with the coverage of their literatures in the data source and also with regard to the validity of citation analysis
- The time lag needed to measure the citation impact of an article after it is published represents a limitation in the study of newly established SFFs
- While we measure the scientific impact of articles, the scientific quality of the research that they represent will need to be determined by more qualitative methods used in the evaluation

We now turn to the possible relation between ‘ground-breaking research’ and citation indicators.

The notion of ground-breaking research has almost never been discussed in the bibliometric literature. As an example, the core journal in bibliometrics, *Scientometrics*, has published 5,629 articles since 1975. The term ‘ground-breaking’ or ‘groundbreaking’ has occurred in only four articles’ titles or abstracts. In two of them, the term is not used in connection with bibliometric indicators. In the other two, the authors claim that the concept is measured by studying co-citation networks or the ten per cent most cited articles, but these measurements are usually related to other concepts (field analysis, citation impact) in bibliometric research.

The most relevant earlier attempt to identify ‘ground-breaking research’ with citation indicators was a commissioned study in Denmark with a very similar purpose to the one we present here. The study was required by Danish National Research Foundation to identify ‘*breakthrough research*’ in the evaluation of Danish Centres of Excellence (Krull et al. 2013). In their bibliometric analysis for the report, Schneider & Costas (2013) responded to the requirement by exploring new bibliometric methods. They assumed that ‘breakthrough articles’ must be among the extremely highly cited articles in the world and selected these among the world’s articles in the Leiden *Web of Science* database. They then filtered out the articles that were referring to other highly cited articles and assumed that these were ‘followers’ while there would be ‘novelty’ or ‘breakthrough’ in the remaining articles. They could indeed identify some such articles from the Danish CoE, but their proportion of the world’s articles was just as high as the proportion of highly cited articles in general.

They concluded that the method was an interesting experiment but did not try to validate the results, and their method has not been used since then. We are not able to provide a similar experiment here because a database similar to the Leiden database with a coverage of the world’s articles is not available to us.

Although we will identify and study articles with *particularly high impact*, our main solution is to regard ground-breaking as a *qualitative* term that expresses the aims and the possible results of a research funding instrument or a funded organization. The term can be used by experts to explain why a publication is highly cited or as an assessment of a particular achievement by a research group or a centre. The mid-term evaluations or self-evaluations of scientific impact provided by some of the SFFs for the RCN are examples of this method.

For our definition of this qualitative term in relation to research organizations, we will use the same expression as is used by RCN in its information about 'Forskingsrådet og vitenskapelig kvalitet' 2019:

Fagmiljøer på høyt internasjonalt nivå (som) utvikler helt ny kunnskap og banebrytende løsninger.

[Internationally high-level research environments that develop completely new knowledge and breakthrough solutions.]

We have used this definition as a guideline to pay particular attention in the citation analysis to indicators representing *proportions of highly cited articles*. We will return to these indicators below.

We still maintain that although an article is extremely highly cited, the extent to which it represents ground-breaking research will need to be determined by other, more qualitative methods. Publications can be highly cited for many other reasons, e.g. useful methods, useful reviews of the state of art, clinical guidelines, large project scale, many international co-authors, good timing, re-publication in textbooks, 'snowball' effects, and controversies.

Two other notions in the four main questions for the bibliometric analysis are 'internationally recognised and competitive' and 'impact on scientific collaboration'. Citation indicators can partly be bibliometric operationalizations of the first of these notions, but here, we include an analysis of the level of publishing (where they publish) and collaboration patterns (who they co-publish with) as well. Collaboration patterns are directly relevant for the second notion.

2.1.3 Data sources, time series, and units of analysis

Given the four main questions for this bibliometric report, citation analysis must be at the core, and a citation database is needed. We use the *National Citation Report for Norway (NCR)*, which is updated annually and delivered by Clarivate Analytics with data from *Web of Science (WoS)*. It covers all articles with at least one author address in Norway and now has a total of almost 300,000 journal articles from 1981-2018.

For our purposes here, the limitation of this WoS database is not the time span, but the basis for counting citations in the most recent years. Citations are counted until to the end of 2018 in the database. Generally, citations to publications can only be counted after 1-2 years after the publication year. Given the high aggregate level of our study, we decided to include publications from 2017 in the analysis, allowing for a minimum of one year's citing time.

For the allocation of articles to the SFFs, we also had to consider that it may take 1-2 years from research is performed until it is published. Considering the options and limitations with regard to publishing and citing time, we decided to allocate publications to an *active* SFF from the *second year after it was started* and *until two years after it ended*. Whenever possible, we also study the performance of an SFF *before* and *after* it was ended by allocating articles to the same persons who were employed in the SFF. We chose to limit these periods to *five years before or after*. For each of the four generations of SFFs, we were then given these options:

- SFF 1 (2003-2012): *Before*: publications from 1998-2003. *Active*: Publications from 2004-2014. *After*: Publications from 2015-2017.
- SFF 2 (2007-2017): *Before*: Publications from 2003-2007. *Active*: Publications from 2008-2017.
- SFF 3 (2013-2022): *Before*: Publications from 2009-2013. *Active*: Publications from 2014-2017.
- SFF 4 (2017-2026): Bibliometric analysis is not possible in the active period.

The fourth generation of SFF is not included in this bibliometric report. Furthermore, the name of an SFF does not systematically occur in the published author addresses in scientific journal articles. The names of the host institutions will often occur, but with different spelling variations, e.g. Norwegian Life Sci; Norwegian Univ Life Sci or Univ Oslo; Univ Oslo. Author names will also appear with spelling variations, e.g. REVECO, FE; REVECO-URZUA, FE.

The RCN does not have a list of publications from the SFFs. Instead, we were provided with a list of the 4,300 persons (1,700 PhD fellows, 1,000 post docs, 1,600 professors) who had been affiliated with one or more SFFs at different times. There was even information for each year about whether they were affiliated or not.

RCN could also provide a list of 956 FRIPRO grantees representing 1,288 different FRIPRO grants. These grantees are principal investigators supported by the RCN funding scheme for independent projects since 2002. We used the list to establish a set of scientific articles that can be compared to those related to the SFFs. Only a few FRIPRO projects were awarded in 2002 and 2003. Taking publishing time into account, we chose 2004 as the first year of publications from FRIPRO.

We decided to include all articles from 2004-2017 that can be attributed to FRIPRO grantees in any of these years, irrespective of the actual project granting period, which may be different for each individual project (no clear ‘generations’, as with the SFF). One could say that our FRIPRO data represents the publications of highly esteemed Norwegian researchers in general.

We used the two lists of persons as the starting point for allocating articles to each SFF and to the parallel FRIPRO funding instrument. It had to be done by matching person names to author names in WoS. In most cases, it was useful to match with two other data sources that are given in the list below and illustrated in *Figure 1*. We combined these four data sources:

- The list of 4,300 SFF researchers and the list of 956 FRIPRO grantees provided by NCR.
- NIFU’s Research Personnel Register (RPR) with data about persons and their affiliations and careers in higher education and research in Norway.
- The Norwegian Science Index (NSI) in Cristin, covering almost 180,000 scientific publications from Norwegian research organizations (HEI, institutes, health sector) 2011-2018. Here, persons have full names and standardized affiliations, while publication data may be matched to similar WoS records.
- The above-mentioned National Citation Report for Norway (NCR), delivered by Clarivate Analytics and based on Web of Science, with almost 300,000 journal articles from Norway 1981-2018.

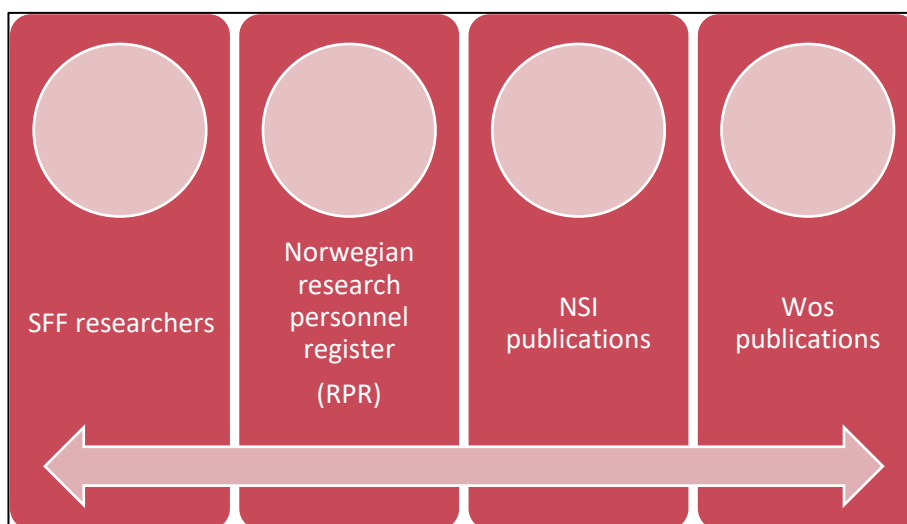


Figure 2.1: Four data sources at the level of individual researchers.

Source: NIFU

Most of the time spent for developing this bibliometric report was used in the first step for establishing a database of cleaned data.

Not all scientists in the SFF (first three generations) and FRIPRO lists could be found as authors in the WoS database in the relevant periods. The main reason for this is the limited coverage in WoS of some areas of research, mainly in the social sciences and humanities. Comparing WoS to NSI, we find that WoS covers 82 per cent of the publications in the life sciences, 81 per cent in the biomedical sciences, 76 per cent in the physical sciences, 46 per cent in the engineering sciences, 26 per cent in the social sciences, and 13 per cent in the humanities. Explanations for these differences in WoS coverage are given in Sivertsen (2016) and in Aksnes and Sivertsen (2019). The matching procedures gave these results:

- 3,384 scientists related to the first three generations of SSF were found as authors in WoS. A total of 36,942 unique scientific articles from 1998-2017 could be attributed to these authors.
- 825 scientists who had been granted by FRIPRO were found as authors in WoS. A total of 23,335 unique scientific articles from 2004-2017 could be attributed to these authors.

From these numbers, the FRIPRO grantees may seem to be more productive than researchers affiliated with an SFF. However, the FRIPRO grantees are only principal investigators while the SFF researchers represent all members of the team including a large number of PhDs. In addition, the second and third generations of SFF were established later than FRIPRO. A third factor is that publications are allocated to FRIPRO grantees irrespective of the actual project granting period.

The main units of analysis in this bibliometric report are the three generations (SFF1, SFF2, SFF 3) in the years before, while, and after they are active. We have chosen the generations as the main units because the focus is on the funding instrument itself, not the individual SFF. However, each SFF within the generation is also a unit of analysis whenever the purpose is to show variations within the generation. The three generations are also compared to each other. The purpose of this is to give a dynamic picture of how the funding instrument has worked over time.

Articles from each generation of SFF is compared to articles from other units of analysis in each relevant period:

- FRIPRO grantees
- Host institutions
- Norway
- The world average (for citation indicators only)

The host institutions of the first three generations of SFF are the five largest Norwegian universities (in terms of scientific output in WoS) and three research institutes:

- Norwegian University of Life Sciences (NMBU)
- Norwegian University of Science and Technology (NTNU)
- University of Bergen (UiB)
- University of Oslo (UiO)
- UiT The Arctic University of Norway
- Norwegian Geophysical Institute (NGI)
- Peace Research Institute Oslo (PRIO)
- Simula Research Laboratory

The eight institutions are not treated separately, only as a group, in the analysis.

Using the most appropriate period for comparison (comparable size of the funding schemes), the latest five years 2013-2017, our database of WoS publications has a total of 66,154 scientific articles from Norway. Of these:

- 46,856 articles (70,8 per cent) can be attributed to the SFF host institutions
- 14,251 articles (21,5 per cent) can be attributed to researchers in the first three generations of SFF
- 12,986 articles (19,6 per cent) can be attributed to FRIPRO grantees
- 5,382 articles (8,1 per cent) overlap and can be attributed to both SFF and FRIPRO

2.1.4 Four SFFs are not included in the analysis

Not all journal articles registered in the Norwegian Science Index have also been indexed for Web of Science, see section 2.1.3 above. Of all journal articles that can be related to SFF in NSI, 85 per cent can be matched to WoS. We calculated this share for each SFF and found that the share was less than 50 per cent for four SFF, all of them publishing mainly in the humanities or in law (see Table 2.1 below): *CASTL* (The Centre for Advanced Study in Theoretical Linguistics) and *CMS* (Centre for Medieval Studies) in generation SFF1, and *Multiling* (Centre for Multilingualism in Society across the Lifespan) and *Pluricourts* (Centre for the Study of the Legitimate Roles of the Judiciary in the Global Order) in generation SFF3. Data coverage, as well as field-dependent citation practices, determine the validity of bibliometric indicators based on data from the WoS (Sivertsen, 2016).

We found the validity questionable for these four SFFs, and decided to exclude them from the main analysis based on WoS. Before the exclusion, we also found that it makes very little difference to the general results at generation level whether we include or exclude these four SFFs from the main analysis, as they have very few publications in WoS.

2.1.5 Indicators

We use four main groups of bibliometric indicators. They cover:

- Thematic research profiles
- Citation impact
- Level of publishing
- Collaboration

The indicators will be presented and explained in each main section below.

2.2 Thematic research profiles

Thematic research profiles can be described on the basis of where the researchers affiliated to the SFFs publish, more specifically in what journals they publish. The database contains a field classification with 251 categories of journals. An analysis of articles per journal gives an indication of the thematic research profile of each SFF and of each generation of SFF. These research profiles may indicate the specific interdisciplinary or specialized research activities of SFFs in a way that pre-defined disciplinary categories may not capture. Such research profiles of the SFFs can be compared to each other and to the profiles of research at more aggregated levels, such as the host institutions.

Table 2.1 shows the main area of research that each SFF is active in. In addition, the three most frequent WoS journal categories for each SFF are named to give a more specific indication of the thematic profiles. The six main areas of research are constructed by grouping the 251 journal categories in the database.

Table 2.1. Thematic research profiles. The main research area and the three most frequent WoS journal categories that each SFF contributes to, according to the number of articles in each area and category.

	Centre	Area	Profile
SFF1	APC	Life sciences	Fisheries; Marine & Freshwater Biology; Agriculture, Dairy & Animal Science
SFF1	BCCR	Physical sciences	Geosciences, Multidisciplinary; Oceanography; Meteorology & Atmospheric Sciences
SFF1	CASTL	Humanities	Language & Linguistics; Linguistics; Psychology, Experimental
SFF1	CBM	Biomedical sciences	Neurosciences; Biochemistry & Molecular Biology; Physiology
SFF1	CESOS	Engineering sciences	Engineering, Civil; Engineering, Mechanical; Engineering, Ocean
SFF1	CIPR	Physical sciences	Geosciences, Multidisciplinary; Mathematics, Applied; Engineering, Chemical
SFF1	CMA	Physical sciences	Astronomy & Astrophysics; Mathematics, Applied; Mathematics
SFF1	CMBN	Biomedical sciences	Neurosciences; Biochemistry & Molecular Biology; Cell Biology
SFF1	CMS	Humanities	History; Medieval & Renaissance Studies; Language & Linguistics
SFF1	CSCW	Social sciences	Political Science; International Relations; Economics
SFF1	ICG	Physical sciences	Geosciences, Multidisciplinary; Geochemistry & Geophysics; Geography, Physical
SFF1	PGP	Physical sciences	Geochemistry & Geophysics; Geosciences, Multidisciplinary; Mineralogy
SFF1	Q2S	Engineering sciences	Engineering, Electrical & Electronic; Telecommunications; Computer Science, Information Systems
SFF2	CBC	Physical sciences	Mathematics, Applied; Mechanics; Engineering, Biomedical
SFF2	CCB	Biomedical sciences	Oncology; Cell Biology; Biochemistry & Molecular Biology
SFF2	CEES	Life sciences	Ecology; Evolutionary Biology; Marine & Freshwater Biology
SFF2	CGB	Physical sciences	Geosciences, Multidisciplinary; Microbiology; Geochemistry & Geophysics
SFF2	CIR	Biomedical sciences	Immunology; Biochemistry & Molecular Biology; Cell Biology
SFF2	CSMN	Humanities	Philosophy; Ethics; Linguistics
SFF2	CTCC	Physical sciences	Chemistry, Physical; Physics, Atomic, Molecular & Chemical; Chemistry, Multidisciplinary
SFF2	ESOP	Social sciences	Economics; Political Science; Environmental Studies
SFF3	AMOS	Engineering sciences	Automation & Control Systems; Engineering, Electrical & Electronic; Engineering, Civil
SFF3	BCSS	Physical sciences	Astronomy & Astrophysics; Meteorology & Atmospheric Sciences; Geosciences, Multidisciplinary
SFF3	CAGE	Physical sciences	Geosciences, Multidisciplinary; Oceanography; Geochemistry & Geophysics
SFF3	CBD	Life sciences	Ecology; Evolutionary Biology; Zoology
SFF3	CCBIO	Biomedical sciences	Oncology; Biochemistry & Molecular Biology; Cell Biology
SFF3	CEED	Physical sciences	Geochemistry & Geophysics; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences
SFF3	CEMIR	Biomedical sciences	Immunology; Cell Biology; Biochemistry & Molecular Biology
SFF3	CERAD	Physical sciences	Environmental Sciences; Physics, Particles & Fields; Astronomy & Astrophysics
SFF3	CISMAC	Biomedical sciences	Public, Environmental & Occupational Health; Infectious Diseases; Nutrition & Diagnostics
SFF3	CNC	Biomedical sciences	Neurosciences; Biochemistry & Molecular Biology; Cell Biology
SFF3	MultiLing	Humanities	Linguistics; Language & Linguistics; Audiology & Speech-Language Pathology
SFF3	NORMENT	Biomedical sciences	Psychiatry; Neurosciences; Physics, Particles & Fields
SFF3	Pluricourts	Social sciences	Political Science; Law; International Relations

Source: NIFU, based on WoS

Thematic research profiles may also be used for comparison with and among more aggregate levels. *Table 2.2* compares the percentage shares among the six major areas of research in each SFF generation with the shares at the three other aggregate levels in this study. Selecting the host institutions for an example of comparison, we see that the first generation of SFF was relatively more focused on the physical and engineering sciences. This focus disappeared in the second generation and reappeared in the third generation only for the physical sciences. The second generation gave more room for the life sciences. The shares for the biomedical sciences have been increasing for each new generation. The social sciences and humanities appear with relatively small shares.

This is mainly due to more limited coverage of these areas in the WoS. The four SSFs in humanities and law that we excluded from the citation analysis are included in Table 2.2

Table 2.2. Shares of articles among six major areas of research at different aggregate levels.

	SFF1	SFF2	SFF3	FRIPRO	Host inst	Norway
Engineering sci	15,4 %	4,8 %	8,8 %	8,5 %	10,9 %	11,4 %
Physical sci	47,9 %	29,8 %	32,9 %	27,6 %	23,8 %	22,9 %
Life sciences	9,3 %	20,8 %	12,8 %	11,7 %	11,1 %	11,4 %
Biomedical sci	20,0 %	32,6 %	37,4 %	43,3 %	40,2 %	38,8 %
Social sciences	6,1 %	9,7 %	6,9 %	7,9 %	11,4 %	13,0 %
Humanities	1,2 %	2,2 %	1,2 %	1,0 %	2,5 %	2,5 %

Note: Each generation of SFF is measured within its active period. The other aggregate levels are measured by their articles from 2004-2017. The percentages should only be compared within each area of research. The social sciences and humanities are underrepresented in Web of Science – see the discussion in sections 2.1.3 and 2.1.4

2.3 Citation impact

2.3.1 Normalization of citation indicators

Citation indicators are incomparable across fields and years unless they are normalized. In our data, each article is compared to other articles (worldwide) in the *field* and *year* it is published. The classification mentioned above of all WoS journals into 251 subject fields is the basis for the normalization. An SFF will be compared to all of the fields it actually publishes in to the same extent as it actually publishes in each field. This ‘individualized’ method is well adopted to the publishing profiles of the SSF, which are often interdisciplinary and specialized on certain topics at the same time. Our normalization method also distinguishes by publication type. Review articles (generally more frequently cited) are compared to other review articles and original articles are compared to other original articles.

2.3.2 The chosen indicators: shares of highly and top cited articles

The Leiden ranking (<https://www.leidenranking.com/information/indicators>) has an information page with an overview of the well-established science-based citation indicators that they apply. We will discuss three of them and present the two used in this report.

Traditionally, field-normalized citations have been measured as the average of the unit of analysis compared to the average of the larger dataset it is compared to. CWTS, the organization behind the Leiden ranking, used to name this indicator the 'Crown Indicator'. They now call it MNCS (mean normalized citation score): "An MNCS value of two for instance means that the publications of a university have been cited twice above the average of their field and publication year." The average MNCS for the world in the dataset will always be 1,00.

We tested this indicator in our data and found that it gives little extra information compared to the other indicators we tested. We also find that measuring the average is not quite in line with the focus on 'excellence' that is asked for in the main questions for this bibliometric report (research quality, ground-breaking research). Citations are extremely skewed among publications: A few publications receive many citations while most publications are seldom cited (Seglen, 1992). It is easier to express the focus on highly cited articles with two other indicators. These indicators are also more readily understood. Both are used in the Leiden ranking as well:

- **1 per cent most cited.** The proportion of a unit's publications that, compared with other publications in the same field and in the same year, belong to the top 1% most frequently cited in the world. This indicator is called PP(top 1%) in the Leiden ranking. We chose this 'narrow' indicator to allow for a possible focus on 'ground-breaking research'. An example of the use of the indicator is given *Figure 2* below.
- **10 per cent most cited.** The proportion of a unit's publications that, compared with other publications in the same field and in the same year, belong to the top 10% most frequently cited in the world. This indicator is called PP(top 10%) in the Leiden ranking. We chose this 'broader' indicator to give a more robust representation (less dependent on a few publications per year) of highly cited articles and of scientific impact in general. An example of the use of the indicator is given in *Figure 3* below.

For the examples, we show the performance of *the group of host institutions* versus *Norway* in all twenty years 1998-2017. We observe that the host institutions (with 71 per cent of Norway's articles) perform very similarly to Norwegian research in general. This may seem surprising since the host institutions are among the largest and most internationally influential in Norwegian research. The explanation is that the Norwegian hospital sector and institute sector in general perform better according to bibliometric indicators than the higher education sector. The host institutions are mainly from the higher education sector.

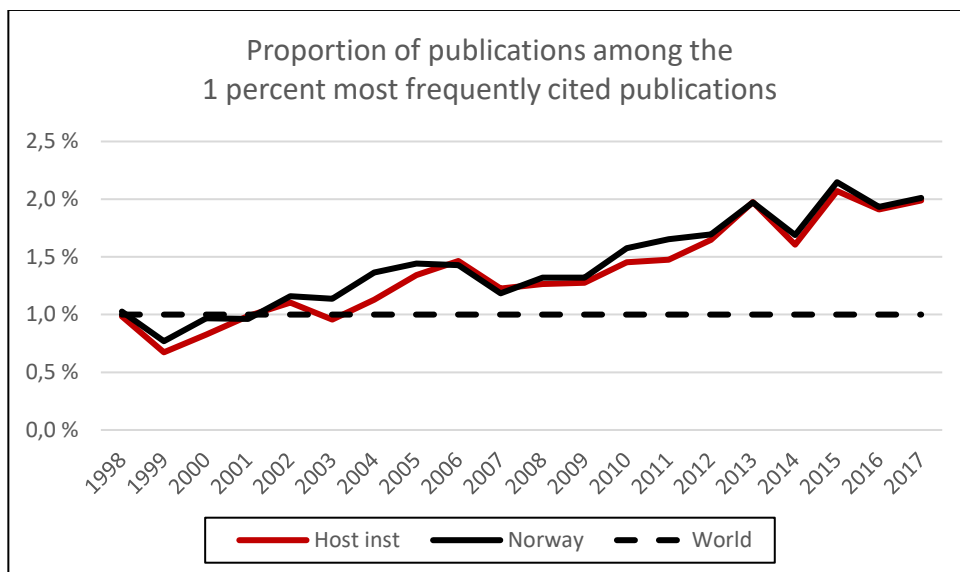


Figure 2.1. Example of the 1 per cent citation indicator: Proportion of publications among the 1 per cent most frequently cited publications in the world (Web of Science, 1998-2017). SFF host institutions are compared to Norway and the world.

