The Research Council of Norway

Evaluation of the Norwegian Centres of Excellence (SFF) Funding Scheme

Report from the evaluation committee (2020)

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The Research Council of Norway

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Centre for Arctic Gas Hydrate, Environment and Climate (CAGE): Luis Lamar, the director of photography at National Geographic and Avatar Alliance Foundation, diving into the ice covered Arctic Ocean. RV Kronprins Haakon in the background. National Geographic joined the CAGE lead expedition to a seamount on the 83°N on the Gakkel Ridge.

Preface from the committee

Groundbreaking research has a tremendous effect on society, both in Norway and the rest of the world. The Norwegian Centres of Excellence (SFF) scheme has been an important contributor to such effects by providing consistent, significant and long-term support of curiosity-driven research at the highest level, which has led to great achievements.

The SFF programme was initiated in 2000, and in 2019, the Research Council of Norway (RCN) invited an international Evaluation Committee (EC) to assess it.

The EC has received a thorough internal report on the SFF programme from the RCN. The Nordic Institute for Studies in Innovation, Research and Education (NIFU) produced two reports: 'Impacts of the SFF scheme on the Norwegian research system', NIFU sub-report I and 'Bibliometric analysis and career mapping of the SFF scheme', NIFU sub-report II. These reports, together with previous reports on the SFFs and the centres' own reports, constitute the main sources for our work on the EC. The information in the written reports was supplemented by information obtained from interviews with key stakeholders. The high quality of the reports and the high level of enthusiasm and cooperation of stakeholders undeniably shaped our perspective in the assessment and facilitated the committee's task of producing a comprehensive report.

We would like to thank the RCN staff responsible for the SFF programme, Liv Furuberg and Åshild Vik, who have been helpful, professional and friendly in their interaction with us.

We initiated the assessment in summer 2019 and delivered the final report in March 2020.

Thank you to the centre leaders, vice-rectors, pro-rectors and rectors for taking the time to meet us in Oslo in January 2020, and for the positive dialogue about the SFF instrument and Norwegian research. Your remarks are highly appreciated. Thank you to RCN Director John-Arne Røttingen and the Board of the Research Council Norway for the opportunity to evaluate the impressive Norwegian SFF programme.

As Chair, I would like to thank the other members of the EC for a competent, professional and engaged collaboration. Thank you very much to Professor Ruedi Aebersold, ETH Zurich, Switzerland; Professor Mette Birkedal Bruun, University of Copenhagen, Denmark; Professor Tomas Hellström, University of Lund, Sweden; Associate Professor Mathilda Mommersteeg, University of Oxford, UK; and Professor Andy Woods, University of Cambridge, UK.

In this report, the committee presents its analysis, main conclusions and recommendations for the development of the SFF scheme. The final version of the report has been read and approved by all committee members.

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Executive Summary

The conclusion of this evaluation is that the SFF programme has been a great success for Norway. The evaluation committee recommends in the strongest terms that it be continued as the main mechanism to support the most innovative and risky research in Norway.

The Norwegian Centres of Excellence SFF scheme is a Research Council of Norway (RCN) funding instrument established in 2000 to promote quality in Norwegian research. The objective is to promote groundbreaking, curiosity-driven research that pushes the frontiers of international research.

The Ministry of Education and Research asked the RCN to perform an evaluation of the SFF scheme focusing on the following areas:

- Has the SFF scheme helped to enhance scientific quality?
- Has the SFF scheme had any impact on the research system?
- Are there recommendations for further development of the scheme?

The international Evaluation Committee (EC), which was approved by the RCN Executive Board, performed the evaluation as presented in this report. The background material for the EC included the reports:

- Bibliometric analysis and career mapping of the SFF scheme (NIFU, 2019b)
- Impacts of the SFF scheme on the Norwegian research system (NIFU, 2019a)

The RCN also provided a self-assessment report for the evaluation and other relevant back-ground material. The methodology was a collaborative evaluation of the material, and dialogue with key stakeholders, including SFF centre leaders, vice-rectors, pro-rectors and rectors in Oslo, in January 2020.

The EC was grateful for the high quality of the material provided and for the very helpful and professional interaction with the RCN staff responsible for the SFF programme, Liv Furuberg and Åshild Vik.

This, like other evaluations, has its limitations. They include the challenge of establishing causality between the SFF scheme and the observed performance metrics, and the difficulty in measuring quality and centre performance across different research fields. We tried to overcome these limitations by applying experience and judgement, by having group discussions about issues that arose and by juxtaposing different sources of information, including statements made during interviews and in written reports.