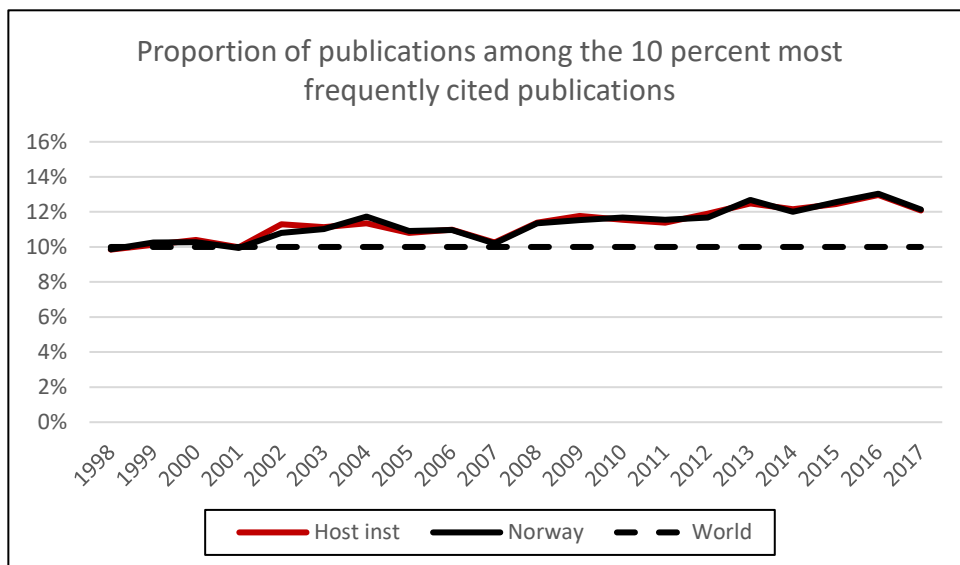


Figure 2.2. Example of the 10 per cent citation indicator: Proportion of publications among the 10 per cent most frequently cited publications in the world (Web of Science, 1998-2017). SFF host institutions are compared to Norway and the world.

Figures 2.3 and 2.2 also show an improvement in performance for the host institutions and Norway over the years, especially on the 1 per cent indicator. Some of this improvement may be due to an expansion of the Web of Science during the years by adding more journals from less cited countries.

In the next sections with results, we will only compare the SFF with FRIPRO and the host institutions since we already showed that the host institutions are representative for Norwegian research in general.

2.3.3 SFF contributions to highly cited articles

We start with the 'broader' 10 per cent indicator which gives the more robust representation (less dependent on a few publications per year) of highly cited articles and of scientific impact in general. For comparison, Figures 2.4-2.6 below present the results for all three generations of SFF in one sequence. The actual numbers of 10 per cent highly cited articles in the active period of each of the generations are:

- 1,639 articles in SFF1 (2004-2014)
- 1,151 articles in SFF2 (2008-2017)
- 917 articles in SFF3 (2014-2017)

These highly cited articles represent 27,5 per cent of Norway's total highly cited articles by the same indicator in the same period.

We observe that the SFF scheme and the FRIPRO scheme both fund researchers that performs above the average of the host institutions according to this indicator. Note that most of the articles related to the funding schemes are also included in the articles from the host institutions. Some of the positive developments for the host institutions may be linked to the two funding schemes, but it is difficult to isolate such effects from other influences on research performance (Langfeldt, Bloch & Sivertsen, 2015).

SFF2 differs from the two other generations with a slightly lower citation impact, but also with an increase in impact after the SFF have become active which continues during the active period. In contrast, SFF1 and SFF3 seem to realize a potential that was already there during the selection process.

All three generations show improvements during most of the active periods and have markedly higher citation impact than their host institutions and Norwegian research in general.

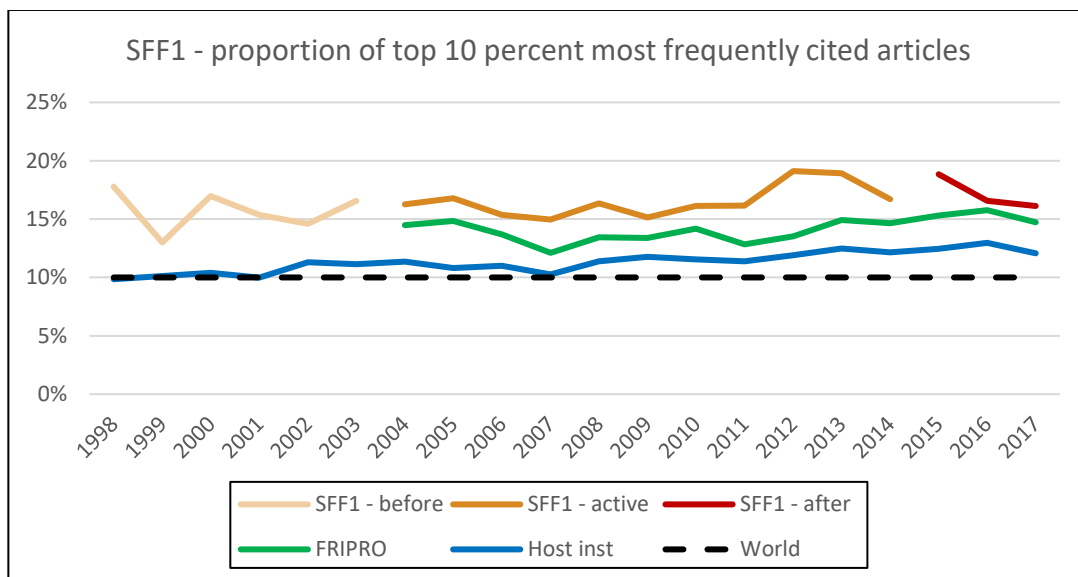


Figure 2.3. SFF1: Proportion of the world’s 10 per cent most frequently cited articles.

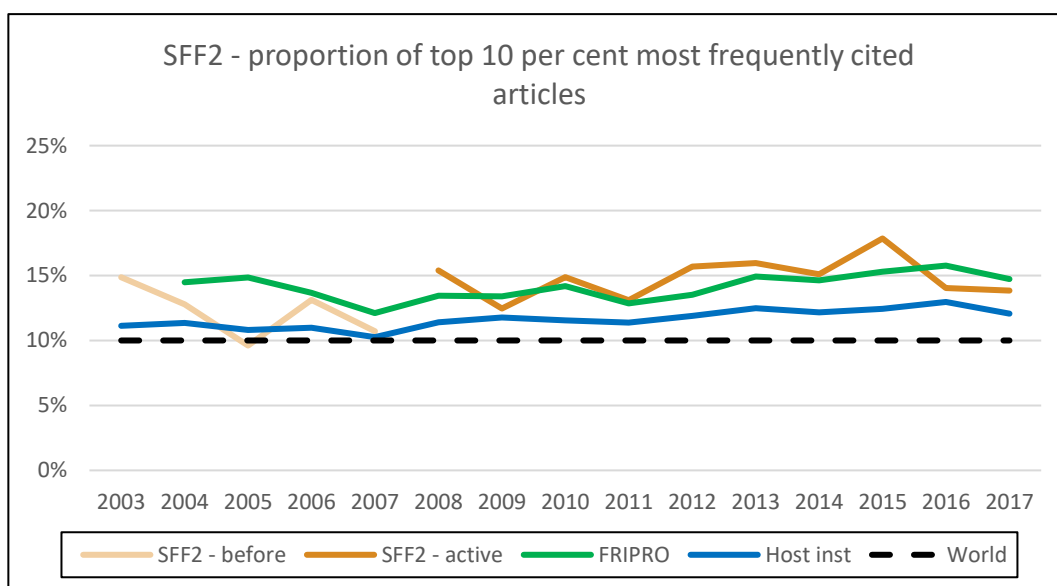


Figure 2.4. SFF2: Proportion of the world’s 10 per cent most frequently cited articles.

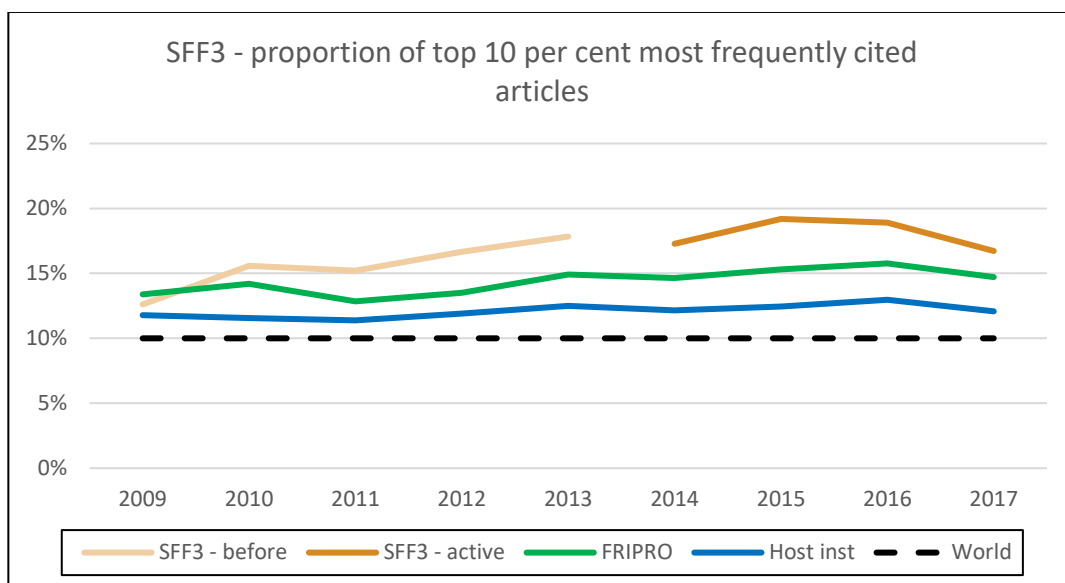


Figure 2.5. SFF3: Proportion of the world’s 10 per cent most frequently cited articles.

2.3.4 SFF contributions to top cited articles

The ‘narrower’ 1 per cent indicator largely confirms the results above but show more fluctuations because relatively few articles contribute to the numerator of the fraction. As an example, there are 55 top cited articles in 2015, 32 top cited articles in 2016, and 59 top cited articles in 2017 behind the extreme values and fluctuations for SSF1 in this period (Figure 2.7). The actual numbers of 1 per cent highly cited articles in the active period of each of the generations are:

- 243 articles in SFF1 (2004-2014)
- 202 articles in SFF2 (2008-2017)
- 178 articles in SFF3 (2014-2017)

These top cited articles represent 31,4 per cent of Norway’s total highly cited articles by the same indicator in the same period.

The measurement by the 1 per cent indicator shows that there might be ground-breaking research emanating from the SFF. The scores are often higher than for articles related to the FRIPRO scheme and clearly higher than for the host institutions and Norwegian research in general.

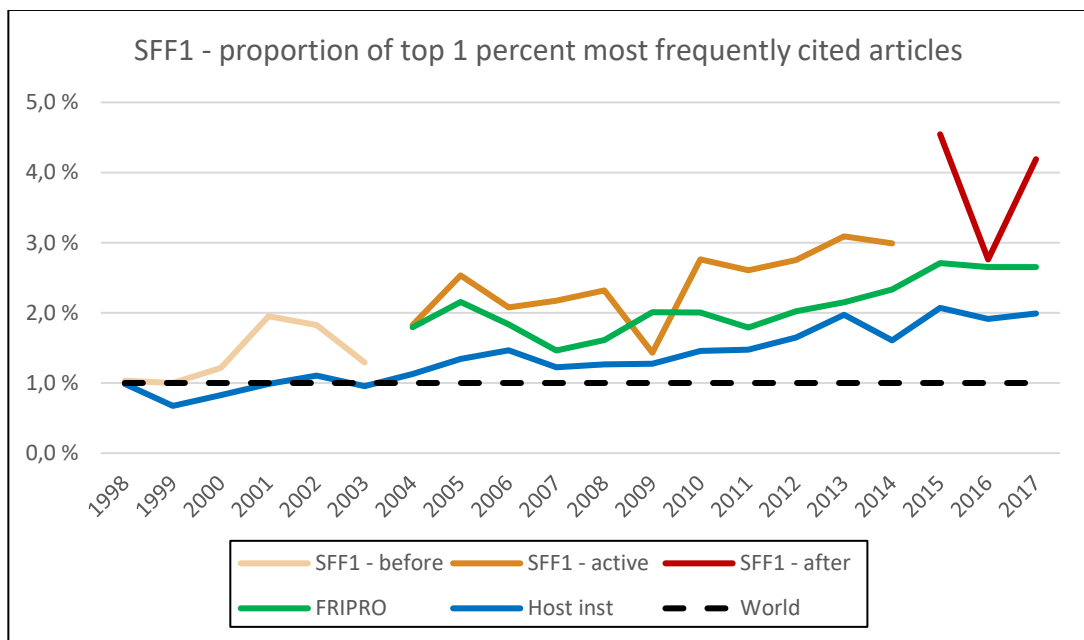


Figure 2.6. SFF1: Proportion of the world's 1 per cent most frequently cited articles.

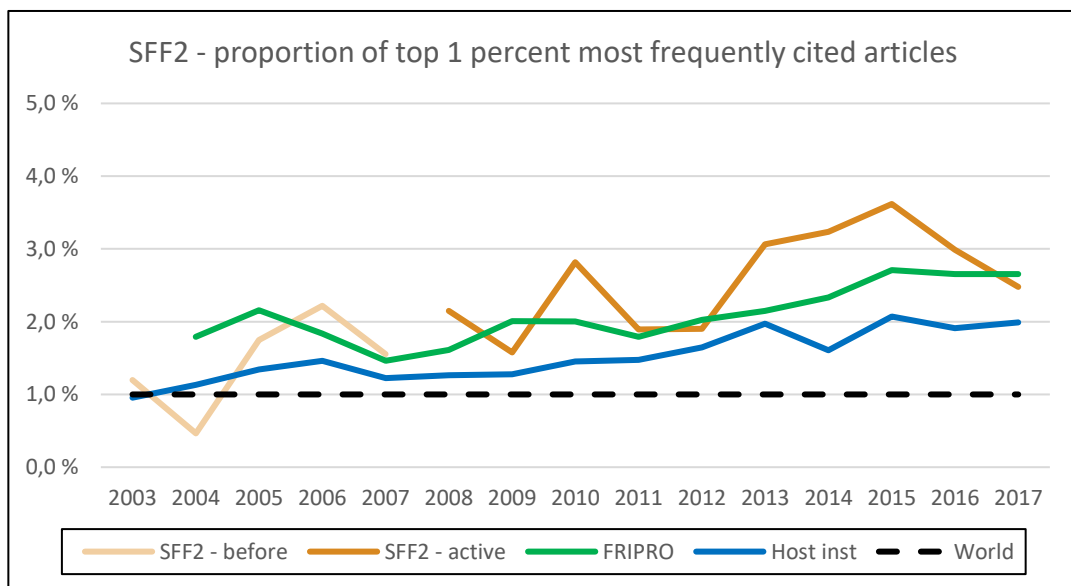


Figure 2.7. SFF2: Proportion of the world's 1 per cent most frequently cited articles.

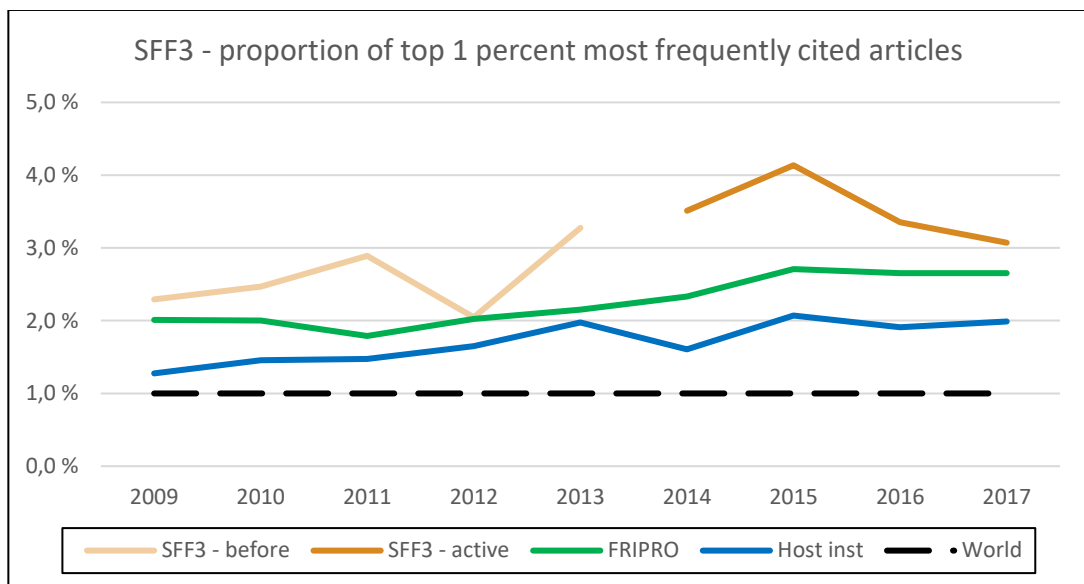


Figure 2.8. SFF3: Proportion of the world's 1 per cent most frequently cited articles.

2.3.5 Variations among the SFFs

There are large variations among the SFF in citation impact. Twelve of the thirty SFFs we measure here have very high impact according to the 10 per cent indicator. All of them belong to the SFF1 and SFF3 generations. Another five SFFs have large proportions of top cited articles according to the 1 per cent indicator. Four of them are in the SFF3 generation and one in the SFF1 generation. Three centres in the SFF1 generation, two centres in the SFF2 generation and two centres in the SFF3 generation have citation impact below the average of the host institutions and Norway.

Table 2.3 shows the 10 per cent indicator for each SFF in the active years and in the years before and after. Most SFFs follow the increasing trends shown in the Figures above, but there are some clear deviations. Large variations are also seen here.

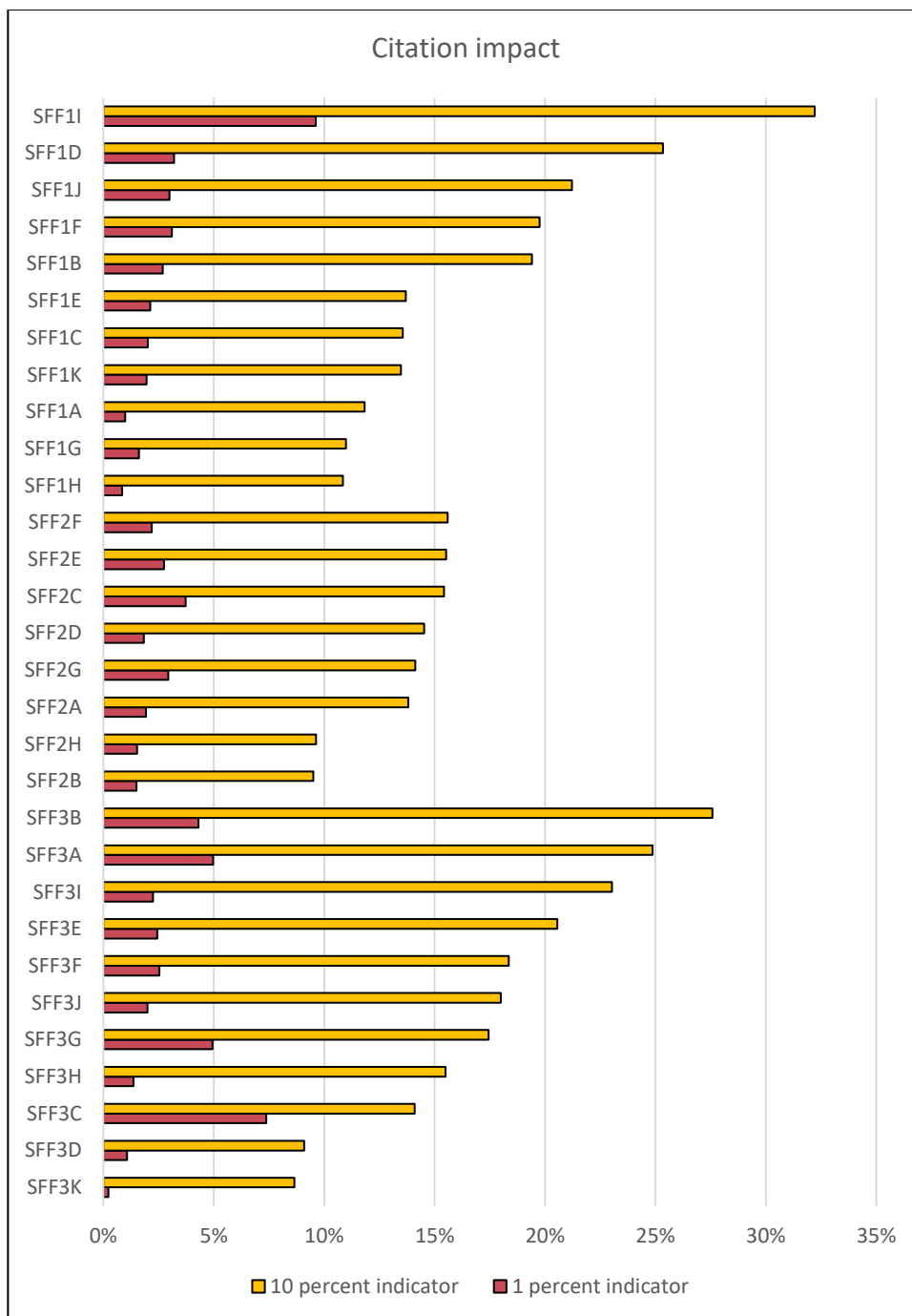


Figure 2.9. Variations in citation impact among the SFFs. The centres (coded for anonymity) are ranked by generation (first to third) and by the 10 per cent indicator within each generation.

Table 2.3. Citation impact by the 10 per cent indicator for each SFF in the active years and in the years before and after. Each SFF is represented by an anonymous code.

Generation	Centre	Before	Active	After
SFF1	SFF1I	25,0 %	32,2 %	25,0 %
SFF1	SFF1D	16,2 %	25,3 %	15,8 %
SFF1	SFF1J	17,9 %	21,2 %	22,0 %
SFF1	SFF1F	19,1 %	19,7 %	20,1 %
SFF1	SFF1B	15,8 %	19,4 %	15,2 %
SFF1	SFF1E	17,4 %	13,7 %	12,1 %
SFF1	SFF1C	8,5 %	13,6 %	13,2 %
SFF1	SFF1K	19,5 %	13,5 %	21,8 %
SFF1	SFF1A	25,0 %	11,8 %	6,0 %
SFF1	SFF1G	11,4 %	11,0 %	8,9 %
SFF1	SFF1H	14,0 %	10,8 %	4,6 %
SFF2	SFF2F	11,9 %	15,6 %	
SFF2	SFF2E	15,5 %	15,5 %	
SFF2	SFF2C	3,7 %	15,4 %	
SFF2	SFF2D	14,9 %	14,5 %	
SFF2	SFF2G	10,4 %	14,1 %	
SFF2	SFF2A	11,7 %	13,8 %	
SFF2	SFF2H	14,3 %	9,6 %	
SFF2	SFF2B	11,7 %	9,5 %	
SFF3	SFF3B	40,0 %	27,6 %	
SFF3	SFF3A	15,8 %	24,9 %	
SFF3	SFF3I	16,4 %	23,0 %	
SFF3	SFF3E	16,6 %	20,6 %	
SFF3	SFF3F	18,3 %	18,4 %	
SFF3	SFF3J	18,2 %	18,0 %	
SFF3	SFF3G	13,0 %	17,4 %	
SFF3	SFF3H	12,0 %	15,5 %	
SFF3	SFF3C	12,5 %	14,1 %	
SFF3	SFF3D	9,9 %	9,1 %	
SFF3	SFF3K	13,6 %	8,6 %	

2.4 Level of publishing

2.4.1 Two curated sets of prestigious journals

Journals can be more or less prestigious and influential. The analysis of the level of publishing may give a partial answer to the main question concerning whether the SFFs are ‘internationally recognised and competitive’. At the start of the millennium, before the first SFF generation was launched, several evaluations of Norwegian research had pointed at a lack of ambitions in the publishing profile.

To describe the level of publishing, we define two sets of prestigious journals and measure the share of articles published in the journals. Following the advice of RCN, we chose to use curated journal sets (based on qualitative judgments by expert panels) rather than Journal Impact Factors to define the journal sets.

One of the journal sets is named *Nordic level 2* in this study. It consists of 1,337 journals that disciplinary panels in Denmark, Finland and Norway agree to rank on the highest level in the national journal evaluation procedures for the bibliometric indicator systems for institutional funding (Sivertsen, 2016). The journals in the set need to be highly ranked in all three countries to be included.

In all three countries, the journals on the high level can only represent around one fifth of the articles worldwide in each field of research. The share can be expected to be somewhat higher in WoS since the indicators also include journals outside of WoS. The restriction to one fifth implies that there will be a balanced representation of all areas of research at the top level. More information about the selection procedures are given in each of these webpages:

- Denmark: <https://bfi.fi.dk/>
- Finland: <https://www.julkaisuforum.fi/en>
- Norway: <https://npi.nsd.no/>

The other set of journals, the *Nature Index* published by Springer Nature, was recommended for this study by the RCN. It includes a narrower selection of 82 of the most prestigious scientific journals in the world, mainly from the natural sciences. The list of 82 journals can be found here: <https://www.natureindex.com/faq#subjects>. We quote from the selection principles:

The journals included in the Nature Index are selected by a panel of active scientists, independently of Nature Research. The selection process reflects researchers’ perceptions of journal quality, rather than using quantitative measures such as Impact Factor. It is intended that the list of journals amounts to a reasonably

consensual upper echelon of journals in the natural sciences and includes both multidisciplinary journals and some of the most highly selective journals within the main disciplines of the natural sciences. The journals included in the Nature Index represent less than 1% of the journals covering natural sciences in the Web of Science (Clarivate Analytics) but account for close to 30% of total citations to natural science journals.

Nature Index does not cover the main areas of research in a balanced way. As seen in *Table 2.4 below*, the highest share of articles in Nature Index is found in the physical sciences. Nordic Level 2 has a more balanced representation. The higher shares in level 2 in the social sciences and humanities here can be explained by the fact that the more frequently used national journals in these areas of research are not covered by Web of Science. To control for the imbalances, particularly in Nature Index, it is important to compare with the thematic research profiles presented in *Table 2.1 above*. SFFs with a thematic profile in the physical sciences will have relatively higher chance of having their articles in Nature Index.

Table 2.4. Total articles in each are of research in the active periods of SFF1, SFF2 and SFF3, and the shares of these articles that are in journals in Nature Index and in Nordic Level 2.

	Total articles	Nature Index	Share of total	Nordic Level 2	Share of total
Engineering sci	2127	12	0,6 %	444	20,9 %
Physical sci	7734	1516	19,6 %	2376	30,7 %
Life sciences	2937	181	6,2 %	646	22,0 %
Biomedical sci	6029	512	8,5 %	1462	24,2 %
Social sciences	1579	13	0,8 %	601	38,1 %
Humanities	328	0	0,0 %	149	45,4 %
Total	20734	2234	10,8 %	5678	27,4 %

2.4.2 Publications in Nordic level 2

Both FRIPRO researchers and SFF researchers publish relatively more frequently in the journals nominated by Nordic scientists as most prestigious. The SFF2 and SFF3 generations also publish above the FRIPRO average, but all three generations can be said to have an ambitious publishing profile.

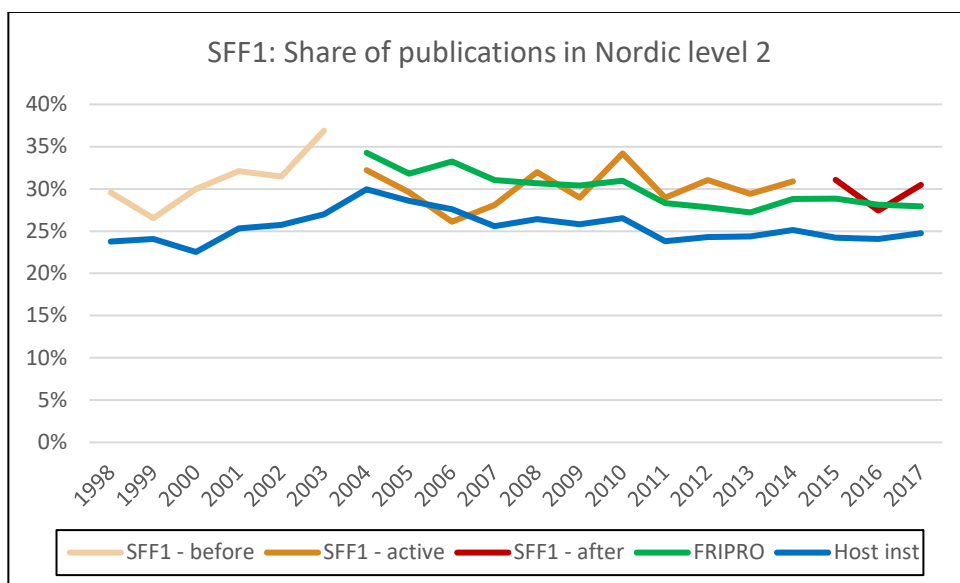


Figure 2.10. SFF1: Share of publications in journals in Nordic level 2.

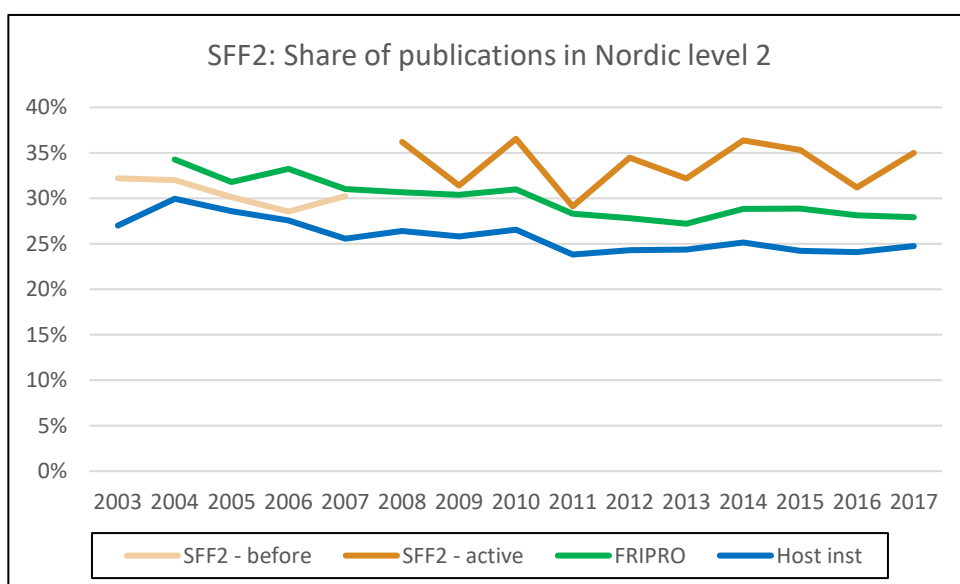


Figure 2.11. SFF2: Share of publications in journals in Nordic level 2.

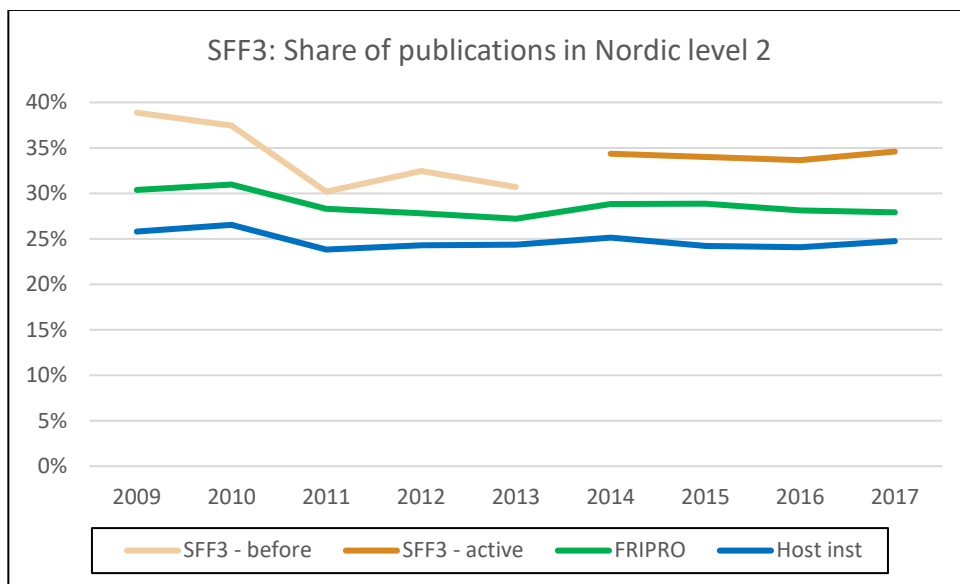


Figure 2.12. SFF3: Share of publications in journals in Nordic level 2.

2.4.3 Publications in Nature Index journals

This indicator, based on publishing in 82 top natural science journals, shows an even more distinct picture for the SFF compared to FRIPRO and the host institutions. All three generations are clearly above with increasing trends as well for SFF1 and SFF2. However, it is important to bear in mind that the Nature Index is biased towards the physical sciences. SFF1 and SFF3 are more focused on the physical sciences than FRIPRO and the host institutions in general. See table 2.1

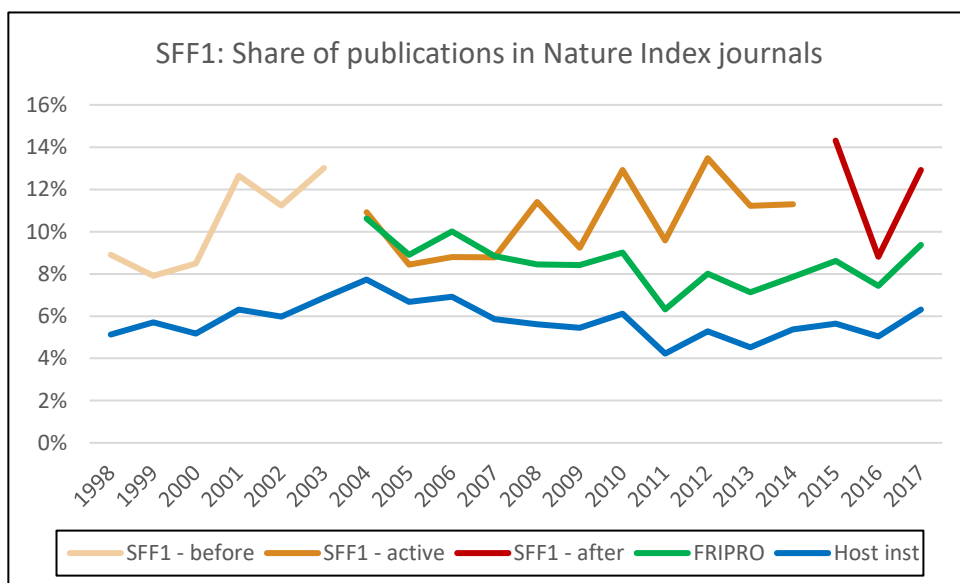


Figure 2.13. SFF1: Share of publications in journals in Nature Index journals.

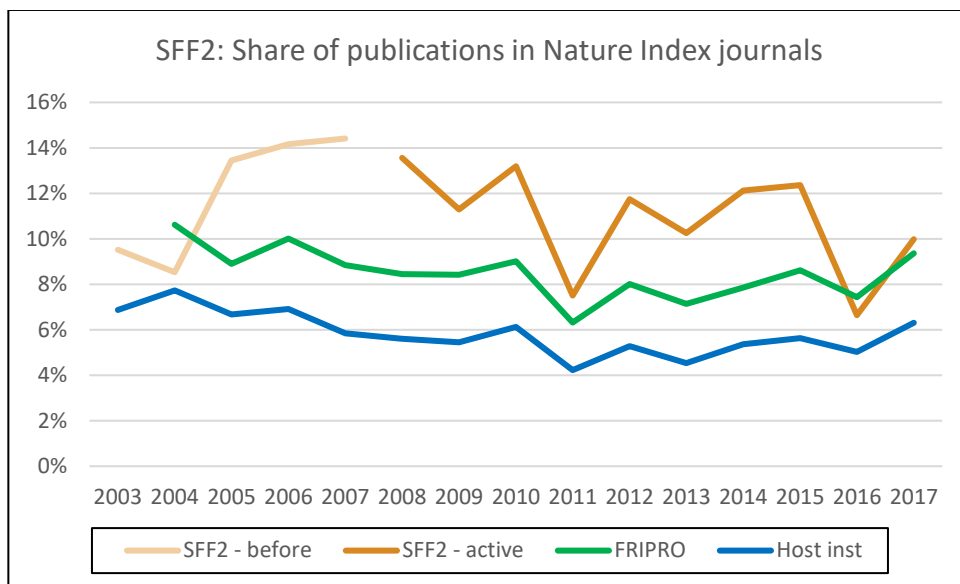


Figure 2.14. SFF2: Share of publications in journals in Nature Index journals.

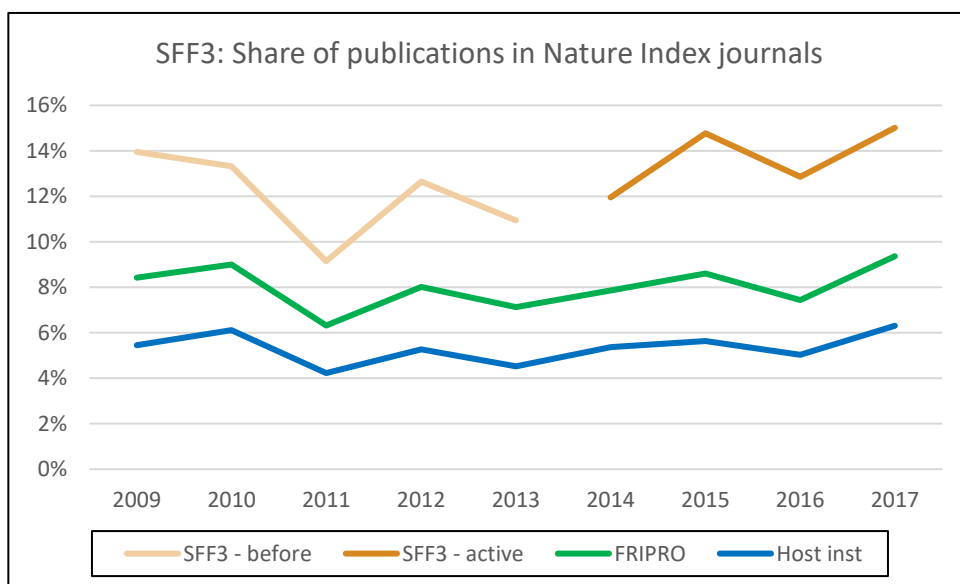


Figure 2.15. SFF3: Share of publications in journals in Nature Index journals.

2.4.4 Variations among the SFFs

We find large variations between the SFFs with regard to their ambitions in levels of publishing, as shown in Figure 2.17. Most of the variations on the Nature Index indicator are due to differences in thematic research profiles.

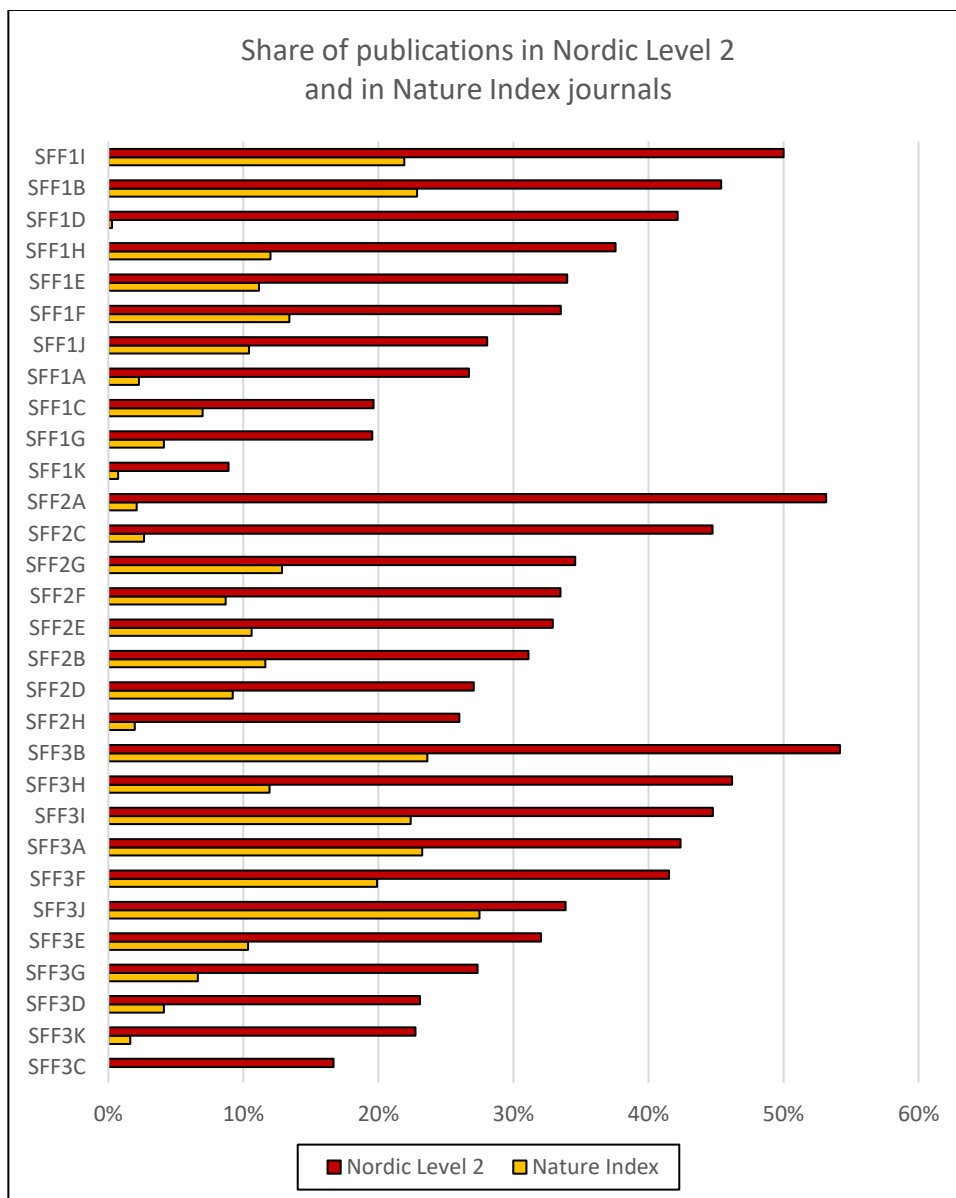


Figure 2.16. Level of publishing measured as share of publications in Nordic Level 2 journals and in Nature Index journals. Each SFF is represented by an anonymous code.

Table 2.5. Share of publications on Nordic Level 2 before, during and after the active SFF. Each SFF is represented by an anonymous code.

Generation	SFF	Before	Active	After
SFF1	SFF1D	38,5 %	42,0 %	46,6 %
SFF1	SFF1I	53,8 %	38,4 %	32,8 %
SFF1	SFF1B	31,3 %	35,3 %	34,1 %
SFF1	SFF1F	30,4 %	31,1 %	39,2 %
SFF1	SFF1H	22,4 %	29,3 %	20,9 %
SFF1	SFF1E	38,4 %	28,3 %	20,7 %
SFF1	SFF1A	25,0 %	25,4 %	32,0 %
SFF1	SFF1J	21,3 %	25,3 %	28,4 %
SFF1	SFF1G	23,6 %	17,3 %	15,0 %
SFF1	SFF1C	21,8 %	16,5 %	17,2 %
SFF1	SFF1K	6,6 %	8,4 %	4,0 %
SFF2	SFF2A	51,7 %	52,4 %	
SFF2	SFF2C	34,6 %	44,1 %	
SFF2	SFF2F	28,5 %	29,5 %	
SFF2	SFF2E	27,7 %	27,0 %	
SFF2	SFF2G	31,3 %	26,8 %	
SFF2	SFF2B	16,7 %	25,7 %	
SFF2	SFF2H	23,0 %	24,8 %	
SFF2	SFF2D	26,0 %	23,2 %	
SFF3	SFF3B	46,2 %	43,1 %	
SFF3	SFF3H	37,5 %	42,4 %	
SFF3	SFF3A	26,8 %	38,0 %	
SFF3	SFF3I	32,1 %	37,6 %	
SFF3	SFF3F	28,1 %	32,8 %	
SFF3	SFF3J	28,7 %	31,0 %	
SFF3	SFF3E	22,6 %	26,8 %	
SFF3	SFF3G	29,5 %	23,5 %	
SFF3	SFF3K	23,9 %	22,2 %	
SFF3	SFF3D	29,4 %	20,0 %	
SFF3	SFF3C	17,8 %	16,7 %	

2.5 Collaboration

2.5.1 Collaboration and the focus of the evaluation

Indicators of collaboration are relevant for two of the general questions for this study: “What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?” and “To what extent are the researchers at SFF centres internationally recognised and competitive?”. Given the general focus on scientific impact and ground-breaking research in this analysis, this chapter puts more emphasis on international than national collaboration. As can be seen in *Table 2.6*, there is a clear relation between citation impact and collaboration. Publications based on international collaboration, particularly with the world’s leading research organizations, are more cited. The distinction we make here between international collaboration in general and collaboration with the leading and top institutions in the world (according to citation impact) will be further explained below.

Table 2.6. Articles from Norway 2004-2017 and their citation impact in different international collaboration relations. Top and leading universities are defined below.

	Number	Share of total	10% citation indicator	1 % citation indicator
In collaboration with 42 top universities	14,907	10,5 %	29,5 %	7,4 %
In collaboration with 273 leading universities	49,135	34,6 %	20,0 %	3,8 %
In international collaboration	84,311	59,4 %	15,6 %	2,6 %
Total articles	141,839	100,0 %	11,9 %	1,7 %

The question about the impact of the SFF funding scheme on national and local collaboration is important because the answers can say something about the local effects and the effects on the Norwegian research system. Our results are presented in section 2.5.7.

2.5.2 Indicators of international collaboration

We chose to use the CWTS Leiden Ranking to differentiate between research organizations abroad, partly because the data from the ranking are openly available and partly because we are confident in the methods by which the ranking is created. The Leiden Ranking 2019 includes 963 universities worldwide that were selected by a minimum number of Web of Science indexed publications in the period 2014–2017. There are five Norwegian universities in the ranking – the same five

that appear as host institutions in our study. They are of course not included in our analysis of collaboration with other organizations abroad.

Among the 958 remaining universities, we used the 1 and 10 per cent indicators to select the most highly cited universities.³ () First, we used a threshold of 1,2 per cent on the 1 per cent indicator and of 12 per cent on the 10 per cent indicator. These thresholds were applied both in general (all areas combined) and in each of five main areas used in the ranking (Biomedical and health sciences, Life and earth sciences, Mathematics and computer science, Physical sciences and engineering, Social sciences and humanities) to allow for specialized research profiles. A total of 273 universities were above these thresholds. This group of universities is named *leading universities* in the following.

Then we applied a threshold of 1,6 per cent on the 1 per cent indicator and of 16 per cent on the 10 per cent indicator. Only 42 universities were above these thresholds. We name them *top universities* in the following. They are presented in *Table 2.7*.

³ Here, we used the 1 and 10 per cent citation indicators as they are published for the ranking by CWTS. Their indicators are in principle the same as we use here, but CWTS base them on fractional counting and field-normalize the indicators with reference to the averages in 4,535 micro-level fields of science (not available in our data). Hence, the scores we used for the thresholds are not directly comparable to the scores we use elsewhere in this study.

Table 2.7. The selected 42 top universities for the study of international collaboration.

University	Country
Massachusetts Institute of Technology	United States
Harvard University	United States
Stanford University	United States
California Institute of Technology	United States
Princeton University	United States
University of Chicago	United States
University of California, Berkeley	United States
Yale University	United States
University of California, Santa Barbara	United States
Northwestern University	United States
University of Oxford	United Kingdom
New York University	United States
University of California, Irvine	United States
University of Pennsylvania	United States
University of California, Santa Cruz	United States
Columbia University	United States
Rice University	United States
Ecole Polytechnique Fédérale de Lausanne	Switzerland
University of Exeter	United Kingdom
City University of Hong Kong	China
University of California, Los Angeles	United States
University of Cambridge	United Kingdom
Eidgenössische Technische Hochschule Zürich	Switzerland
Weizmann Institute of Science	Israel
University of Washington - Seattle	United States
Washington University in St. Louis	United States
University of Geneva	Switzerland
University of California, San Francisco	United States
London School of Hygiene & Tropical Medicine	United Kingdom
Shenzhen University	China
University of Leeds	United Kingdom
University College London	United Kingdom
University of North Carolina, Chapel Hill	United States
University of California, San Diego	United States
Duke University	United States
Cornell University	United States
University of Texas at Austin	United States
University of Colorado, Boulder	United States
Brown University	United States
Hong Kong University of Science and Technology	China
Imperial College London	United Kingdom
Utrecht University	Netherlands

Examples of the collaboration indicators are presented in *Figure 2.18* (host institutions) and *Figure 2.19* (Norway). The trend is increased international collaboration in all relations. This is in itself an international trend which is also seen in other countries. The degree of collaboration is almost the same for the host institutions and for Norway in general.

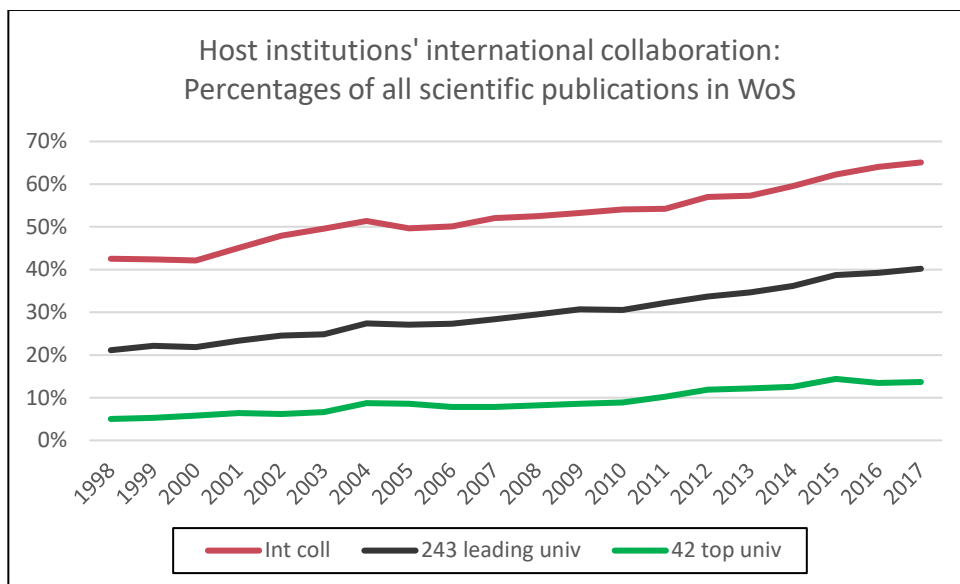


Figure 2.17. Host institutions. Shares of articles with international collaboration in general, collaboration with 273 leading universities, and collaboration with 42 top universities.