The SFF scheme has now funded 44 centres, and the first three generations are the focus of this evaluation report. Thus far, the SFF scheme has provided approximately NOK 3.9 billion in funding, and is obliged to allocate a further NOK 2.1 billion. The funding is distributed across four generations of SFF centres, in total 44. The first generation, SFF-I, was comprised of 13 centres that started up in 2002/2003 and ended their activities in 2012/2013. The second generation, SFF-II, was comprised of eight centres established in 2007, which ended their activities in 2017. The currently active centres are the 13 SFF-III centres that started in 2013 and the 10 SFF-IV centres that started in 2017.

The SFF scheme is comparable to other centre of excellence programmes with a basic science focus, such as the Swedish Linnaeus Centres of Excellence, the Australian Cooperative Research Centre Programme, the Danish National Research Foundation and the Swiss NCCR Programme.

This report aims to provide answers to the ultimate question: 'What is the value of such schemes?'. With all the necessary caveats, the short conclusion is that the scientific quality of research at the SFF centres has been excellent. The funding and establishment of the centres of excellence has changed the mindset of researchers, introduced the concept of excellence and allowed the best researchers to come together to design and conduct groundbreaking research and projects. They have sustained long-term results for society. The centres have produced more than 25% of Norway's top 10 cited articles and the centres have produced more than 30% of the top 1% of cited papers in Norway.

The SFF centres also excel when it comes to international collaboration, outperforming the Norwegian funding scheme for independent projects (FRIPRO) and the Norwegian average. The difference is particularly striking when it comes to collaboration with the top 42 universities in the world. Being part of a centre has allowed researchers to establish high-level collaboration, attracting top researchers and leading to groundbreaking research and publications. At the same time, the national collaboration in Norway has been maintained or extended. The establishment of the centres has allowed the best scientists to come together, creating a working environment that has driven excellence in research. SFF scientists have won important prizes and awards, including the Nobel Prize in Physiology or Medicine in 2014, which went to May-Britt Moser and Edvard Moser, together with John O'Keefe, for a discovery made in 2005 at their first SFF centre. The generous, long-term and flexible funding granted on the basis of international peer assessment of scientific quality, and centre directors of

eminent class, have been crucial factors. The centre leaders have been scientific drivers through their dynamism, and their specific individual blend of energy, ingenuity, scientific ambition and leadership has been plugged into the institution and spilled over into the general quality of research at the institutions.

The EC is convinced that the SFFs have helped to advance the quality of the Norwegian research system through collaboration in Norway and particularly with top universities across the world. Academic flexibility, the management of talent and collaboration, the necessary infrastructure and good organisational governance have been crucial to the success. The SFFs have been fertile hotbeds for researcher training, and the programme has decisively opened the gate and lowered hurdles between Norwegian and international research. Researcher training and recruitment have been of a high international standard, and the SFFs show creativity, robustness and ambition in their endeavour to provide the optimal researcher training for their young scholars, both individually and collectively.

Through the next generation, the SFF scheme has created the researchers of the future. Collaboration between and within institutions has been influenced by the centres' prestige, which have functioned as a beacon, and their positive impact on the host institutions is clearly seen from the viewpoint of the leaders, who claim that the SFFs have contributed to changing the research culture at the institutions. Talking about excellence is now accepted, and the centres are good examples of how to organise and initiate research. The centres' most important contribution to the universities has been the positive impact on the departments' ability to generate reliable, robust research results of the highest quality which address key scientific challenges and important societal challenges. This has been manifest by the production of impressive, top-level international research. As regards gender policy and diversity, the centres are on par with other research centres and groups in Norway, but could perhaps in the future become role models for diversity strategy and policy that includes age and gender. An improved exit strategy has been requested and should be considered.

The centres have societal impact through commercialisation, patents, spin-offs and involvement in product development, new methods and services, and translational research with improved clinical practice and better patient treatment in hospitals. Some centres have influenced policy through consultancy and advisory work, also at an international top-level scale. The centres have emphasised dissemination of research results to the general public and policy-makers through teaching, museum exhibitions, popular science books, presentations in mass media and interviews broadcast in documentaries and through mass media outlets.