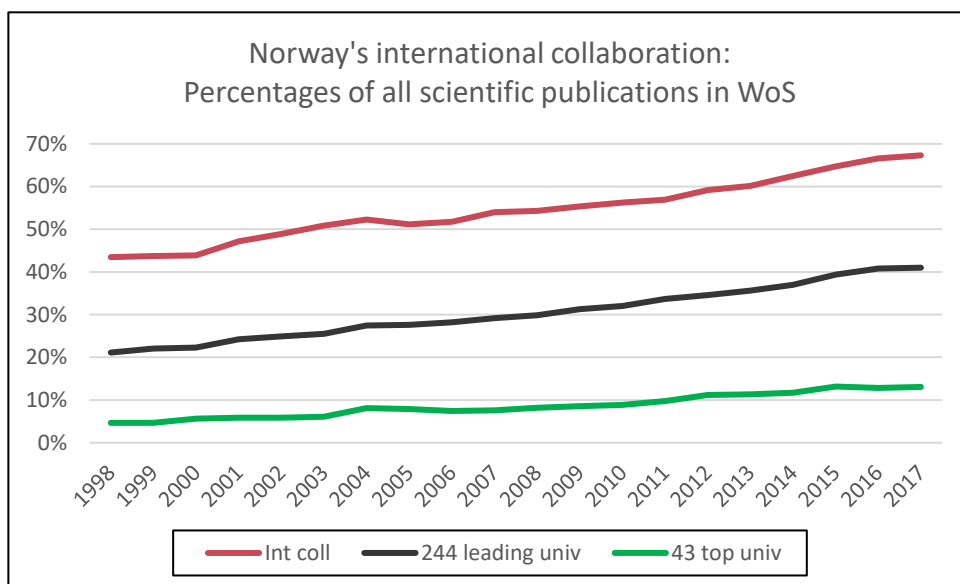


Figure 2.18. Norway. Shares of articles with international collaboration in general, collaboration with 273 leading universities, and collaboration with 42 top universities.

2.5.3 International collaboration in general

All three generations of SFF have relatively more international collaboration than their host institutions and FRIPRO grantees. Apart from this, the trends are similar, as seen in Figures 2.10-2.22.

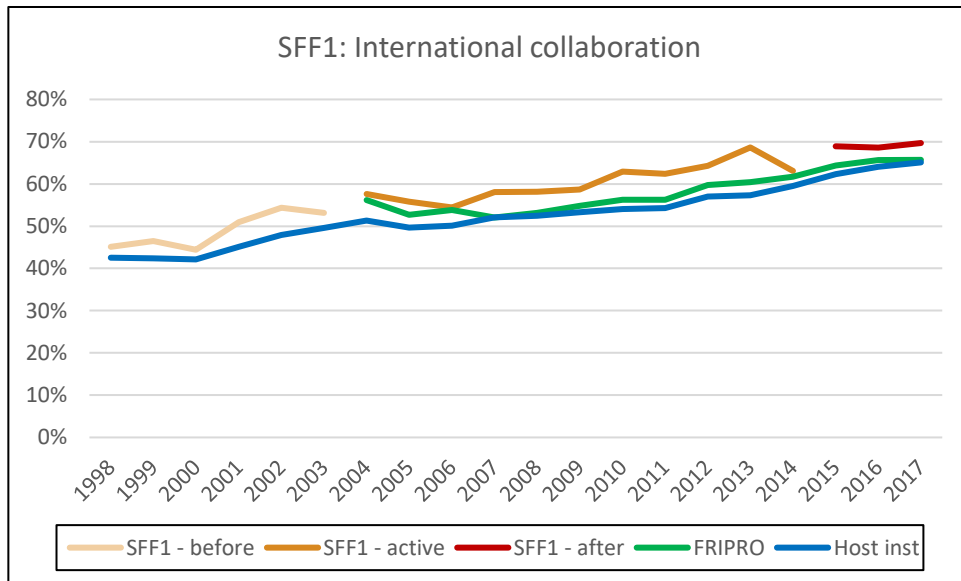


Figure 2.19. SFF1 and international collaboration (external co-authors) measured as share of all articles.

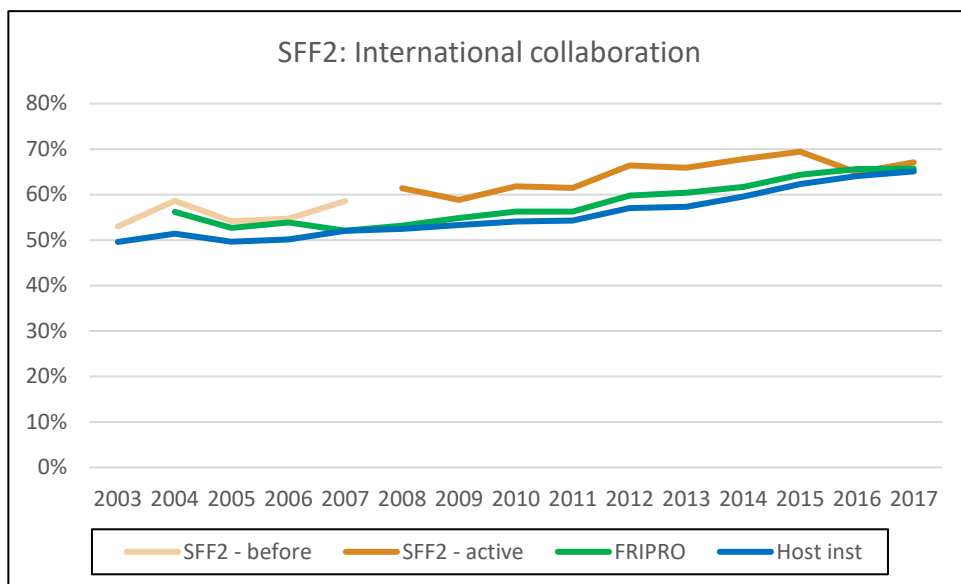


Figure 2.20. SFF2 and international collaboration (external co-authors) measured as share of all articles.

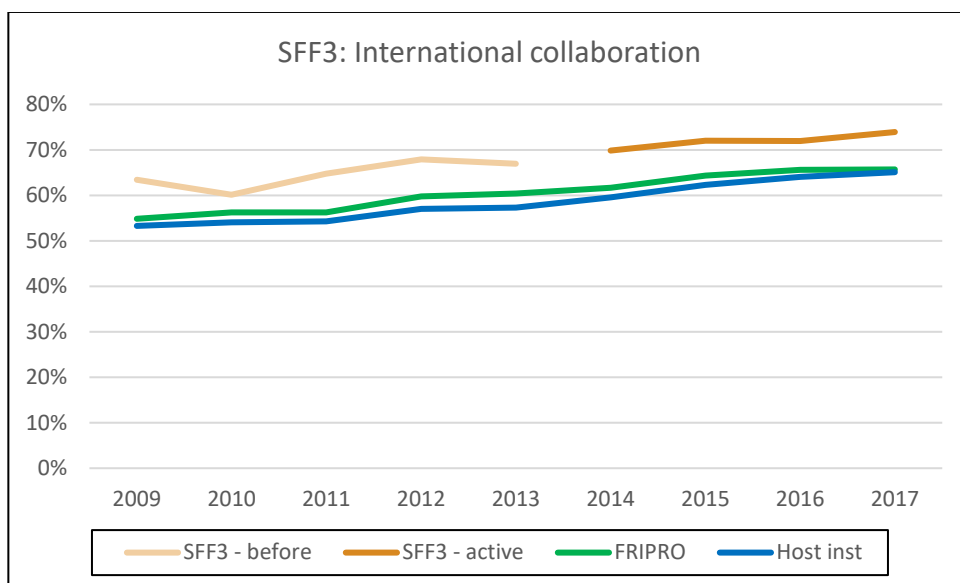


Figure 2.21. SFF3 and international collaboration (external co-authors) measured as share of all articles.

2.5.4 Collaboration with 273 leading universities

Over time, there is a clear trend towards relatively more collaboration with leading universities abroad, both in Norwegian research in general and at the host institutions. By relatively more, we mean that these increases are steeper than for international collaboration in general, as seen in section 2.5.2 above. Both FRIPRO and SFF-related articles follow this trend on a higher level, as measured by shares of articles. There is a steeper increase for the SFFs from 2010 onwards followed by a stabilization four years later. This is a deviation from the trends for FRIPRO and the host institutions.

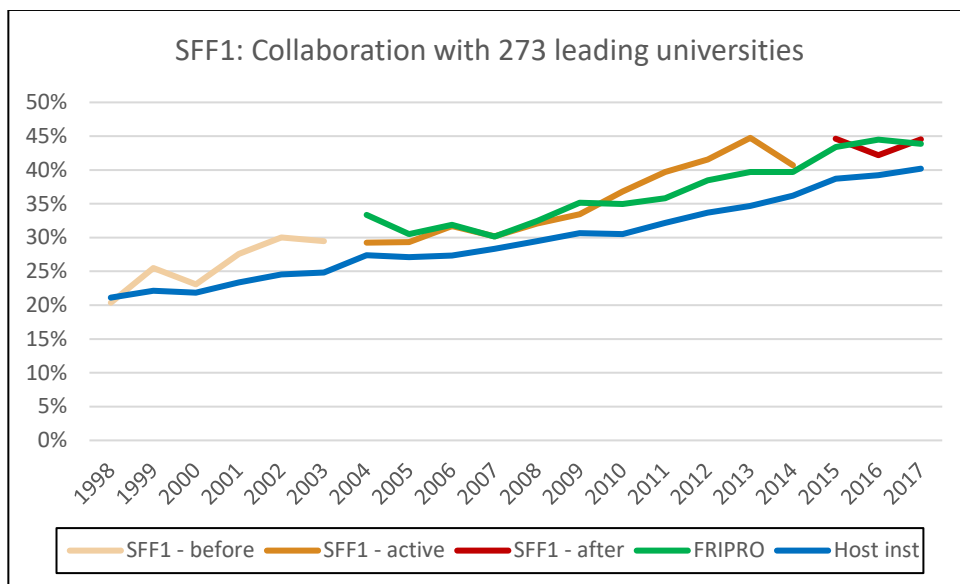


Figure 2.22. SFF1 and collaboration with 273 leading universities (external co-authors) measured as share of all articles.

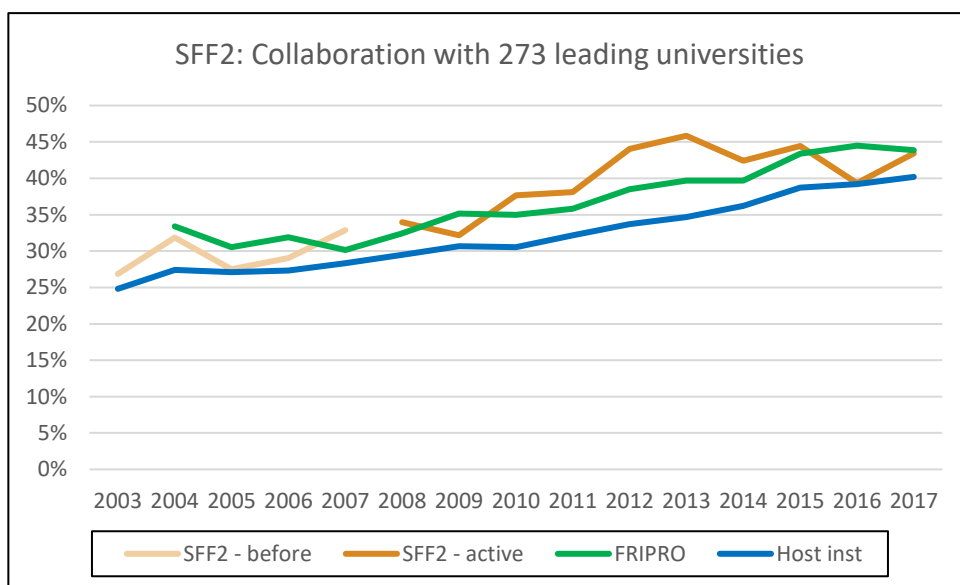


Figure 2.23. SFF2 and collaboration with 273 leading universities (external co-authors) measured as share of all articles.

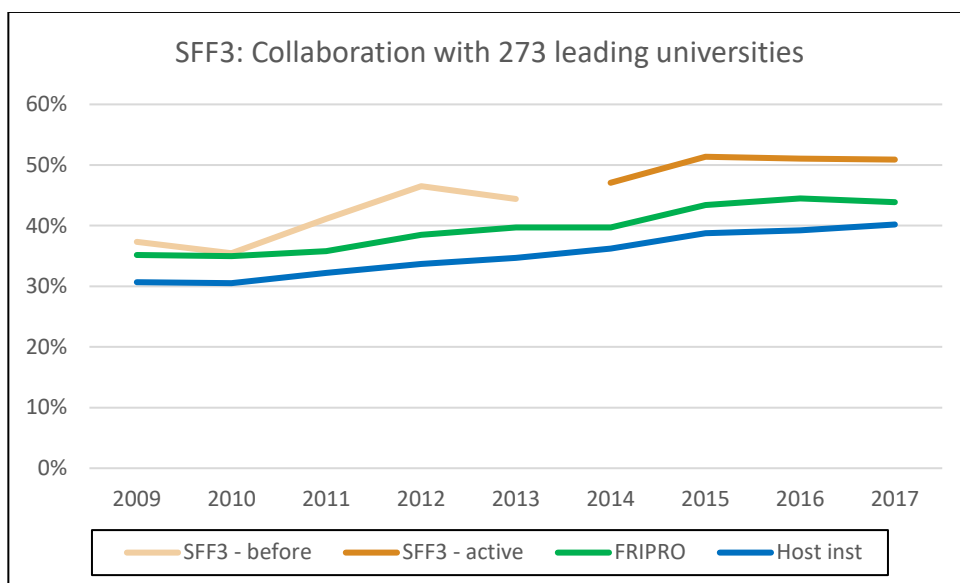


Figure 2.24. SFF3 and collaboration with 273 leading universities (external co-authors) measured as share of all articles.

2.5.5 Collaboration with 42 top universities

The trends are even more characteristic in the development of collaboration with the top universities. We see a steep increase in the shares of articles dedicated to collaboration with top universities after the SFF scheme was introduced. All three generations deviate at a higher level from the general trend for FRIPRO and the host institutions. This seems to be one of the effects of the funding scheme. But for some reason unknown to us, there are decreasing trends after 2013. We see an increase followed by a decrease for all three generations of SFF (figures 19-21), but most markedly in the first and second generation. SFF1 has 110 articles with top university collaboration in 2009. The number increases to 289 in 2012 and decreases to 240 in 2014. SFF2 has 80 articles with top university collaboration in 2009. The number increases to 186 in 2012 and decreases to 164 in 2014.

As mentioned above, Figure 2.19 is interesting to compare to the 1 per cent citation indicator.

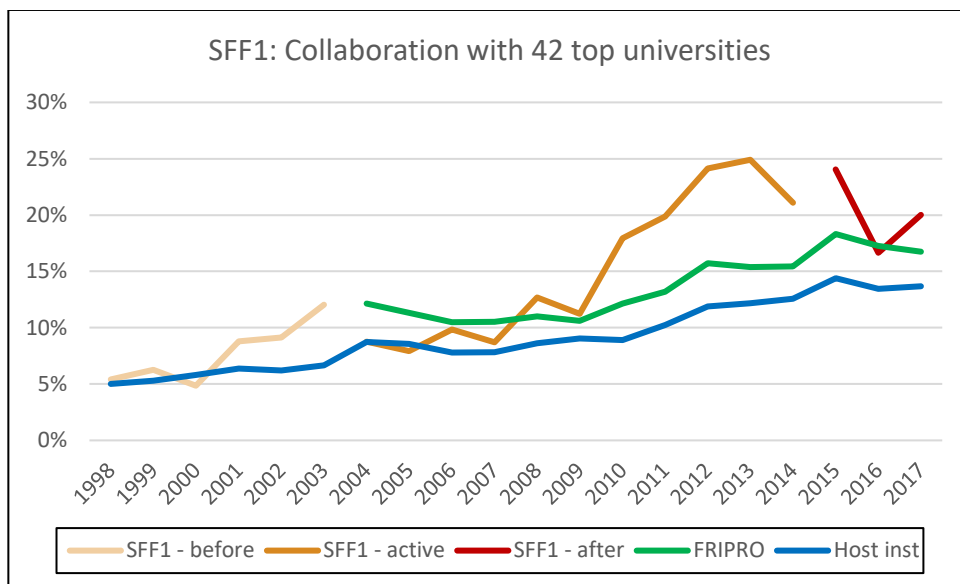


Figure 2.25. SFF1 and collaboration with 42 top universities (external co-authors) measured as share of all articles.

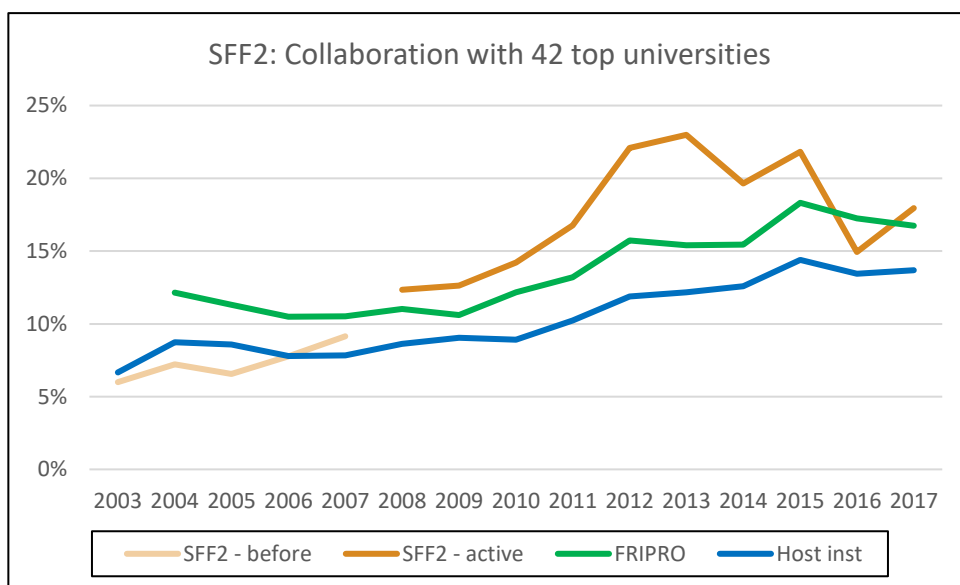


Figure 2.26. SFF2 and collaboration with 42 top universities (external co-authors) measured as share of all articles.

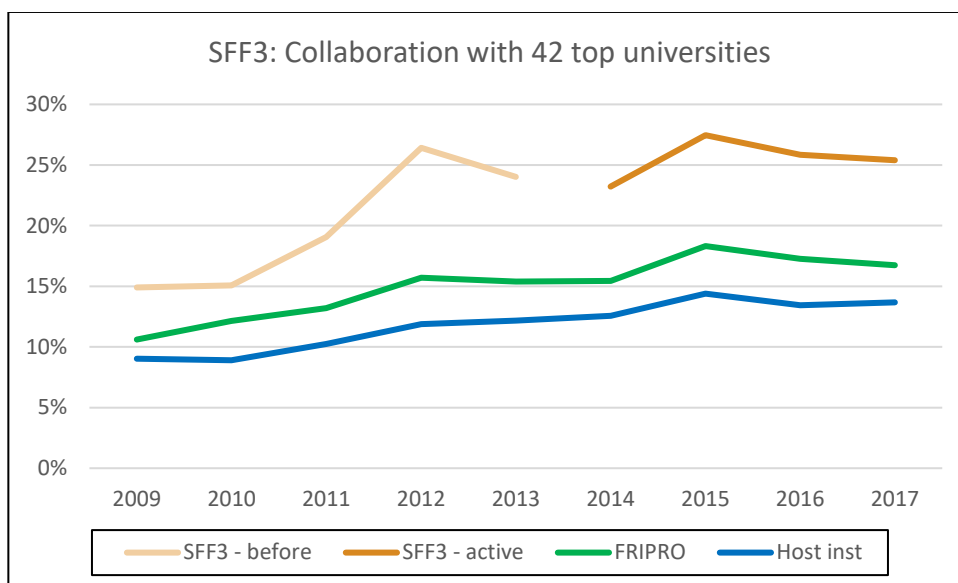


Figure 2.27. SFF2 and collaboration with 42 top universities (external co-authors) measured as share of all articles.

2.5.6 Variations among the SFFs

There are large variations among the SFFS in the degree of international collaboration. Some of these variations are probably related to differences in thematic research profiles. International collaboration, particularly with top universities, can be more or less relevant depending on field of research. The SFF3 generation stands out with relatively more collaboration with leading and top universities.

Table 2.8 shows the degree of collaboration with the 42 top universities before, during and after the active period of each SFF. There are two clear examples of SFFS with a relative decrease in collaboration after the SFF has become active.

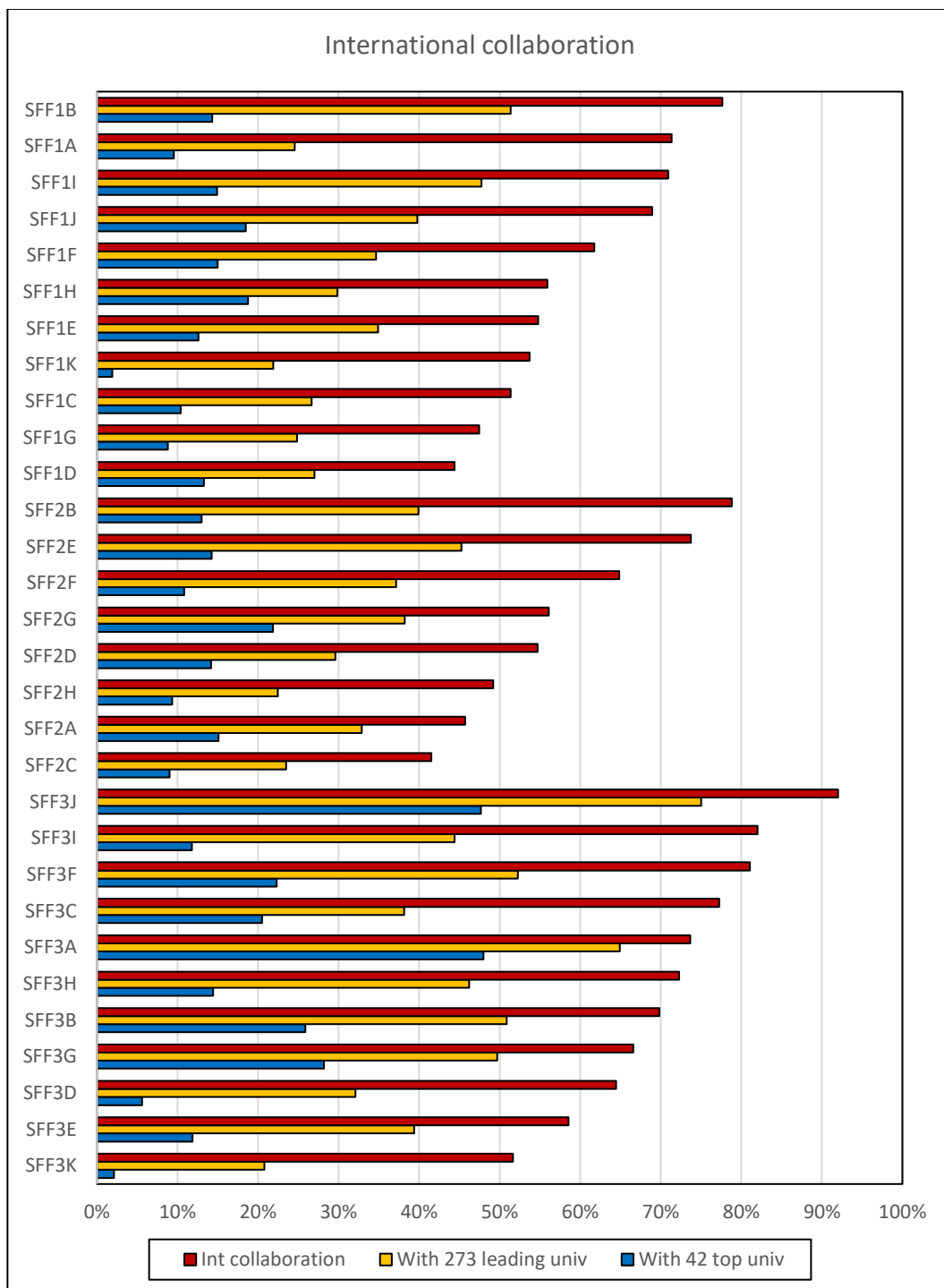


Figure 2.28. Percentage of articles in three international collaboration dimensions during the active periods of each generation of SFF. The centres are ranked by generation and the shares of articles with international collaboration within each generation. Each SFF is represented by an anonymous code.

Table 2.8. Percentage of articles in collaboration with 42 top universities before, during and after the active SFF. Each SFF is represented by an anonymous code.

Generation	SFF	Before	Active	After
SFF1	SFF1J	6,9 %	18,3 %	20,0 %
SFF1	SFF1H	7,9 %	16,6 %	0,5 %
SFF1	SFF1F	6,3 %	14,6 %	26,7 %
SFF1	SFF1B	8,7 %	14,4 %	18,4 %
SFF1	SFF1I	3,1 %	14,4 %	10,9 %
SFF1	SFF1D	4,8 %	12,0 %	13,7 %
SFF1	SFF1E	18,9 %	12,0 %	12,1 %
SFF1	SFF1C	3,6 %	11,2 %	14,1 %
SFF1	SFF1A	20,8 %	9,9 %	4,0 %
SFF1	SFF1G	3,1 %	9,2 %	13,1 %
SFF1	SFF1K	1,6 %	2,0 %	6,9 %
SFF2	SFF2G	5,2 %	17,0 %	
SFF2	SFF2A	12,3 %	14,0 %	
SFF2	SFF2E	8,7 %	13,6 %	
SFF2	SFF2D	11,4 %	12,6 %	
SFF2	SFF2B	4,3 %	11,9 %	
SFF2	SFF2F	6,7 %	10,2 %	
SFF2	SFF2H	11,3 %	10,1 %	
SFF2	SFF2C	0,0 %	8,0 %	
SFF3	SFF3A	20,0 %	48,0 %	
SFF3	SFF3J	33,9 %	47,7 %	
SFF3	SFF3G	13,0 %	28,2 %	
SFF3	SFF3B	25,9 %	25,9 %	
SFF3	SFF3F	15,7 %	22,3 %	
SFF3	SFF3C	7,5 %	20,5 %	
SFF3	SFF3H	9,5 %	14,4 %	
SFF3	SFF3E	11,1 %	11,8 %	
SFF3	SFF3I	4,7 %	11,8 %	
SFF3	SFF3D	17,6 %	5,6 %	
SFF3	SFF3K	2,8 %	2,1 %	

2.5.7 National and local collaboration

Our analysis of international collaboration above was based on a standardization of the addresses of 273 non-Norwegian institutions in our data. This procedure is not sufficient for a study of local collaboration. We need to focus on authors related to an SFF and their co-authors within the same institution. We therefore chose to

rely on the NSI database and the available time series of data, 2011-2018 (see section 2.1.3 above). We include the year 2018 in this analysis because we do not need to consider citations. We include all scientific publications in NSI, not only those indexed in Web of Science. The total is 22,536 scientific publications related to the SFFs that were published during the eight years 2011-2018. We analyse whether these articles have co-authors who are not affiliated with an but instead are affiliated with:

- The host institution
- Other Norwegian institutions
- Other SFFs

In this analysis, we chose not to distinguish between different generations of SFF since the time period is limited and at least two generations are active all of these years. Instead, our focus is on whether there is any change in the collaboration patterns.

The results are presented in Figure 2.30 below. More than half of the articles from the SFFs are published with non-SFF co-authors at the host institutions. There is a slightly increasing trend, indicating that the SFFs do not break away from their normal collaboration patterns at their institutions. Instead, one half of the publications is an indication that there is interdependency between the research performance of the SFFs and their host institutions.

There is collaboration with other Norwegian institutions (representing around 30 per cent of the Norwegian output) in around 20 per cent of the articles. This share is stable. Again, the SFF scheme does not seem to affect normal collaboration patterns.

Interestingly, another 20 per cent of the publications have co-authors in other SFFs. However, this is as expected given that the SFFs represent the most active research environments in Norway and that some of the most productive researchers participate in more than one SFF.

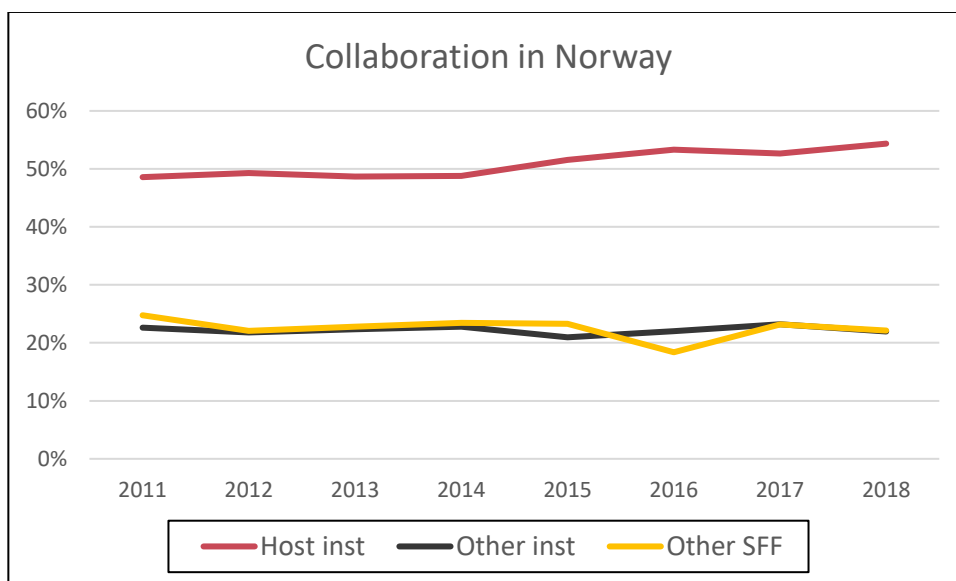


Figure 2.29. Articles from SFF (three generations) published in collaboration with non-SFF researchers who are affiliated with the host institutions, other institutions in Norway, and other SFF.

2.6 Main findings from the bibliometric analysis

Four specific questions have been identified in advance by the RCN as particularly relevant to be addressed partly with the help of bibliometric analysis:

- *To what extent do the centres produce ground-breaking research?*
- *To what extent are the researchers at SFF centres internationally recognised and competitive?*
- *Has the SFF scheme helped to enhance scientific quality, and if so, how?*
- *What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?*

The aim of this chapter has been to answer these questions – to the extent that they can be enlightened by bibliometric methods. We used the introduction to explain the limitations. Bibliometric indicators cannot directly express qualitative notions such as ‘scientific quality’ and ‘ground-breaking research’. We chose *citation* indicators, proportions of highly and top cited articles compared to the world average, the host institutions, and FRIPRO-related articles, as to provide part of the basis to answer the questions. We added indicators of collaboration with the world’s leading and top universities and indicators of journals’ prestige to broaden the same basis. We also shortly analysed local and national collaboration to cover all aspects of the fourth question. Tentative answers to the four questions can thereby be given:

- *To what extent do the centres produce ground-breaking research?*

Some SFF in each of the three generations, particularly in the first and third generations, have relatively large proportions of highly cited and top cited articles. The relatively high number of top cited articles emanating from the SFF *might* indicate ground-breaking results, but this needs to be validated by experts in the field.

There are large variations within each generation with regard to citation impact, as summarized in *Table 2.9* below. Although each generation as a group performs clearly above their host institutions in Norway (representing 71 per cent of Norwegian research in Web of Science), a few centres are even performing below the Norwegian average. However, most SFFs are clearly above the Norwegian average.

A tentative answer to the first question is: Some SFF in each generation are probably producing ground-breaking research. The probability is higher for SFF than for Norwegian research in general and even compared to FRIPRO grant receivers.

- *To what extent are the researchers at SFF centres internationally recognised and competitive?*

High numbers of top cited and highly cited articles are indications of international recognition as well. We also see in *Table 2.9* that the high-performing SFF publish relatively large proportions of their articles in collaboration with top and leading universities abroad, and that high shares of their articles are published in the most prestigious journals.

A tentative answer to the second question is: Most SFFs in each generation have international collaboration and publishing profiles indicating that the researchers are indeed internationally recognized and competitive. In this respect, researchers at some SFFs in each generation clearly stand out from Norwegian researchers in general as well as from FRIPRO grant receivers.

- *Has the SFF scheme helped to enhance scientific quality, and if so, how?*

Again, there are large variations among the centres in each generation. The trends are generally positive for those with high performance and for each generation in general. The positive trends concur with similar trends for Norwegian research in general, perhaps indicating that the SFF have contributed positively to their Norwegian research environments.

A tentative answer to the third question is: Yes, the indicators can be interpreted in this direction: The SFF seem to have helped the enhancement of scientific quality in Norwegian research. Bibliometrics usually cannot tell *how* such possible improvements happen, but we have seen an indication in the increased collaboration with leading and top universities abroad.

- *What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?*

International collaboration has been increasing steadily in the period studied here, both from a Norwegian and an international perspective. The SFF stand out from the general Norwegian pattern with a rapid increase since 2009 in the share of articles with top universities (mainly in the USA). This trend reaches a peak around 2013.

A tentative answer to the fourth question is: The SFF has indeed steered the general Norwegian international collaboration pattern in the direction of the world's most influential institutions in research. At the same time, the national and local collaboration patterns remain stable, indicating the SFF are not breaking away from close collaborations with their research environments.

The summary in *Table 2.9* below should be interpreted with care. This bibliometric study is not aimed at providing the basis for an evaluation of each SFF. The focus is on the funding scheme itself. The most important message in the table is that there are *large variations* within each generation of SFF when it comes to performance that can be measured by bibliometric indicators. These indicators are based on scientific communication and collaboration in scientific articles. They thereby provide relevant about *scientific performance*. To the extent that SFF have been established with *other* aims than scientific progress, e.g. with the aim of industrial innovation, bibliometric performance indicators are not relevant.

Table 2.9. Summary of results of the bibliometric analysis. Indicators (high, medium, low) are relative to other SFF and the baseline (host institutions).

Generation	Citations	Trend	Int coll	Trend	Publ level	Trend
SFF1	High	↗	High	↗	High	→
	High	↗	High	↗	High	↘
	High	→	High	↗	High	→
	High	↗	High	↗	Medium	↗
	High	↗	Medium	↗	High	→
	Medium	↘	High	↘	Medium	↘
	Medium	↗	Medium	↗	Low	↘
	Medium	↘	Low	→	Low	→
	Low	↘	High	↗	Medium	↗
	Low	→	Medium	↗	Low	↘
Low	↘	Medium	↘	Medium	→	
SFF2	High	↗	High	↗	Medium	→
	High	↗	Medium	↗	High	↗
	High	↗	High	↗	Medium	↘
	High	→	High	↗	Medium	→
	Medium	↗	High	→	High	→
	Medium	→	Medium	→	Low	→
	Low	↘	High	↗	Medium	↗
	Low	↘	Low	→	Medium	→
SFF3	High	↗	High	↗	High	↗
	High	↗	High	↗	High	↗
	High	→	High	↗	High	→
	High	→	High	↗	High	→
	High	↘	High	→	High	→
	High	↗	High	↗	Medium	↘
	High	↗	Medium	→	Medium	↗
	High	→	Medium	↗	Low	→
	Medium	↗	Medium	↗	High	↗
	Low	→	Low	↘	Low	↘
	Low	↘	Low	→	Low	→

Note: The measurement is based on the active periods of the SFF. Trends (up, down, stable) are based on possible changes in performance between before and after the SFF became active. Citations are based on a combination of the 1 per cent and 10 per cent indicators. International collaboration is based on the degree of collaboration with top/leading universities relative to international collaboration in general. Publishing level is based on the Nordic Level 2 indicator. The purpose of the table is to show the variation within each generation, not the performance of each (anonymized) centre.

3 Recruitment and researcher careers

Attracting and developing future research talents has been another main purpose of the SFF-scheme, ever since the first generation of centres in 2002. This was apparent already in the Government white paper which officially launched the idea of establishing the scheme (St.meld. nr. 39 (1998-99) *Forskning ved et tidsskille*). Today, nearly 20 years after the establishment of the scheme, it is both relevant and to some extent possible to map the careers of those PhDs, Postdocs and researchers who have been involved in the centres. Two questions raised in the terms of reference are of particular importance here:

- *What impact does the SFF scheme have on the careers of students and other employees of the centres?*
- *What impact has the scheme had on recruitment to Norwegian research?*

In the following sections we describe the approach and main findings from our registry-based analysis of these questions.

3.1 Main approach

The career mapping is primarily based on matching the complete list of SFF-personnel provided by RCN with NIFU's Research Personnel Register (RPR). A similar approach has been used for the same purpose in a number of previous studies carried out by NIFU (see for instance Ramberg et al, 2015; Solberg et al 2017 and Solberg et al, 2019). This matching enables us to carry out register based mapping of the careers of nearly half of all 4604 persons who have been involved in the centres⁴. The remaining half consists of persons who, for various reasons, are not registered in the RPR by 2017. For most of these persons we have performed manual searches to identify their current position and location.

While the RPR provides a complete overview of careers *within* the Norwegian research system (as described above), the register does not cover researchers who pursue careers in the business enterprise sector, the private non-profit sector and/or in non-R&D-performing parts of the public sector. In addition, and more importantly, the register only covers the Norwegian system, which means that researchers who pursue careers outside Norway will not be captured by RPR after

⁴ The total number of SFF researchers in this part of the analysis differs from the numbers used for the bibliometric analysis in chapter 2 and the analysis of participation in EU-projects in chapter 4. The explanation for this is given in the introduction, see chapter 1.3

leaving the country, except in those cases where they maintain an affiliated position of more than 40 per cent at a Norwegian institution included in the RPR. In these cases, we have traced their careers by conducting manual web-based searches through ResearchGate, LinkedIn, Google Scholar and other social platforms where active researchers are likely to appear.

3.1.1 Methodological aspects

Two aspects are particularly important to bear in mind when interpreting the results of this career mapping:

Time aspect

Firstly, the four generations of SFF-centres cover different time periods, which requires different approaches. The figure below illustrates the different time-periods as well as total budgets and staff involved in all four generations of SFF.

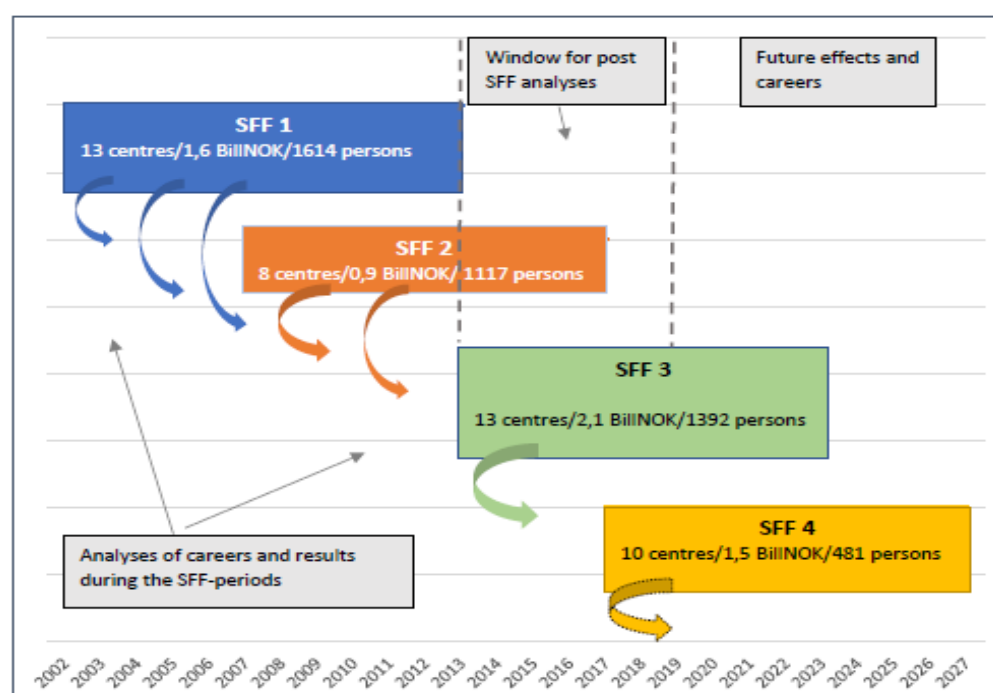


Figure 3.1: Overview of the SFF-scheme by generations, budgets and total personnel.

Source: NIFU, based on RCN

As the figure illustrates, tracing career paths after the SFF-period is most relevant for the SFF1-scheme and partly for SFF2. For SFF3 and SFF4, there is little or no room for studying the careers of SFF-personnel after their involvement in the centres. Therefore, we focus more on the careers and current positions of researchers involved in SFF1 and SFF2. However, for all generations, researchers enter and

exit the centres during the active period of the centre. In addition, we seek to identify “vertical careers” for SFF-researchers also during their active time within the centre(s).

Comparison groups and causality

The second aspect concerns comparison groups: While career tracking of selected researchers provides relevant information in itself, we need comparative data to see if the careers of SFF-researchers differ from general career patterns in the Norwegian R&D system. Again, the RPR as well as previous studies, provide a baseline for comparing SFF-careers with the total population of active researchers in the Norwegian research system as well as with more selective comparison groups. These comparisons are described further in the sections below.

Comparisons over time and with the entire Norwegian R&D system give us an indication as to the impact of the SFF scheme on career outcomes. Yet causal inferences should be made with caution. SFF status is far from randomly assigned. Given the prestige and resources attached, it seems reasonable to expect that SFF centres are better positioned than their competitors to recruit the most promising PhD students and postdocs, and the most qualified personnel, in general. As a result, the researchers who have been affiliated with an SFF could be expected to do better than the average Norwegian researcher even if they had not been part of the SFF scheme. Relatively minor career advantages among SFF personnel compared to other Norwegian researchers should therefore not be considered clear evidence of a causal impact of the SFF scheme.

3.1.2 An overview of the SFF-personnel

According to the project lists provided by RCN, 4604 persons have been involved in one or several SFF-centres. These researchers represent a variety of positions, roles and degrees of involvement, from fully dedicated centre-leaders to researchers in partner institutions whose involvement is only marginal.

According to the staff lists provided by RCN to this project, the total SFF staff consisted of the following estimates divided in three broad categories (according to their most recent position): i) 1700 Ph.D fellows, ii) 1000 Postdoctoral fellows and iii) 1600 professors/researchers

However, these lists were not based on complete registers and contained both duplicates, missings and inconsistent categories. After data cleaning, inclusion of additional information and matching with the Norwegian Research Personnel Register (see above), the total number of unique names was 4604 persons. Figure 3.2 displays how these (4604) persons match with the RPR.

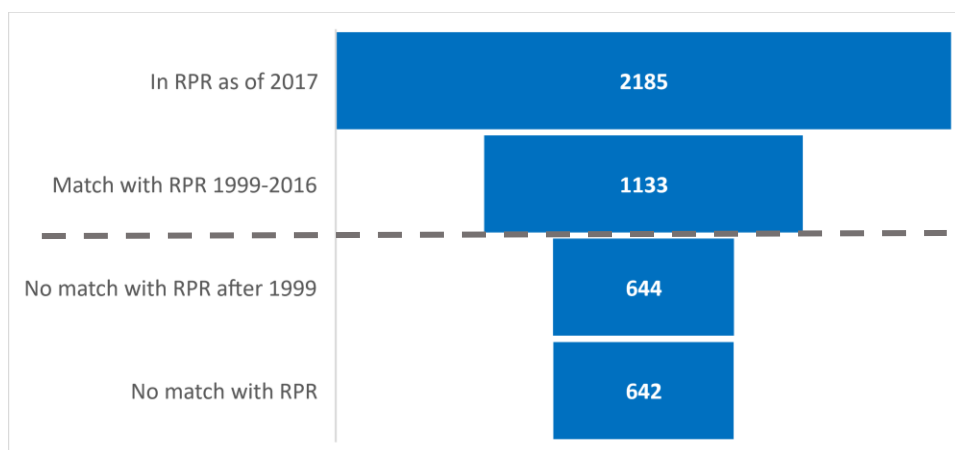


Figure 3.2: Overview of SFF personnel and match with NIFU's Research Personnel Register (RPR) by 2017.

Source: NIFU, based on RCN and RPR

As the figure shows, more than 600 persons have been involved in at least one SFF without any appearance in the Norwegian RPR. An equal number have been registered before 1999, but do not appear in our registers after that year.

While both categories are relevant in principle, we exclude these two groups (below the dotted line in Figure 3.2) from most of our career analyses. Since the RPR captures all researchers and university graduated personnel with a job share of 40 per cent or more in Norwegian institutions, we assume that SFF personnel not covered by the RPR are persons employed at partner institutions abroad and/or persons with only minor positions at Norwegian R&D institutions. By focusing on the persons who have been registered in RPR during the SFF-period, we are able to distinguish the most actively and formally involved persons. In addition, the RPR provides an opportunity to carry out register based analyses of the research careers of the persons in question. We close the chapter with a more cursory look at the careers of the personnel that fall below the dotted line in Figure 3.2. This information is, however, based on manual internet searches and less accurate.

3.2 Four generations of SFF: Baseline characteristics

This section provides the baseline for the career-tracking, and describes the SFF-affiliated personnel at the time when they joined their first SFF.

Coverage: For the *SFF personnel who have a match in RPR in the 1999-2017 period* (the 3318 persons above the dotted line in Figure 3.2), it is relatively straightforward to report their baseline characteristics during their first year in an SFF⁵.

When reporting age and gender distributions, we also include the 1286 researchers who do not have a match in RPR at any point in time, or whose only match predates 1999. The lack of a (recent) match in RPR means we are unable to report on variables that change over time, like sector and field of research, for this group.

For each of the variables gender, age, sector and field of research, we compare the distribution of all SFF researchers with available information to at least one of two relevant reference groups: First, we compare them to the subset of *SFF personnel who have a match in RPR in 2017* (2185 people), meaning they are still in the core Norwegian research system as of 2017. This comparison allows us to see whether there are obvious differences in gender, age, and initial sector and field of research between the SFF-researchers who are still active in the Norwegian research system and those who have left the system. Second, whenever possible, we compare them to the profile of all Norwegian research personnel. Occasionally, we restrict the latter comparison to research personnel in the Higher education sector and the Institute sector.

In order to account for differences over time, we report the characteristics of each SFF generation separately and compare with the core Norwegian research system for specific years.⁶

3.2.1 Gender and age composition

In studying the SFF-scheme's contribution to recruitment in the Norwegian research system, we start with the gender and age profile of the SFFs.

Gender balance

Figure 3.3 shows firstly that the gender balance in the full group of SFF affiliated personnel differs little from the group of SFF researchers still employed in the core Norwegian R&D system as of 2017. Hence, there is little sign of a gender difference

⁵ Due to data limitations, we make exceptions to this coding rule for two groups of researchers. First, 198 people have their only match in RPR before their first recorded participation in an SFF (but not before 1999). For this group, we use their reported characteristics the last year they are recorded in the RPR. Second, we lack information about what year 359 of the researchers first participated in an SFF. For this group, we report their characteristics for the first year in the first generation of SFFs they were affiliated with (2002 for SFF1, 2007 for SFF2, 2003 for SFF3, 2017 for SFF4).

⁶ We compare each SFF generation (except the fourth) to Norwegian averages 4-5 years into the operation of the SFF in order to compare with the profile of each centre when they are fully operative.

between those who leave and those who remain active in the core Norwegian research system.

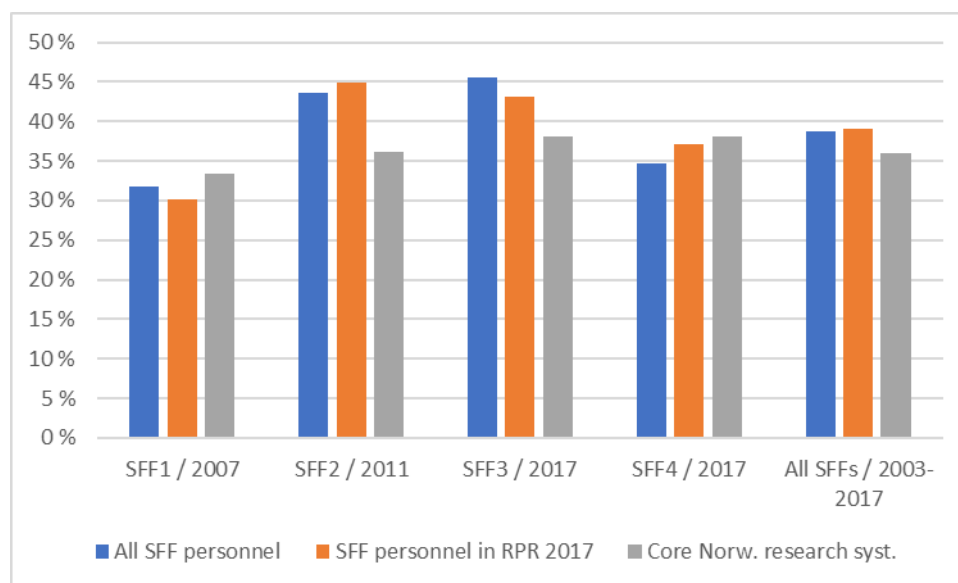


Figure 3.3: Share of women among SFF personnel and in the core Norwegian research system; by SFF generation.

Source: NIFU based on RCN-data and RPR

The picture is more mixed when we compare the gender profile of different generations of SFFs with the core Norwegian research system. In the first generation of SFFs, the share of women was slightly below the national average for the year in question. However, for the second and third generation, it stood above the national averages. While the share of women in the fourth generation falls just below the national average for 2017, it is important to keep in mind that the gender balance for this generation is observed only for the centres' first year of operation. Hence, the gender balance may change as the centres start recruiting more personnel.