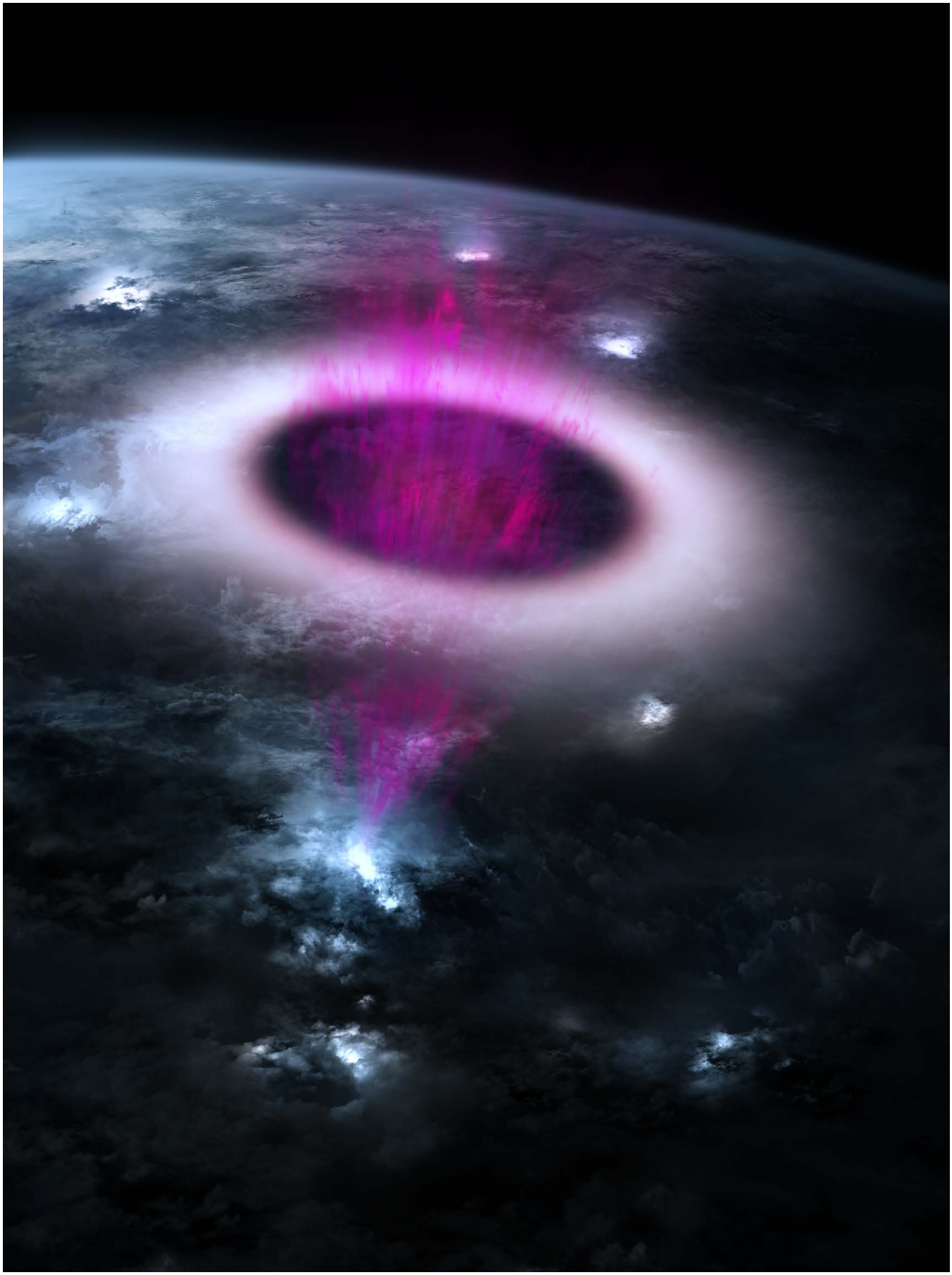
The negative effects of the SFF scheme have been few. A concern that the SFF scheme changes priorities in the host institution and thereby reduces resources for groups in the environment outside the centres has been voiced by some.

The criteria for selection of the SFF scheme has, through the first four generations, been solely on scientific excellence. It is the EC's opinion that it is crucial for the SFF scheme that the selection criteria continue to do so going forward. With the new organisation of selection criteria, it is a concern of the EC that more emphasis might be placed on impact and implementation. A drift in this direction should be avoided and this issue should be followed closely.