If we break down the gender balance by age categories, the share of women decreases incrementally with age. While the share of women is 44 per cent among the SFF personnel below the age of 30, the share is down to 20 per cent among researchers above 60 years. Moreover, we find significant gender differences between sectors and fields of research. The share of women is significantly higher for SFF personnel with a background in medicine and the humanities (at about 54 per cent) than in technology (18 per cent). The share of women among SFF-researchers within mathematics/natural sciences and social sciences are 32 per cent and 39 per cent, respectively. This profile reflects to a large extent the general patterns of gender balance by fields of research within Norwegian academia, although the share of women in social sciences and mathematics/natural sciences is lower

for SFF researchers than in Norwegian academia (defined as higher education institutions).

Age profiles

To compare the age profile of SFF staff we use the same approach as above and compare the age profile of SFF personnel with the age of Norwegian researchers in general at given years.

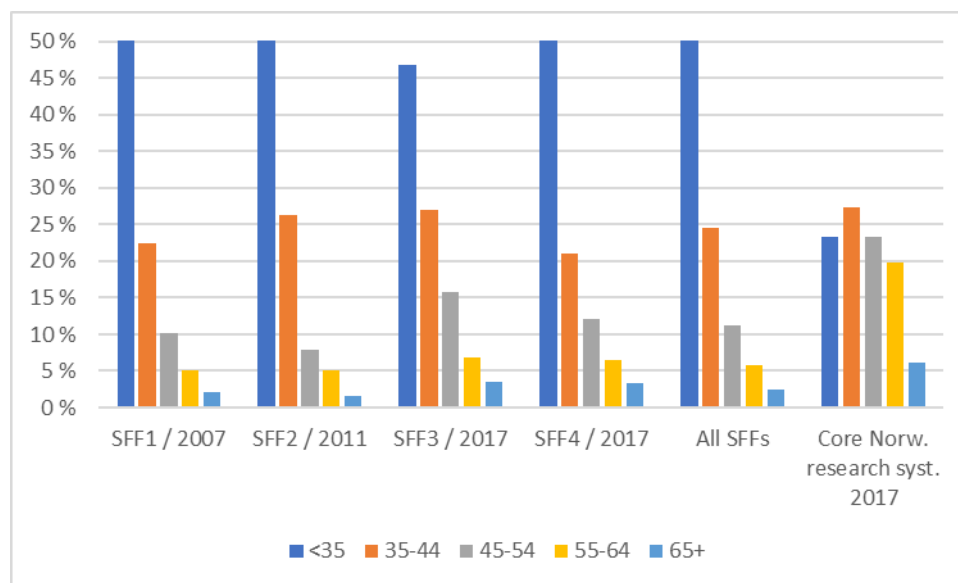


Figure 3.4: Age composition among SFF personnel and in the core Norwegian research system; by SFF generation.

Source: NIFU based on RCN-data and RPR

For the specific years selected for comparison, we observe that a majority of each SFF generation's personnel were below the age of 35, with gradually decreasing shares in the higher age categories. The share of researchers below the age of 35 in the SFFs is about twice as high as the share in the core Norwegian research system as a whole for the corresponding years,⁷ and the amount of researchers over 44 years correspondingly low.

⁷ It makes sense to restrict our figures for the comparison with the core Norwegian research system to 2017, because the age composition in the system has remained fairly constant in the whole SFF period.

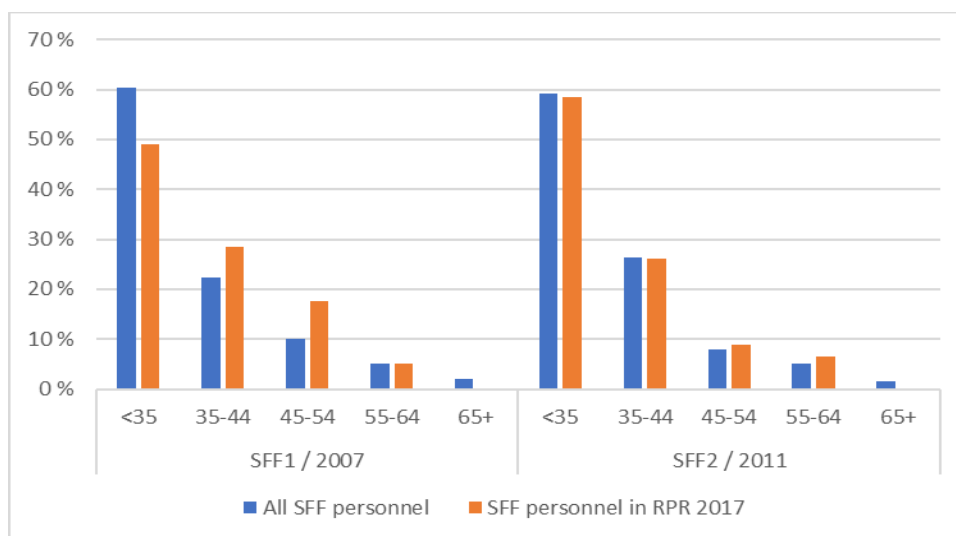


Figure 3.5: Age composition among SFF personnel; by SFF generation (SFF1 and 2).

Source: NIFU based on RCN-data and RPR

A comparison of the age of all personnel in the first two SFF generations to those who are still in the core Norwegian research system today in 2017 (Figure 3.5) suggests that the chance of having left Norwegian academia by 2017 is somewhat higher among researchers who were relatively young when they joined an SFF, and lower among researchers aged 35 and above. This indicates that researchers who joined SFFs as PhD-candidates and in other early stages of their careers are more likely to have found careers outside the core Norwegian research system.

3.2.2 SFF researchers by sector, field of research and academic position

Field of research

Figure 3.6 shows the distribution of SFF personnel by their field of research when first employed at an SFF⁸. Firstly, the data confirms that the SFF scheme as a whole has been dominated by researchers within mathematics and natural sciences.⁹ We also see a considerable share of researchers from medicine, especially in SFF3 and

⁸ Around 30 per cent of the SFF affiliated personnel are not registered in RPR in the SFF period (39 per cent in SSF4). Because we do not know their sector and field of research, these 1286 researchers are not included in the figures in this section. We also exclude the 2 per cent of SFF personnel who, while working at least 40 per cent in the core Norwegian research system, held their primary position outside it; i.e. elsewhere in the public sector, in the private sector, or outside Norway.

⁹ Mathematics and natural sciences category includes the 79 SFF researchers classified as 'Agriculture, fisheries and veterinary medicine' in the RPR. 7 persons classified as 'Administration/library' are not included in the figure.

SFF4. Social sciences stand for a higher share of SFF-researchers than technology both in SF2 and SFF4, while humanities stand for less than 10 per cent of researchers in all generations of SFF. This is of course highly contingent on the disciplinary profile of the centres and their host departments (see also chapter 2.2).

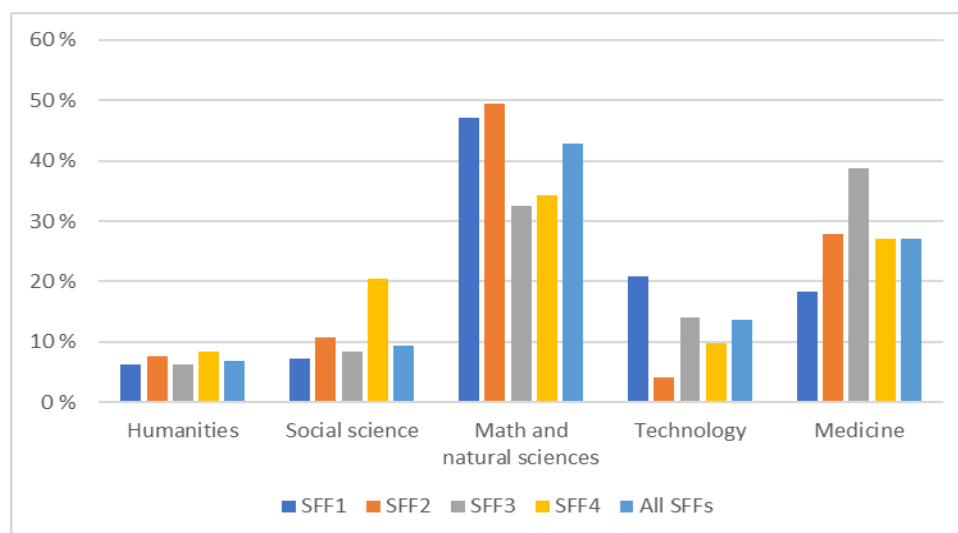


Figure 3.6: Fields of research among SFF personnel (in their first year in SFF) by SFF generation.

Source: NIFU based on RCN-data and RPR

When we compare all SFF personnel with the subset of SFF personnel who are still registered in the core Norwegian research system as of 2017, we do not find that researchers within particular fields have a stronger tendency to follow careers outside the core Norwegian research system. The largest difference is within mathematics and natural sciences in SFF2, which makes up a 5 percentage point lower share among the researchers still in the Norwegian system.

Academic position

To determine whether the centres and the scheme as such has recruited young or senior researchers, we also look at the academic position of SFF researchers at their first year of employment in the centres. As expected, given the scheme's strong focus on recruiting future research talents, we find that researchers first employed as PhD fellows, postdocs and researchers make up a larger share of all SFF personnel compared with the profile of the Norwegian HEI sector as a whole in 2017 (Figure 3.7).¹⁰ The share of professors and associate professors is

¹⁰ It makes sense to restrict our figures for the comparison with the core Norwegian research system to 2017, as the general distribution of academic positions in Norway has been fairly stable throughout the duration of the SFF scheme.

correspondingly low in the SFFs. When we compare the full group of SFF personnel to the subset of SFF researchers who are still in the core Norwegian research system in 2017, it is apparent that SFF researchers first employed as PhD fellows and postdocs are slightly more likely to have left the system by 2017 than the other SFF researchers. This reflects the age pattern revealed in section 1.2.1.

To put these numbers in perspective, a previous study of researchers in the core Norwegian research system found that about 35 per cent of the postdocs registered in 2001 and 2005 had left the system 6-8 years later (Gunnes and Børing, 2015). Although this is not directly comparable to our numbers, a rough comparison is possible. Arguably the most comparable SFF-group here is the postdocs from the second generation, of which about 40 per cent have left the core Norwegian research system by 2017. Thus, a rough comparison suggests that SFF postdocs follow a similar pattern to Norwegian postdocs in general in terms of whether they pursue careers within or outside the core Norwegian research system.

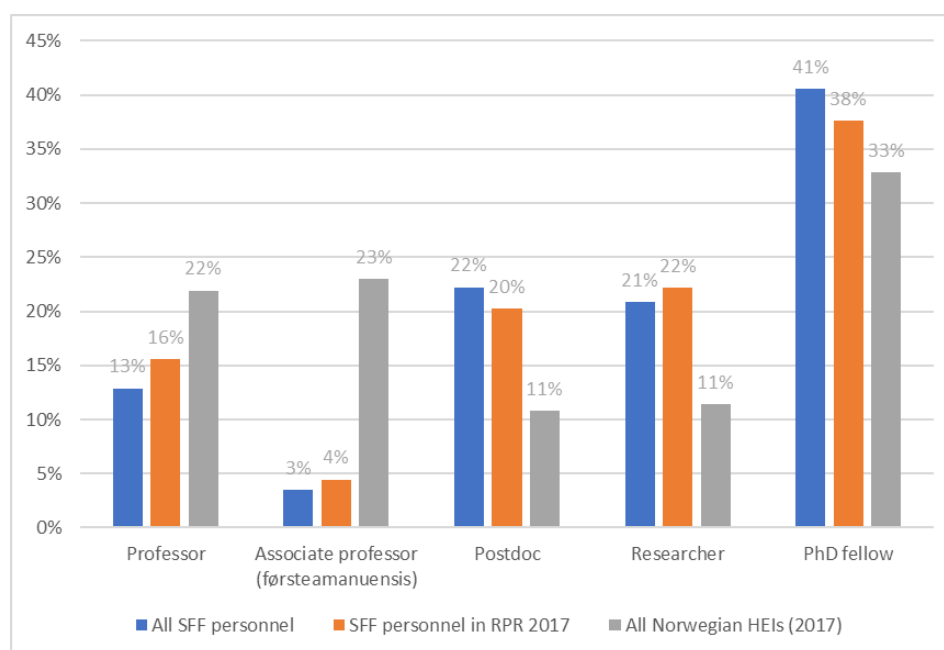


Figure 3.7: Academic positions among SFF personnel in their first year in SFF and in the Norwegian HEI sector; by SFF generation.

Source: NIFU based on RCN-data and RPR

3.2.3 Norwegian and foreign PhD degrees

Although the SFF scheme is largely geared towards developing future research talents in Norway, we see that a large share of SFF researchers already had completed a PhD degree when they started in their respective centres. For three selected years (2007, 2011 and 2017), around half of all SFF researchers had a PhD

at their first year of employment in the centre. This is the same share as in the Norwegian Higher education sector in general in 2017. Given that recruiting future researchers is one of the main objectives of the scheme, the share of completed PhDs in the first year of employment must be considered relatively high. This indicates that a PhD constitutes more of a “minimum qualification” than elsewhere in the system, and that for the SFFs, the postdoc position may be considered an equally important recruitment position. This is also very much in line with qualitative evidence collected in the parallel report to this evaluation (see Borlaug et al, 2019).

For the SFF personnel, we can also distinguish between PhDs obtained in Norway and those from abroad. As we lack reliable information on the citizenship of the SFF personnel, the national status of the doctoral degree provides an alternative indication of the international profile of the SFF personnel.

Among the SFF-personnel who started their career in an SFF as doctorate holders, we find that the share with Norwegian and foreign degrees is rather equal (Figure 3.8). The variation across SFF generations is also rather small in this regard.

If we consider the careers of researchers from SFF1 and SFF2, we see, not surprisingly, that researchers with a Norwegian degree are more likely to find careers in the Norwegian system compared to the rest. At the same time, it is worth noting that a substantial number of researchers with foreign degrees also remain in the Norwegian research system. Out of 727 researchers who entered an SFF with a foreign degree, we find that 442 are still active researchers in the Norwegian research system by 2017. This can be seen as an indication of the SFF-scheme’s ability to recruit and maintain foreign researchers in the Norwegian system.

A previous study (Gunnes and Børing, 2015) found that about 25 per cent of all Norwegian postdocs registered in 2001 and 2005 with a Norwegian PhD had left the core Norwegian research system 6-8 years later; versus about 55 per cent of those with a PhD from another country. In comparison, 20 per cent of SFF2 researchers with a Norwegian PhD had left the system by 2017, while this was the case for 44 per cent with a foreign PhD. This comparison indicates that SFF researchers with both Norwegian and foreign PhDs leave the core Norwegian research system to a somewhat lesser extent than comparable Norwegian researchers. However, it is important to keep in mind, that the SFF-figures are not restricted to postdocs, and that the time periods are not directly comparable.

Personnel who started at an SFF without a PhD are somewhat more likely to have left the core Norwegian research system by 2017. The latter category is dominated by PhD fellows, but also includes research assistants and administrative personnel.

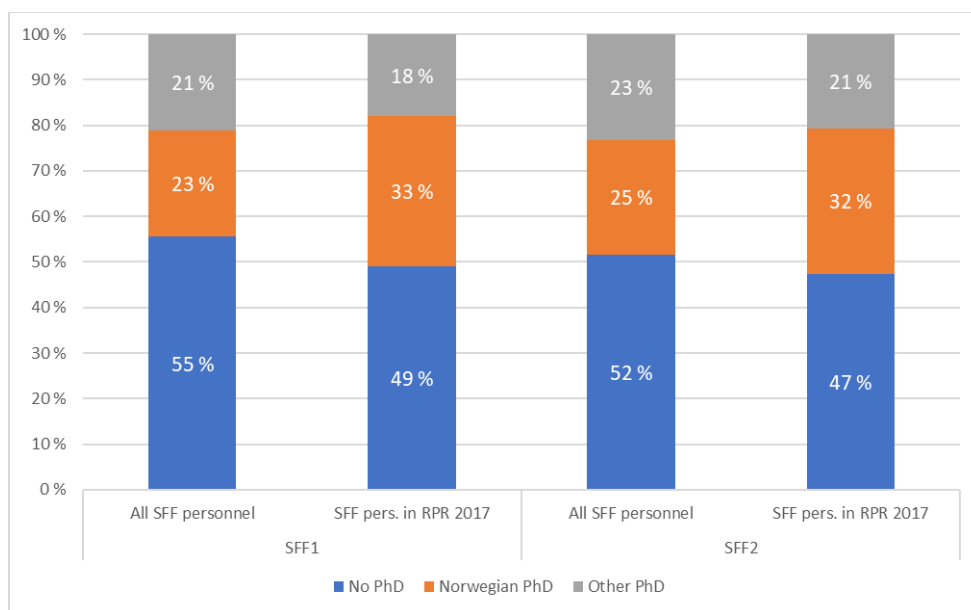


Figure 3.8: Norwegian vs. foreign PhD degrees among SFF personnel (in their first year); by SFF generation.

Source: NIFU based on RCN-data and RPR

3.3 Careers within the core Norwegian research system

In this section we track the careers of the researchers who are/ have been affiliated with an SFF. Due to data limitation, most of these analyses are restricted to the SFF researchers that are still employed at a Norwegian R&D institution (within higher education, research institutes or health trusts) as of 2017. In total, this amounts to 2185 persons¹¹. We refer to this group as the “core SFF-personnel”, and to the institutions covered by the RPR as the “core Norwegian research system”. For researchers that are outside this system, we use alternative approaches and data (see chapter 3.4), with less room for tracing careers over time.

In the sub-sections below, we look first at PhD attainment. This analysis applies to all SFF-personnel. Second, we look at horizontal mobility within the Norwegian R&D-system, notably between research institutes and higher education institutions (HEI). Third, we describe patterns of vertical mobility, i.e. to what degree researchers obtain promotions to higher and more permanent academic positions in the core Norwegian research system.

¹¹ Among the 2185 person, 78 persons joined their first SFF in 2018.

3.3.1 PhD attainment

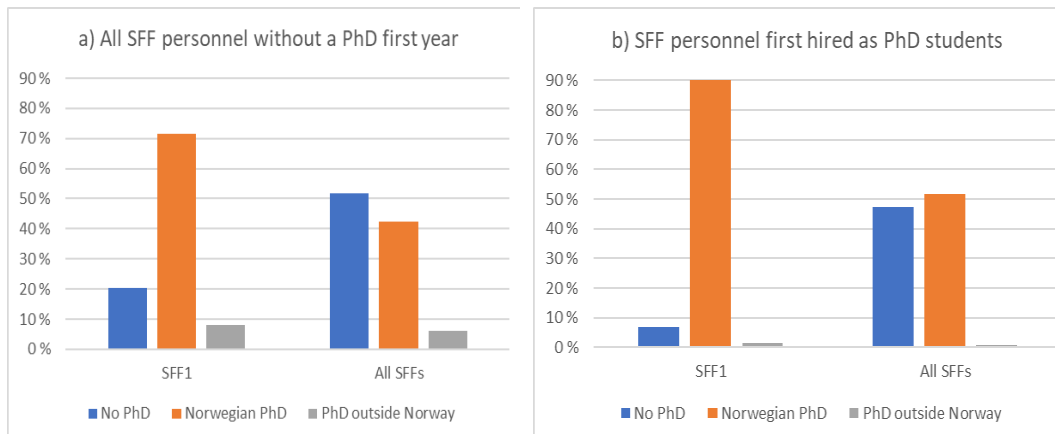


Figure 3.9: a) PhD attainment in 2017 among SFF personnel who had no PhD in their first year. b) PhD attainment in 2017 among SFF personnel who were first hired as PhD fellows. Both restricted to researchers that have a match in RPR in 2017.

Source: NIFU based on RCN-data and RPR

Although a relatively high share of SFF researchers started their career in the scheme as doctorate holders, the number of researchers who started without a PhD is also substantial. Among the SFF personnel who joined their first SFF without a PhD (and are still in the core Norwegian research system in 2017), about 70 per cent had completed their PhD by 2017. In absolute numbers the scheme has produced 1183 Norwegian doctorate degrees during the period 2003-2017. This constitutes around 7 per cent of all Norwegian PhDs in the period. It is difficult to say whether these degrees can be entirely attributed to the scheme or not. Some degrees may have been nearly finalised when the researchers joined the centre, or researchers may have obtained a PhD degree with only a minor role in the centre.

A more direct attribution can be established by looking exclusively at the personnel who joined the centres as PhD-fellows. Figure 3.9 b) shows that 90 per cent of PhD fellows from SFF1 had completed their PhDs by 2017. For all four generations, the degree of completion is substantially lower, but this is largely due to the fact that many PhD-fellows from SFF 3 began their PhD less than three years before 2017. They can therefore not be expected to have finished by 2017.

If we account for this by introducing 2015 as a cut-off year, we find that among SFF PhD-fellows who started at an SFF prior to 2015, 82 per cent have finished their degrees by 2017. In comparison, previous studies of PhD completion in Norway have found that completion rates revolve around 65 per cent 6 years after completion and around 75 per cent 8-10 years after completion (Thune et al, 2012; DIKU, 2019). Hence, our data indicate a higher completion rate for SFF PhD candidates than the average in Norway.

3.3.2 Sectoral mobility

While a large majority of SFFs are hosted by universities, it is relevant to explore whether SFF-researchers move to other sectors after their engagement in the SFF. Cross sectoral mobility is interesting in terms of the scheme's ability to produce effects beyond the host institutions.

By 2017, 77 per cent of the core SFF staff are employed at higher education institutions, including university hospitals, while the institute sector stands for 21 per cent (Figure 3.10).¹² This balance is not very different from the general pattern in the Norwegian research system, where the distribution of R&D-staff between these two sectors is around 75/25. Besides, the balance between SFF-centres hosted by higher education institutions vs. research institutes is 40/4. In addition, given the strong emphasis on basic research in the SFF-scheme, it is not surprising that researchers with a background from these centres are more likely to pursue careers at universities rather than applied research institutes. It is also important to note that a large share of the core SFF-personnel is still involved in SFFs (SFF3 and SFF4). As nearly all centres in these two generations are hosted by universities, the affiliation of current SFF-staff will contribute to the stronghold of the higher education sector. Thus, the share of core SFF-personnel employed at research institutes in 2017 can be considered relatively high.

There is also reason to assume that the balance between careers in the institute sector vs. higher education sector may become more equal over time. For instance, research institutes are frequently involved as partner institutions in consortia headed by universities. Furthermore, due to a general scarcity of permanent research positions and lengthy hiring processes in the HEI-system, young researchers may turn to the institute sector for research positions after their involvement in the centres. To explore this possible effect, we need to consider sector affiliation over time and by SFF generation. Figure 3.11 therefore shows the current sector of employment (as of 2017) for SFF researchers by the four different generations of SFFs.

¹² Researchers with a career abroad or in the business enterprise sector are not covered by the RPR and therefore not included in this part of the analysis. About 2% of the SFF personnel with a match in RPR are researchers with a main position in the business enterprise sector or abroad and in affiliated positions at Norwegian research institutes. They are not included in this section.

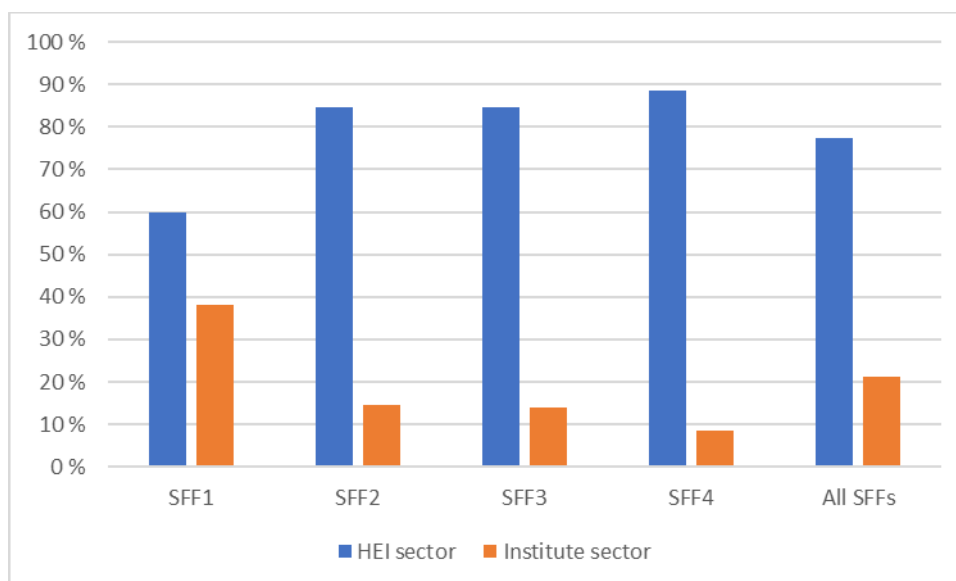


Figure 3.10: Sector of employment for core SFF personnel in 2017 (N=2185) by SFF generation.

Source: NIFU based on RCN-data and RPR

We see that as of 2017, the researchers who had participated in SFF1 are more evenly distributed between the institute sector and the Higher education sector than researchers in the following generations. The fact that 2 of 13 SFF1 centres were hosted by research institutes cannot fully explain the high share of former SFF-researchers presently employed in this sector. For SFF2, the researchers have had considerably less time to change their sector of employment after the closure of the centres. Hence, when most of these researchers are employed in the Higher education sector in 2017, this is largely explained by the fact that 7 out of 8 centres were hosted by universities. Over time, one might expect that more former SFF researchers from SFF2 may change their sector of employment.

In order to explore the sectoral mobility further, we combine data on the SFF researchers' sectoral affiliation during their first year in an SFF with their sectoral affiliation as of 2017. This gives us a broad indication of whether SFF-personnel have remained in or moved from the sector they belonged to at their first year of employment in the SFF. Our focus here is on the higher education sector (including university hospitals) vs. the institute sector, as this constitutes the main sectors covered by RPR.

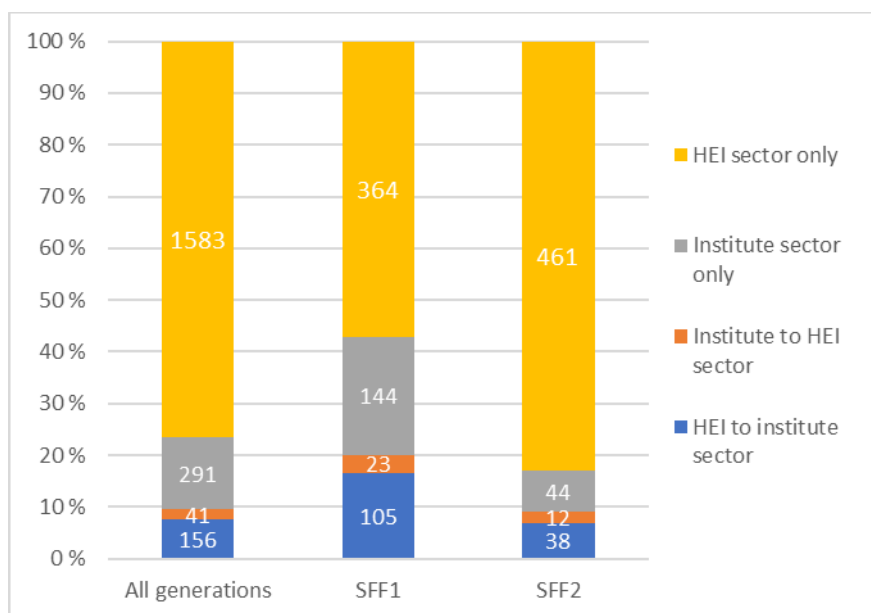


Figure 3.11: SFF-researchers by initial and current sector of employment (2017); SFF1 and SFF2.

Source: NIFU, based on RCN and RPR

Figure 3.11 shows the aggregate mobility between these sectors for all core SFF-personnel as well as the personnel who participated in SFF 1 (2002-2012) and SFF2 (2007-2017). The main pattern is a rather low mobility of SFF researchers between the higher education sector and the institute sector, as 90 per cent of the core SFF staff are employed in the same sector today as when they started their career at the SFF¹³. Furthermore, we see that almost 80 per cent of the core SFF personnel started their careers in the higher education sector. Again, this is not surprising, given the fact that most SFFs are hosted by universities and a large share of the SFF-staff consists of PhDs and postdocs mainly employed in the host institutions.

When we zoom in on the SFF1 researchers, the cross-sectoral mobility increases somewhat, as around 20 per cent have switched sector since their first employment in the SFF. Within this group we see that the mobility from the higher education sector to the institute sector has been significantly higher than the other way around. On the one hand, this is surprising, as SFF researchers in general are deemed more academically oriented than the research personnel in general. On the other hand, permanent positions are scarcer at Norwegian universities compared to the research institutes, where most vacant positions are permanent. This point is discussed further in the next section. The difference is smaller in relative

¹³ This number does not account for all possible mobility patterns between the initial year of employment in the SFF and 2017. Especially for SFF1 some researchers may have switched sector and then come back again during the period in question.

than in absolute terms, however. In SFF1, 22 per cent of researchers who started their SFF career in the higher education sector have moved to the institute sector by 2017. The corresponding number for the institute sector is 14 per cent.

3.3.3 Vertical career patterns

In this section we look at the SFF researchers' academic promotions and ability to attain permanent positions. The analysis is based on the past and current academic position of each SFF-researcher within the core Norwegian research system (as identified in RPR).

Figure 3.12 shows how the distribution of positions among the core SFF personnel has changed between their first year in SFF and 2017. This analysis is restricted to the first and second generation of SFF, to ensure a certain amount of time has passed after participation in the scheme.

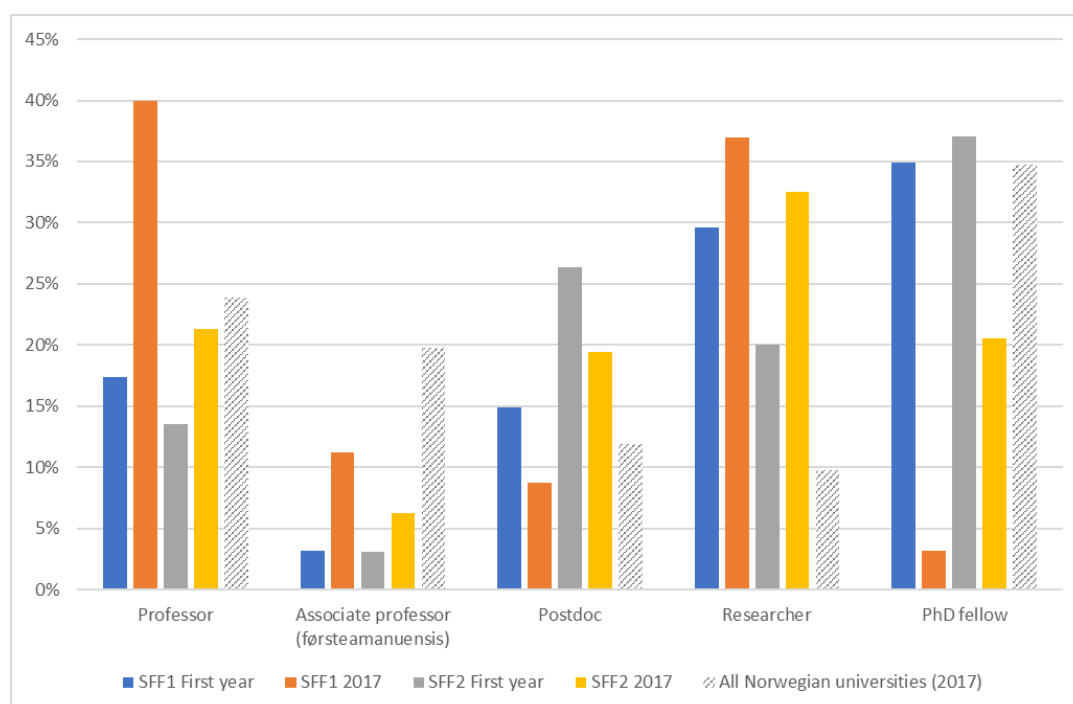


Figure 3.12: Academic positions in 2017 among SFF personnel and in the Norwegian HEI sector; by SFF generation (SFF1 and 2).¹⁴

Source: NIFU, based on RCN and RPR

Comparing the orange to the blue columns for SFF1, and the yellow to the grey columns for SFF2, we see that the share of PhDs decreases sharply over time. The share of postdocs also decreases. This is an expected pattern. PhD-fellows and

¹⁴ The category 'Other' encompasses leadership positions, teaching positions, doctors, administrative positions, research assistants, and non-R&D positions.

postdocs constitute a substantial share of the personnel in each centre. As these candidates finish their PhDs and Postdoc periods, we expect to find them in more permanent and subsequently top academic positions. Largely in line with this expectation, a significantly higher share of the core SFF personnel are *professors* in 2017 than in their first year in SFF. This is especially true for the first generation. In 2017, approximately 5 years after the closure of the first 13 centres, we find that around 40 per cent are *professors* and another 11 per cent in positions as *associate professors* (førsteamanuensis). The share of professors from SFF1 is substantially higher than in the Norwegian HEI-sector in general by 2017, while the share of *associate professors* is lower. The latter is again an indication of the difficulties in obtaining permanent positions.

The increase in *researchers* is particularly high for the second generation. This mirrors the finding discussed in the previous section, that a substantial number of SFF researchers move to careers in the institute sector, where the position *Researcher* is more widespread.

A more precise way to get at vertical mobility is to look at the career paths of postdocs and PhD-candidates. In SFF3 and SFF4, persons hired as postdocs are generally still postdocs, as can be expected for SFF generations that are still underway. However, among postdocs from SFF1 and SFF2, a substantial share (about 45 per cent) have moved on to researcher positions, and some to professor and associate professor positions (Figure 3.14). The latter is more common among former postdocs from SFF1, where 13 per cent are associate professors and 22 per cent have obtained permanent positions in 2017. In the more recent SFF2, a large share of the researchers hired as postdocs are still postdocs in 2017. 9 per cent are associate professors and 6 per cent professors.

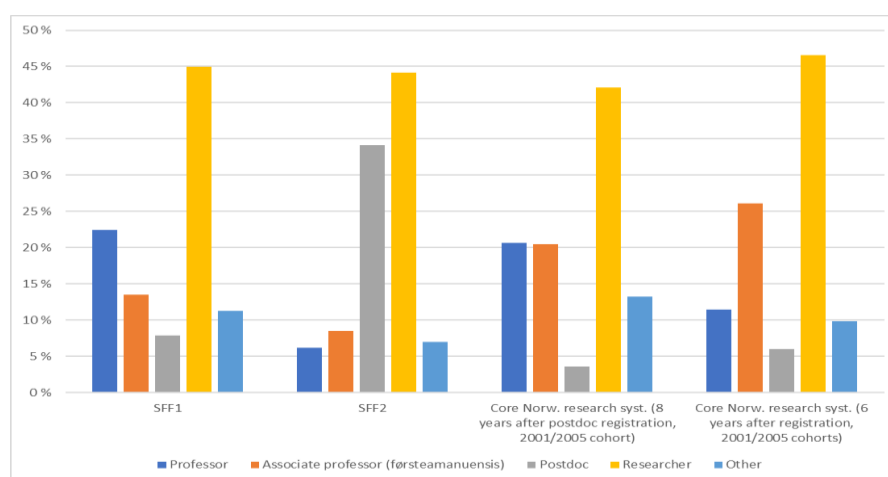


Figure 3.13: Academic positions in 2017 among SFF personnel employed as postdocs in first year (with match in RPR in 2017); by SFF generation (SFF1 and 2). Compared to full postdoc cohorts for 2001/2005, 6 and 8 years after their registration.

Source: NIFU, based on RCN and RPR

In comparison, the figure also includes data on all Norwegian postdocs registered in 2001 and 2005 and their position 6 and 8 years after the start of the postdoc (Gunnæs and Børing, 2015). The SFF1 postdocs constitute the most realistic comparison in this regard. For this group, the time from the first year as postdoc to year of reference 2017 is minimum 5 years and maximum 14 years. Nevertheless, we see that the share still in postdoc positions is higher for SFF1 than for the comparison groups, and that the share in associate in associate professor positions is lower. The share of professors from the SFF1 generation is, however, comparable to the 8 years comparison group. Hence, although the cohorts are not directly comparable, we observe a general tendency of longer careers in postdoc positions among the SFF1 researchers than for Norwegian postdocs in general.

To get an even more accurate comparison of vertical career patterns over time, we look at the attainment of academic positions among comparable cohorts of researchers. In Figure 3.14 a and b we have gathered data for all SFF-researchers who have completed a PhD in Norway during the centre period (RCN, 2019). We compare them with the career paths of the same cohorts for all persons who completed Norwegian PhDs¹⁵. The figures show the employment status of both groups for selected time periods (0-4; 5-9 and 10-14 years after the completion of their PhD).

¹⁵ Both sets include those who are still in the core Norwegian research system (RPR) in 2017.

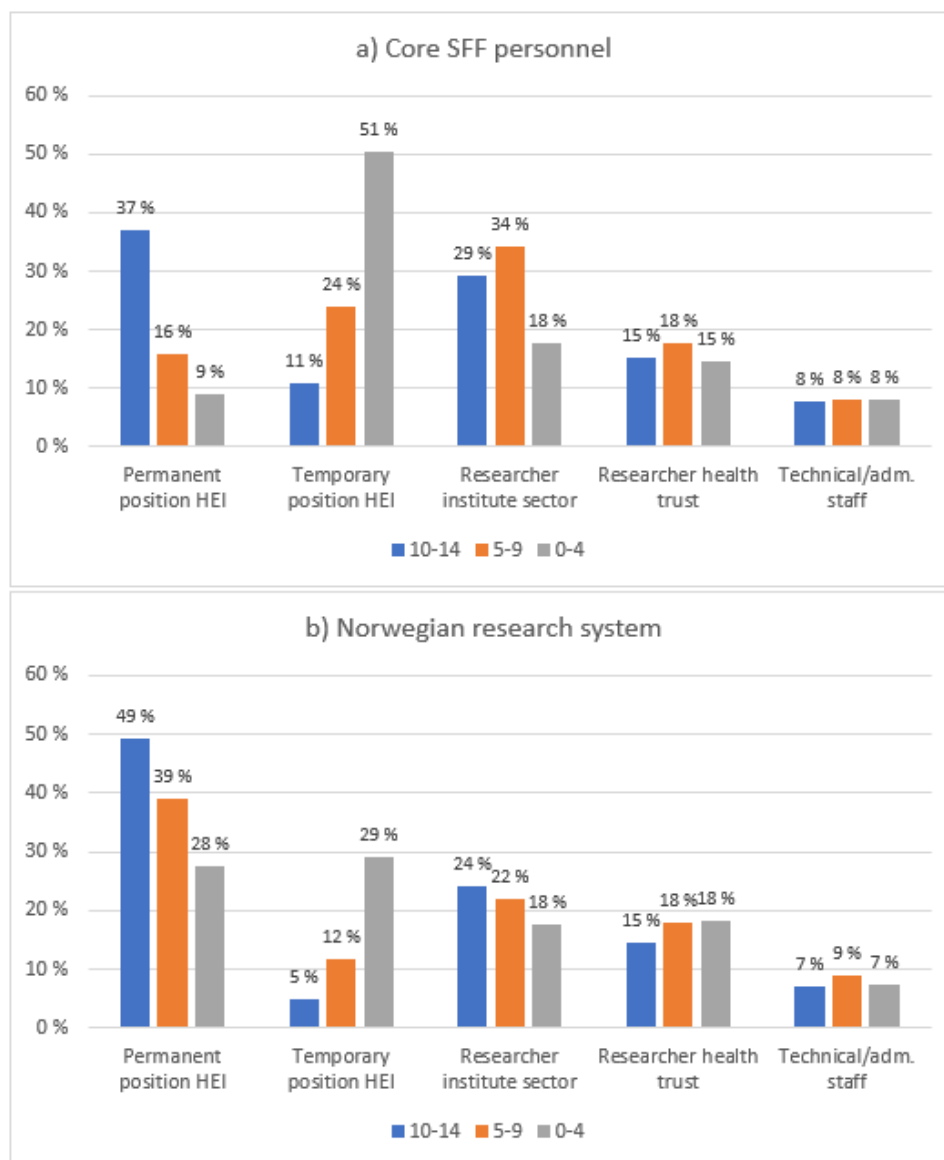


Figure 3.14: Academic position in 2017 by cohorts of researchers (number of years after completion of PhD). Among SFF-researchers (a) and all Norwegian doctorates (b).

Source: NIFU based on RPR and RCN

Although the picture is rather varied, we observe that doctorate holders with an SFF-background seem to have more difficulty obtaining permanent academic positions in the HEI sector the first years after they complete their PhDs, compared to the full cohorts of doctorate holders in the Norwegian system. After a ten years period we see signs of a changing balance, where the SFF-doctorate holders begin to catch up with the share among doctorate holders in general. However, they still lag behind the general pattern for Norwegian researchers. This is rather surprising, given that most SFF researchers should, in principle, have better career prospects, due to the prestige and favourable working conditions associated with

SFFs. One possible interpretation of this finding is that doctorate holders from SFFs have high academic ambitions and are particularly focused on obtaining positions with sufficient time for research. As a consequence, they could be more willing to endure long periods in temporary positions to qualify for the “right position”, instead of settling for permanent positions in less attractive research environments and/or with less time for research. The same motivation could also explain the high share of SFF doctorate holders pursuing careers at research institutes, as positions in this sector are generally more research oriented than many available positions in the higher education sector, where the teaching obligations can be quite substantial. Moreover, there is reason to assume that many SFF researchers operate within fields and topics with high prestige and correspondingly strong competition for permanent positions. This assumption is strengthened by qualitative evidence discussed in the parallel report on the SFF scheme’s impact on the research system (Borlaug et al. 2019).

To explore different career patterns further, we disaggregate the permanent and temporary positions in the HEI sector by type of institution, distinguishing between the oldest universities (UiB, UiO, UiT, NTNU), newer universities (NMBU, UiS, UiA, NordU, OsloMet, USN, UNIS), and other HEIs (NHH, NLA, BI, HK, HVL, HiNN). Using this classification, Figure 3.15 reveals that the difficulties for SFF PhDs to get a permanent position in the HEI sector is primarily driven by the largest and oldest universities.

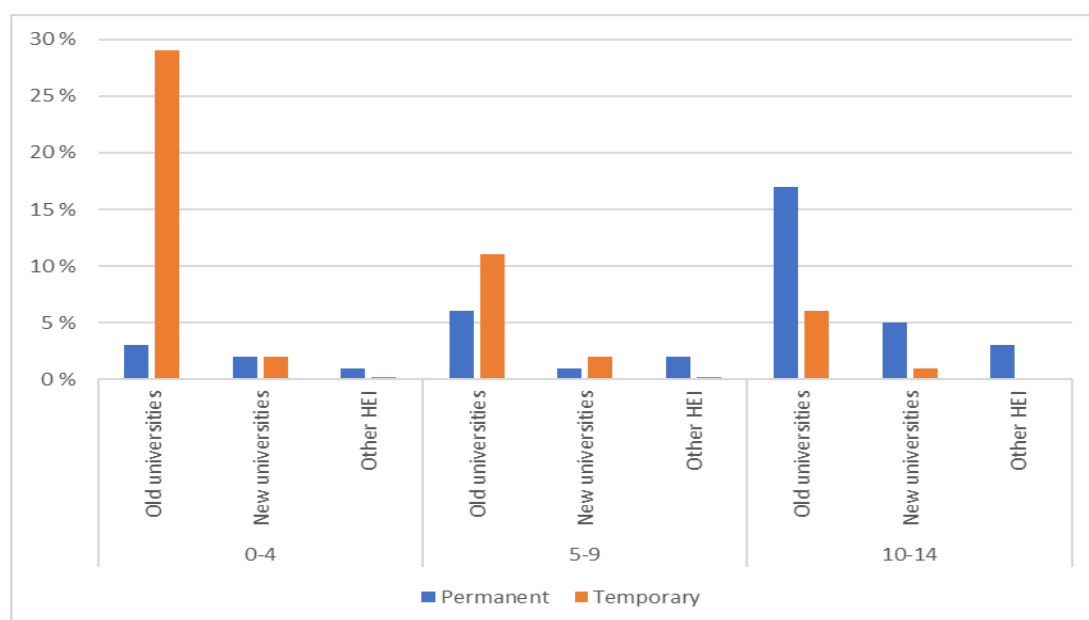


Figure 3.16: Academic positions in the HEI sector in 2017; by cohorts of researchers (number of years after completion of PhD), type of position and type of HEI.

Note: Old universities include UiO, NTNU, UiB and UiT

Source: NIFU based on RPR and RCN

Disaggregating the cohort analysis above by gender reveals relatively minor differences between men and women. A somewhat larger share of women than men are employed in the health trusts (around 10 vs 7 per cent) and technical or administrative staff (around 20 vs 11 per cent). Correspondingly, somewhat fewer women are employed in temporary positions in the HEIs. The share of SFF PhDs with permanent positions in the HEI sector 10-14 years after their completion of PhD is, however rather similar for women (38 per cent) and men (36 per cent). There are some signs that fewer female researchers obtain permanent positions 5-9 years after PhD completion. But in general, we find few systematic gender differences regarding the likelihood of obtaining permanent positions at given periods after PhD. This is line with previous studies of gender differences related to permanent positions in Norwegian academia (See Gunnes and Børing, 2015).

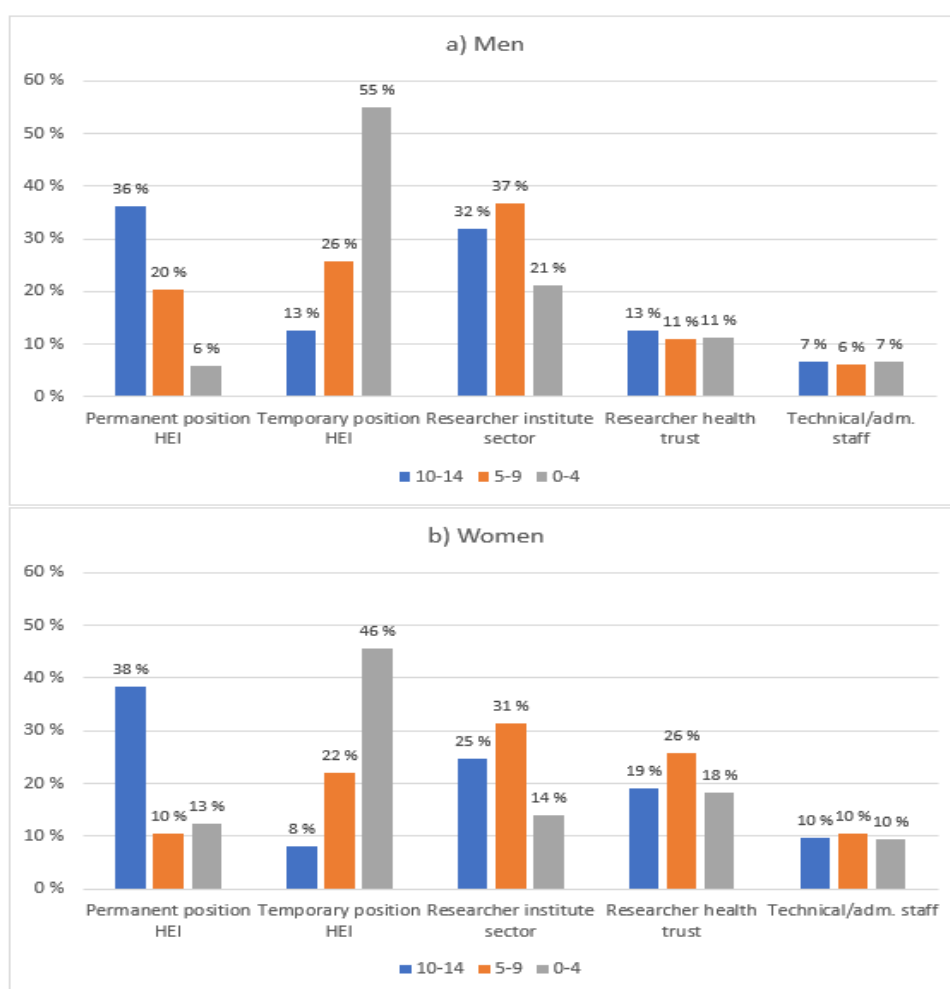


Figure 3.17: Academic positions in the HEI sector in 2017; by gender, cohorts of researchers (number of years after completion of PhD), type of position and type of HEI.

Finally, if we disaggregate the same cohorts by fields of research, we find that ¹⁶ around 70 per cent of SFF1 researchers from Humanities and Social sciences have obtained permanent positions in the Higher education sector 10-14 years after completing their PhDs. The share is slightly higher for Humanities, but on the other hand, researchers from the Humanities are more likely to be in temporary positions in the Higher education sector up until 9 years after the completion of their PhDs. SFF1-researchers within the Social sciences seem more inclined to take on permanent positions in the institute sector during the first years after the completion of their PhDs. This pattern largely reflects structural features of the Norwegian R&D system, where the Institute sector constitutes an important labour market for social science researchers and less so for researchers from the Humanities.

A similar pattern appears for SFF1-researchers within mathematics/natural sciences, technology and medicine. For these fields we see that researchers from the technology fields tend to find permanent positions in the institute sector, while researchers from medicine are often found in permanent researcher positions in the Health trusts. Researchers from mathematics/natural sciences also use the institute sector as a career-path, but seem slightly more willing or forced to endure longer time in temporary positions in the Higher education sector before, eventually, obtaining permanent positions there.

3.4 Careers outside the core Norwegian research system

As indicated in figure 3.2, a total number of 1133 (former and present) SFF-researchers have held main positions in the core Norwegian R&D-system, but are not registered in the RPR by 2017. In most cases, this means that they have pursued careers outside the institutions covered by RPR¹⁷ (universities, university colleges, hospitals, research institutes and certain research-intensive public institutions). In this section, we take a closer look at this group. As discussed in the section on baseline characteristics, we see no indication that these researchers differ significantly from the people still in the research system in terms of gender or field of research. However, they do seem to be somewhat younger and more likely to have been employed as PhDs and Postdocs (rather than professors or associate professors) when they first joined an SFF.