The conclusion of this evaluation is that the programme has been a tremendous success for Norway and we recommend in the strongest terms that it be continued as the main mechanism to support the most innovative and risky research in Norway. The centres have produced new knowledge, catalysed changes and updates in the education and training of scientists, created important innovation for the Norwegian and global industry and public sector, and have generally raised the international visibility and standing of Norwegian science. Science is global and many of the centres have had a remarkable effect on the global society. Groundbreaking research has produced benefits for the global community, and several of the SFF centres have influenced the world with their knowledge, expertise and innovation. For example, research conducted in the centres has developed methods that have led to increased survival rates for low birth-weight babies and precision diagnostics for cancer. Several new spin-off companies have been established and new processes that have been taken up by industries have increased their economic performance. Natural geohazard prediction methods have saved hundreds of lives, reduced economic losses by millions of Euros and improved the quality of life and resilience of many communities around the world. Research has influenced international recommendations and guidance on environmental protection and approaches for regulating releases of radioactivity, and research on the consequences of war and post-conflict peace has led to policy shifts at the World Bank and the construction of Sustainable Development Goal 16 by the United Nations.

The centres have been remarkably successful in terms of attracting European Research Council (ERC) grants to Norway – a clear sign of excellence in research. They have been instrumental for making the research culture in Norway more international and for recruiting, and to some extent retaining, top international scientists in the country. The SFF programme has consistently adhered to the principle of funding excellent, groundbreaking basic research for a period of 10 years per project. The consistent adherence to this principle has produced real societal impact. The programme has covered all fields of research, from geohazards and environmental radioactivity to breakthrough studies on societal conflicts and wars, marine biology and paradigm shifts in medicine.

The programme has evolved over the years and is now a refined and fine-tuned instrument. Excellence and predictability of SFF policies and objectives have been core to the programme's



Birkeland Centre for Space Science (BCSS): Animation of the Sun's and the Earth's magnetic fields meeting in the upper atmosphere, featured on the front page of Science in December 2019. The Atmosphere Space Interaction Monitor (ASIM) has instruments measuring gamma radiation and optical signals from lightning. Both detectors and electronics were developed and built by the instrument group at BCSS. ASIM was launched in April 2018. © Birkeland Centre for Space Science - Daniel Schmelling/Mount Visual

success. Scientific panels have been useful in the process of selecting new SFF centres, and the quality of this procedure going forward is essential for continued success. To assure the success of the programme also in the future, continued evolution of the programme will depend on the ability to retain what is good and develop what could be improved. Also, the framework conditions for research in Norway at large are important since they also form the basis of the SFF scheme. The continued improvement of the Norwegian universities and higher education landscape will be important for future generations of SFFs. It will be important to advance the cutting edge and thereby provide leverage to the whole Norwegian research ecosystem.

Our recommendations for the SFF programme going forward include:

- To continue the SFF programme for excellent, transformative and groundbreaking research as a 10-year programme for all research fields and preserve the criteria of excellence used hitherto to achieve groundbreaking curiosity-driven research.

- To continue to acknowledge the impact of the SFFs as a role-model for the Norwegian research landscape in the pursuit of excellence in Norwegian research.

- Risk-taking is crucial to foster the best research and should be supported by a true bottom-up process with focus also on the most advanced research methods and concepts, international and interdisciplinary collaboration and mobility to attract the very best researchers from abroad to Norway.

- Diversity, including gender aspects, should be strengthened. It will be particularly important to identify and prepare a younger generation of future centre leaders.

- The mid-term evaluation could be postponed until after 5-6 years to minimise the incentive to carry out mainstream research with a focus on rapid results and publications at the beginning of a centre's life. The rules and objectives of the mid-term evaluations should be clear, transparent and used to phase-out dysfunctional or underperforming centres.

- Universities should share 'best practice' in managing SFFs to achieve the best results for centres, the departments' hosting centres and the institution as a whole. Flexibility in handling the centres is important, especially for interdisciplinary centres and centres anchored in more than one department. To ensure fairness, coordination among the universities on how to support researchers in the application process is considered crucial.

- The competences of world-class centres with scientific knowledge of importance to the whole world should be retained. Therefore, a strategy for the final exit after 10 years should be considered. A solution for 'the most excellent of the excellent' should be considered with funding from outside the traditional SFF scheme to avoid cannibalising the next SFF generations. Tenure track, embedment in universities after exit and flexible solutions could also be considered.