The current position of these researchers is interesting to explore more systematically as an indication of SFF career patterns outside academia and outside of Norway. In order to trace the current position of these researchers, we have

¹⁶ In the administration and library field, most of the 25 SFF PhDs who are still in the core Norwegian research system are technical and administrative staff.

¹⁷ In some cases, researchers may maintain part time positions or positions as research fellows in the Norwegian research system, but as long as the positions are below 40%, they are not formally registered in the RPR, except those registered from 2017, when the threshold was lowered to 25 per cent.

carried out manual searches on platforms such as LinkedIn, Google Scholar, Google and ResearchGate. We excluded persons above 70 years (assumed retired) as well as researchers employed at ongoing centres (SFF3 and SFF4), since we assume that most of these researchers are still involved in the centres and therefore less relevant for analyses of careers after the SFF-engagement. Consequently, the number of persons to trace amounted to 720. Although we were able to identify the whereabouts of most of these persons, the information is sometimes scarce and incomplete. Results from this tracing should therefore be read with caution.

For instance, while RCN's list of personnel contains information on nationality and country of residence, the information is not reported in a consistent way and without quality assurance. Bearing these reservations in mind, we estimate that more than 40 per cent of the researchers that are outside the core Norwegian research system in 2017 are registered with a non-Norwegian nationality or a country of residence other than Norway during their time in the SFF scheme. Figure 3.16 shows the result of our manual searches combining the identified current country and sector of employment and reported nationality/country of residence (when in SFF) for SFF researchers outside the RPR-system as of 2017.

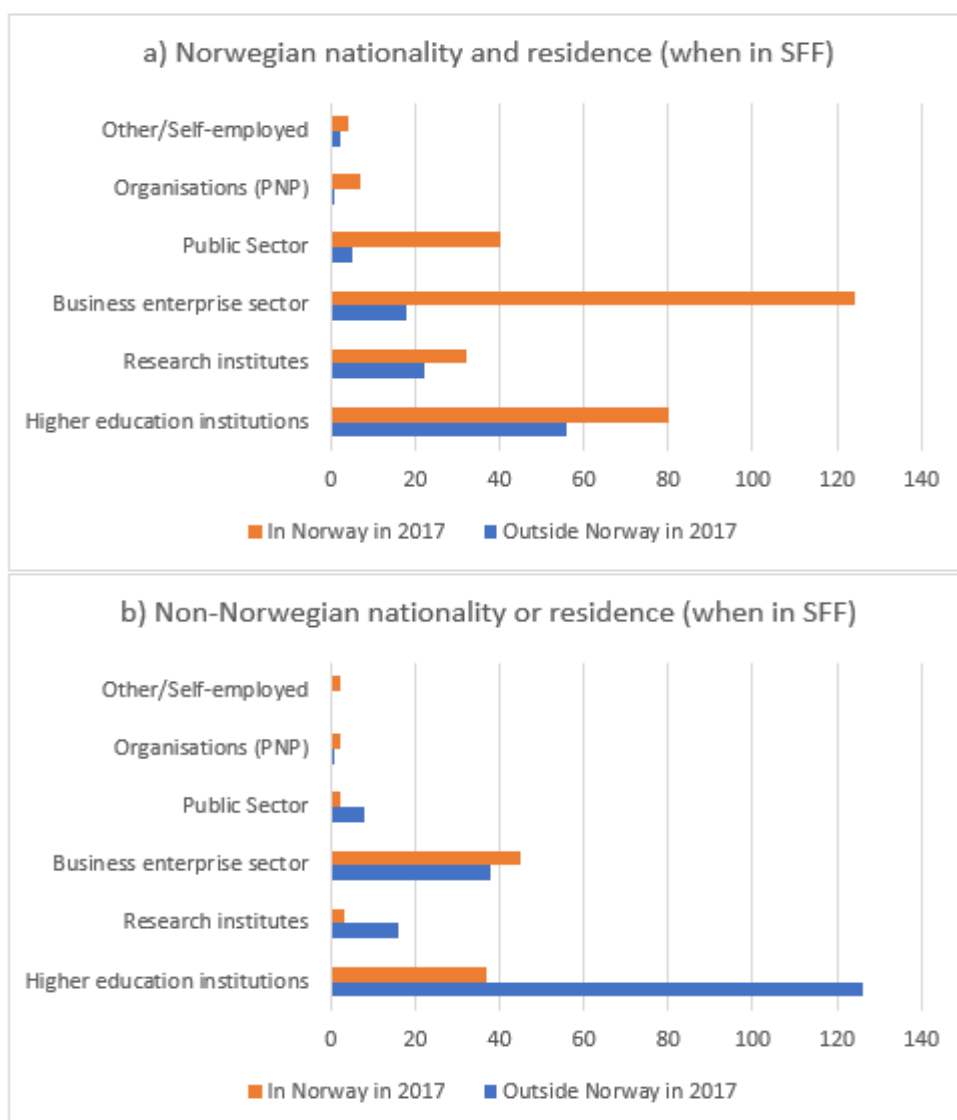


Figure 3.16: SFF researchers not registered in the core Norwegian R&D-system (RPR) in 2017, by current sector of employment, current country of residence and nationality/residence when in SFF. SFF1 and SFF2.

Source: NIFU, based on manual search

As expected, a large share of the researchers that are outside the RPR register by 2017 can be traced to careers in academia abroad. More precisely, we find that more than 50 Norwegian researchers and more than 120 of the researchers registered with a non-Norwegian nationality or country of residence during their first year in SFF are currently employed at universities outside Norway, often in professorships, assistant professors and as senior lecturers. More surprising is the fact that we find more than 100 persons still connected to higher education institutions in Norway. In some of these cases, these are in lecturer positions or part of the technical administrative staff at universities.

However, in most cases they appear as PhDs, Postdocs or in other active research positions, and should in principle be included in the RPR. Investigating this for each person is beyond the scope of this report. However, based in previous experience with quality assurance of the RPR, we assume that a large share of the persons in question maintain minor, inactive or fellow positions at Norwegian Higher education institutions besides a full position in another country, or that the manual searchers retrieved outdated information.

Furthermore, we see that more than 200 researchers have found employment in the business enterprise sector, either in Norway or abroad. Most Norwegians pursue business careers in their own country, but we also observe that a substantial share of the foreign researchers are found in positions in Norwegian enterprises. In both cases, large companies within the energy and offshore industry are among the most frequent employers. In addition, we find quite a few researchers in companies operating within health and medicine, as well as consulting and financial services. These patterns reflect both the general structure of the Norwegian R&D system and the thematic orientation of the SFFs in question (SFF1 and SFF2).

3.5 Main findings

A general overview of all researchers who have been engaged in the SFF- scheme reflects many of the characteristics of the overall Norwegian R&D system.

Main characteristics of the SFF personnel

The gender balance of SFF staff is generally in line with the balance in the Norwegian research system, although with moderate variations between the four generations of SFFs. In terms of age, we find that SFFs have recruited a significantly higher share of young researchers (below 35) than the overall Norwegian research system did in the same time period. PhD-fellows and postdocs are also more frequent in the SFFs than elsewhere in the system, which confirms the role of SFFs as a means to recruit future researchers to the Norwegian research system. At the same time, we find that young SFF researchers are more likely to pursue careers outside Norway or outside the core research system compared with older and more established colleagues.

The disciplinary profile of the SFF staff largely reflects the thematic profile of the SFFs, with a stronghold in mathematics/natural sciences as well as medicine in all four generations of SFF. Social sciences make up a significant share in SFF4, while technology was quite important in SFF1. Humanities appears with a relatively low proportion of staff through all four generations.

High share of doctorate holders

For the three selected years of comparison, we see that around half of all SFF researchers had completed a PhD before their first year of employment in the centre. Given that recruiting future researchers is one of the main objectives of the scheme, the share of completed PhDs in the first year of employment must be considered relatively high. This indicates that a PhD constitutes more of a “minimum qualification” than elsewhere in the system, and that for the SFFs, the postdoc position may be considered an equally important recruitment position.

Holders of foreign doctorate degrees pursue careers in Norway

As expected, researchers with a Norwegian doctorate degree are more likely to pursue careers in the Norwegian system compared to those who entered SFFs with foreign degrees. Nevertheless, we find that a substantial number of researchers with foreign degrees choose to stay in the Norwegian research system. By 2017, more than half of the researchers who started their SFF-careers with a foreign degree are still active researchers in the Norwegian research system. This indicates that the SFF-scheme has been able to recruit and maintain foreign researchers in the Norwegian research system.

High completion rates among PhD-fellows in SFFs

Among those who have started their careers as PhD-fellows at SFFs, we find that 90 per cent of PhD-fellows from SFF1 have completed their degrees by 2017. The completion rates are also above 80 per cent for all SFF-related PhD-fellows who started their PhD prior to 2015. This indicates a rather high rate of completion.

Substantial absorption SFF-researchers by research institutes

In terms of sectoral mobility, we find that most SFF researchers pursue careers within the same sector as the one they were in when they started their career as SFF researchers. However, although the SFFs are primarily academically oriented and hosted by universities, the majority of those who switch sectors seem to move towards careers in the research institute sector. For SFF1, the number of researchers who have moved from Higher education to the institute sector is more than four times as high as the number of moves in the other direction. We assume that the prospects of finding full time research positions as well as permanent positions are important factors behind this sectoral mobility.

Difficulties in obtaining permanent positions in academia

The latter point above relates to the observation that doctorate holders with an SFF-background seem to have more difficulties in obtaining permanent academic positions in the Higher education sector after they complete their PhDs. In fact, PhD holders from SFFs seem less likely to obtain such positions than Norwegian doctorate holders in general. These difficulties are particularly pronounced in the old universities, and among researchers within humanities and to some extent natural sciences/mathematics. It is likely that these findings reflect a combination of i) a scarcity of permanent positions in certain parts of Norwegian academia; ii) strong competition within the research areas where SFFs operate, driven in part by the success the SFFs have had in recruiting talented researchers; and iii) high academic ambitions among young SFF-researchers in general, and a corresponding willingness to endure temporary employment while waiting for “the right position”.

Alternative career trajectories

Among SFF researchers with careers outside the core Norwegian research system, we find that the largest share pursue careers in the business enterprise sector. More than 200 of the 720 researchers we investigated are traced with an occupation in this sector. As expected, careers in the Norwegian business enterprise sector is by far the most common pathway among Norwegian researchers who have left the core Norwegian research system. More surprisingly, we find that SFF-researchers registered with a non-Norwegian nationality or residence at their time in SFF are slightly more likely to have found jobs in the Norwegian business enterprise sector than abroad.

4 Participation and success in EU-programmes

While the SFF-scheme constitutes a competitive grant in itself, there is reason to expect that researchers involved in the centres also are able to attract additional grants, both during and after the period they have been involved in the centres.

In this chapter we focus on the SFF-researchers' ability to attract competitive grants from the EU Framework programmes in general and the European Research Council (ERC) in particular. During the last decade, this aspect has received increased priority and attention in Norwegian R&D policy. In 2013-2014, targets for increased return and participation have been set, both in The Government's EU Strategy (MER, 2014) and in the first Long term plan for Research and Higher education (Meld. St. 7 (2014-2015)). Against this backdrop, there is reason to explore the participation and success of SFF-researchers in the competition for EU-grants.

4.1 SFF researchers in the EU FPs

Our starting point is the list of all SFF staff. These names were matched with the European Commission's database ECORDA which includes information about all proposals submitted to and granted by the European Framework Programmes (EU FPs). For the purpose of matching names of SFF-staff with the ECORDA-database the total list consisted of 4431 unique names¹⁸. Since the main focus of this analysis is the European Research Council (ERC), we only matched data from FP7 and Horizon 2020. These programmes cover the period from 2007 to present, which is relevant to see in relation to the duration of the SFF-scheme.

4.1.1 Data cleaning and limitations

In total, we identified 225 SFF researchers in the ECORDA database. These researchers had received a total of 299 grants. Notice that this does not mean that the total number of SFF researchers that have participated in the EU FPs is limited to 225 and 299 projects. These numbers represent the persons that we were able to identify in ECORDA.

¹⁸ As mentioned in the introduction (see section 1.3) and in chapter 2 and 3, the total number of names included in the lists differ in chapter 2, 3 and 4 due to the cleaning and matching of names to different data-sets.

Matching procedure

For all projects in ECORDA we do have the names of all principal investigators, but these again are not linked to a specific institutional address. This means that the matching of SFF researchers with names in ECORDA has been subject to a manual reading of all names against all participating institutions in a project, with the aim of identifying SFF researchers. In many cases it has been difficult to decide whether the EU FP grant recipient is the same person as the SFF researcher. In most cases of doubt, manual internet searches were carried out, revealing for instance that e.g. the Danish researcher “Claus Nielsen” in ECORDA was not the same “Claus Nielsen” as the one appearing in the Norwegian SFF.

Hence, the real number of SFF researchers in ECORDA exceeds probably the number of names we have been able to identify with certainty. However, for the purpose of this study, we have chosen to base our analyses on the conservative number of researchers in ECORDA that are clearly identical to the SFF-researchers.

ERC grant receivers

As for ERC projects, the most recent data from ERC shows that a total of 112 researchers from Norwegian host institutions have received ERC grants as *principal investigators (PI)* during the period 2007-2018¹⁹. However, in our analyses of SFF-researchers the number of ERC recipients is higher than ERCs number of 112 “Norwegian” PIs. This is because we also include ERC grantees affiliated to an SFF but whose main position is at a foreign university or research institution. Hence when interpreting the data, it is important to account for the following two distinctions:

- 1) Norwegian ERC grantees are not necessarily grants received by Norwegian citizens, as the national dimension is linked to the host institution and not the nationality of the grant receiver. In fact, most “Norwegian” ERC-grants are received by foreign researchers with main positions at Norwegian research institutions.
- 2) The number of ERC grants received by SFF researchers is not restricted to the SFF share of “Norwegian” ERC grants (according to the definition above), but also includes grants received by SFF researchers with main positions at institutions outside Norway.

¹⁹ <https://erc.europa.eu/projects-figures/erc-funded-projects/results?f%5B0%5D=country%3ANorway>

In concrete numbers, we find that 51 of 112 Norwegian ERC grants can be linked to an SFF. This means that SFF researchers stand for just above 45 per cent of all Norwegian ERC grants (according to definition 1 above) since 2007.²⁰

4.1.2 SFF's EU-participation by main programmes

Table 6.1 below shows the distribution of SFF-researchers' total participation in EU FP7 and H2020 by main type of programme. For SFF researchers, the most common type of EU grant was the Marie Skłodowska-Curie Actions (MSCA) for researcher mobility, followed by ERC grants. Within the latter category, we see that starting grants and advanced grants make up 75 per cent of all ERC grants won by SFF researchers.

Table 4.1: EU grants for SFF-researchers, Norway and by Norwegian sectors. EU FP7 and H2020 (2007-2018)

Type of grant	SFF	Norway (excl. SFF)	HES	REC	PRC	PUB	Other
Marie Skłodowska-Curie Actions (MSCA)	137	155	128	19	2	6	0
European Research Council (ERC)	93	64	58	6	0	0	0
- Starting grant	34	32	30	2	0	0	0
- Advanced grant	35	10	9	1	0	0	0
- Consolidator grant	19	20	17	3	0	0	0
- Proof of concept grant	3	2	2	0	0	0	0
- Synergy grant	2	0	0	0	0	0	0
Other programmes	72	497	81	179	215	13	9
Total	302	716	267	204	217	19	9

Source: NIFU, based on ECORDA

The participation profile of SFF researchers differs substantially from the total portfolio of Norwegian EU-projects during the same period:

Norway generally performs well in the societal challenges pillar (under "Other programmes" in the table above) and less well in the Excellence pillars, while the profile of SFF-researchers shows the opposite pattern. This is not surprising as SFF-researchers are both more oriented towards and better qualified for obtaining grants from so-called excellence programmes.

If we compare the figures for SFF researchers with the performance of the entire Higher education sector in Norway (HES), we still see that SFF researchers have retrieved a considerably higher number of ERC-grants. This is also the case for Marie Skłodowska Curie Actions (MSCA), where SFF researchers also

²⁰ The numbers are somewhat higher for FP7 projects than H2020, due to the fact that ECORDA for FP7 also includes names of the contact person at partner institutions, while this was not possible for H2020, which is restricted to the names of the principal investigators (except in a few MSCA projects).

outnumber the rest of the Norwegian higher education sector and almost reaches up to the total national number of such projects.

As noted above, it is important to bear in mind that the group of SFF researchers also includes researchers from foreign research institutions with a connection to an SFF.

Furthermore, if we look at the participation pattern within the programmes oriented towards societal challenges (under “Other programmes”), SFF-researchers appear to have more success and stronger participation in the Environment and ICT-programmes, while Norway’s general strongholds seem to lie within the FOOD and ICT-programme for SMEs (LEIT-ICT). Without further comparison, we can conclude that the SFFs contribute to diversify the Norwegian participation in the European framework programmes.

4.2 EU-participation by SFF-generations

As the 44 SFFs in question have been operative for different and overlapping periods, we focus in this section on the EU-participation for each of the four generations of SFFs. The table below only includes projects where the SFF researchers are principal investigators (PI).

The table also specifies whether the EU grant was received before, during or after the SFF generation in question. This information provides an indication of the effects of the SFF scheme on the researchers’ ability to attract EU funding. Grants received before the SFF period indicate that the researchers in question were able to attract such funding already before they entered the centre, while grants received during and after the SFF-period can be seen as signs of an added value of the centres. However, strict causal effects of the scheme cannot be established for certain, even for the grants received after the SFF-scheme.

Table 6.2: EU FP-projects with Principal Investigator from SFF-centres, by generations of SFFs and types of ERC grants. EU FP7 and Horizon 2020

SFF generation	Before SFF	During SFF	After SFF	Total	Starting grant	Consolidator	Advanced grant	Proof of concept	Synergy	ERC total
SFF1		77	48	125	15	8	11	1	2	37
SFF2		64	18	82	11	4	14	0	0	29
SFF3	43	54		97	8	6	12	0	1	27
SFF4	60	20		80	8	5	11	3	1	28

Source: NIFU, based on ECORDA

The table shows that researchers from SFF1 are in total affiliated to 125 EU FP projects, of which the majority was obtained during the SFF period. For this generation, the participation is rather skewed, with three centres accounting for more than half of all projects.

In the second generation of SFFs, two centres stand out with a large number of EU projects both during and after the SFF period. The lower number of grants obtained after the SFF period relates naturally to the fact that the SFF-period in question ended in 2017.

The SFF3 generation displays the strongest and broadest EU-participation, as all 13 centres have had at least one EU project, either before or during the centre period. Among the 13 centres funded in this generation, five centres appear with 10 EU-projects or more. The balance between projects obtained before and during the centre period is rather mixed: Two centres stand out with more EU-projects before the centre period than after, while researchers involved in a third centre showed as much as twelve EU projects prior to the SFF period, with only one new project obtained during the SFF-period.

For SFF4 we observe (so far) some of the same skewness as in SFF1 and SFF2, as three centres stand for nearly two thirds of all grants received. The same three centres also stand for more than half of all ERC-grants from this generation. In general, the number of projects during the SFF period are for obvious reasons lower for SFF4 than for SFFs from earlier funding periods.

4.3 Main findings

In total, we find that the 44 SFFs have been actively involved in EU-projects during the course of EUs 7th framework programme and Horizon 2020. In total, more than 300 EU-projects can be connected to Principal investigators with an affiliation to SFFs. This number may also be underestimated as EU-projects where SFF-researchers participate as partners are not included in these analyses.

In general, we see that the SFFs contribute to counterbalance the total profile of Norway's EU participation. Firstly, while Norway generally fares well within programmes addressing societal challenges and less well within the excellence programmes, the SFFs display an opposite profile. In fact, we can observe that SFF researchers based in Norway contributes to nearly half of all Norwegian ERC-grants, which in turn indicates that the centres have been able to recruit and cooperate with a substantial number of research talents.

The SFF participation in EU-projects is however rather skewed. With the exception of SFF3 (where at least five centres appear to be quite active in EU-projects), we find that 2-3 centres stand for more than half of all EU-projects. These patterns reflect much of the same skewness identified in the bibliometric part of this study (see chapter 2).

Finally, there seems to be little evidence of a "boost" in EU projects after the researchers join an SFF. In fact, for the two SFF-generations where such comparisons are possible, we find that many of the researchers in question had already

retrieved EU-funding before they joined the centre. Data on SFF-related EU-funding is therefore not sufficient to establish a causal relation between SFFs and increased EU funding. Instead, there is reason to conclude that the centres have been able to attract a large number of researchers with sufficient competencies and capacities to be successful in the competition for prestigious EU-grants and projects. Furthermore, given the high number of EU-projects related to SFFs, we can conclude that SFF researchers have made significant contributions to Norway's total performance in the Excellence pillar within EU-programmes.

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Appendix 1: The international visibility of SFFs

As an additional approach under this project, we have explored the possibility of tracing the international web visibility of the SFF by using the first generation of centres as a case. We find that the web visibility of the SFFs is primarily connected to their researchers and publications. The centres themselves as organization are seldom the main subject on these web pages. Differences in visibility are also difficult to interpret. It seems that citation analysis so far remains the most adequate quantification of international scientific impact. Our methods and results are shortly explained below.

Methods

We have traced the World Wide Web visibility of the first 13 SFFs operative in the 2003-2012 period using online web searches for verbatim centre names. The full SFF-centre names were entered to search for the frequency of appearance both inside and outside the Norwegian *.no* top-level *domain*. Search strings contained the official centre names registered by the RCN. We identified homonyms in the search results for two of the centre names²¹. Consequently, we added city name to the search string for those centres to exclude centres from other countries with an identical name.

Results

The Verbatim SFF-centre name searches resulted in wide differences among the centres, between approx. 600 to about 137,000 results (references to web pages) outside the Norwegian *.no* domain. Additionally, the searches were delimited to book references indexed by Google²². Most of the centre names searches returned 30 or more book references (+++), others between 20 and 29 (++) and two centre

²¹ Searches for the Norwegian SFF on civil war also returned results on George Tyler Moore Center for the Study of (the American) civil war.

²² Search delimitation to book references only within the returned search results was obtained using the function - More - Books (drop down item).

names searches returned 1-10 (+) book references. Repeated searches with identical search terms in October 2019 returned similar, but not identical number of search results. Complementary searches on the verbatim name of a selection of permanent Norwegian research institutions (with different size) were conducted for reference. Table 1b below gives the results, indicating that the results obtained by the SFFs which appear the most visible according to this method (40,000 to 137,000), are above some established/permanent Norwegian research institutions.

Table X1: Reference search results for permanent Norwegian research institutions outside the .no top-level domain

Search term	Norwegian URLs excluded [site:-.no]	Number of books
"Nordic Institute for Studies in Innovation, Research and Education"	About 17,400 results	++
"Norwegian Institute for Air Research"	About 72,300 results	+++
"Peace Research Institute Oslo (PRIO)"	About 98,600 results	+++
"Oslo University Hospital"	About 426,000 results	+++
"University of Oslo"	About 5,660,000 results	+++

Source: https://www.google.com/advanced_search

We find the lowest SFF centre web visibility for four of the first generation SSF centres where verbatim name searches returned 4,000 or less results. Five of the centre name searches returned between 4,001 and 40,000 results (moderate visibility) while another four SFF centre names returned more than 40,001 research results (high visibility).

There are a number of shortcomings to this simplified quantitative approach to measure web visibility. The presence of homonyms and incorrect spelling of affiliations are two obvious shortcomings. As noted, we added city connections to exclude identical centre names from non-SFF institutions in the search results. However, this may also exclude results from pages where actual SFF centres appear without the proper city name. Also, returned results for the verbatim centre name searches vary over time as web pages mentioning the centre names are edited, deleted or added²³. Exclusion of the .no top domain in repeated searches, also turned out to be only partly successful.

Consequently, the level of web visibility described above should be considered as indicative only. In addition, we have skimmed the search results from searches and found the highest ranked search results mainly to include researchers (faculty)

²³ Repeated searches with identical search terms in October 2019 returned similar, but not the identical number of search results. References to relevant pages published on URLs such as .org - and .edu were included in the search results.

personal presentations and references to books or scientific papers. In the research results we also typically find:

- references to magazines²⁴ and newspaper articles in e.g. New York Times²⁵
- references to research data repositories
- reference to research field overviews²⁶

The latter two types of references may indicate the importance of the centre to peers in the international research community.

In sum, it seems that the web visibility of the SFF is primarily connected to their researchers and publications. The centres themselves as organizations are seldom the main subject on these web pages. There is a large variation in numbers of search results between the centres. Still, differences in visibility are difficult to interpret. They seem to be partly dependent on thematic profiles and main areas of research.

²⁴ <https://www.scientificamerican.com/article/el-nino-found-to-influence-civil-wars/>

²⁵ <https://www.nytimes.com/2004/11/22/opinion/roots-of-conflict-dont-blame-environmental-decay-for-the-next-war.html>

²⁶ <https://www.annualreviews.org/doi/annurev-polisci-060415-093921>

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