- The RCN section that manages the SFF programme is small and efficient, and praised by all of the centres and universities. Panels established to assist procedures must be trustworthy and comprise eminent international scientists. Strengthening the SFF scheme with an international committee of eminent scientists should be considered to assist the RCN in further developing the scheme. This committee could oversee the evaluations, secure the best use of peer review in round two and act as a strong advocate for the programme. An internal 'champion' on the committee could be the director of the RCN. The regular follow-up meetings with centres could be strengthened by inviting this new committee to the meetings. The SFF programme could share best practice with similar excellence programmes in the Nordic countries and the rest of the world.

- All RCN funding programmes should be open to researchers within the SFFs.

- Academic freedom in all respects should be continued for the SFFs, including freedom of choice in relation to research subjects, aims, hypotheses, methods, approaches and an unconditional freedom of choice for where to publish.

Sammendrag

Konklusjonen av denne evalueringen er at SFF-ordningen har vært en stor suksess for Norge. Evalueringskomiteen anbefaler på det sterkeste at den blir videreført som hovedmekanisme for å støtte den mest nyskapende og risikofylte forskningen i Norge.

Sentre for fremragende forskning (SFF) er et finansieringsvirkemiddel administrert av Norges forskningsråd som ble etablert i 2000 for å fremme kvaliteten i norsk forskning. Målet er å fremme banebrytende, nysgjerrighetsdrevet forskning som flytter den internasjonale forskningsfronten.

Kunnskapsdepartementet har bedt Forskningsrådet om å gjennomføre en evaluering av SFF-ordningen med søkelys på følgende:

- Har SFF-ordningen bidratt til å styrke vitenskapelig kvalitet?
- Har SFF-ordningen hatt innvirkning på forskningssystemet?
- Hvilke anbefalinger er det for videreutvikling av ordningen?

En internasjonal evalueringskomite godkjent av Forskningsrådets styre har utført evalueringen som presenteres i denne rapporten. Bakgrunnsmaterialet for evalueringskomiteen har inkludert de to underrapportene:

- Bibliometric analysis and career mapping of the SFF scheme (NIFU, 2019b)
- Impacts of the SFF scheme on the Norwegian research system (NIFU, 2019a)

Forskningsrådet har også bidratt med en egenvurderingsrapport og annet relevant bakgrunnsmateriale. Metodikken har bestått av en felles vurdering av det innsamlede materialet i komiteen og dialog med sentrale aktører, inkludert SFF-senterledere, viserektorer, prorektorer og rektorer, som fant sted i Oslo i januar 2020.

Evalueringskomiteen er takknemlig for den høye kvaliteten på det tilgjengelige materialet og for det hjelpsomme og profesjonelle samarbeidet med Forskningsrådets ansatte som er ansvarlig for SFF-ordningen, Liv Furuberg og Åshild Vik.

Evalueringen har, som andre evalueringer, sine begrensninger. De inkluderer utfordringen med å etablere årsakssammenheng mellom SFF-ordningen og de observerte resultatene, samt utfordringen med å måle vitenskapelig kvalitet og resultater for sentrene på tvers av ulike forskningsfelt. Vi har prøvd å takle disse begrensningene ved å bruke vår erfaring og dømmekraft, gjennom gruppediskusjoner om problemstillinger som oppsto underveis og sammenstilling av forskjellige informasjonskilder, inkludert uttalelser fra intervjuer og skriftlige rapporter.

SFF-ordningen har til nå finansiert 44 sentre fordelt på fire sentergenerasjoner. Det er de tre første generasjonene som er vektlagt i denne evalueringsrapporten. Så langt har SFF-ordningen utbetalt omtrent 3,9 milliarder kroner og er forpliktet til å utbetale ytterligere 2,1 milliarder kroner. Den første generasjonen, SFF-I, besto av 13 sentre som startet opp i 2002/2003 og ble avsluttet i 2012/2013. Andre generasjon, SFF-II, besto av 8 sentre som ble opprettet i 2007 og avsluttet i 2017. Sentrene som er aktive i dag er 13 SFF-III sentre som startet i 2013 og ti SFF-IV-sentre som startet i 2017.

SFF-ordningen kan sammenlignes med andre senterprogrammer med fokus på fremragende forskning, også kalt Center of Excellence (CoE) programmer, som de svenske Linnecentrene, det australske Cooperative Research Centre Programme, Danmarks Grundforskningsfonds Centers of Excellence program og det sveitsiske NCCR-programmet.

Denne rapporten tar sikte på å gi svar på det sentrale spørsmålet om hva som er verdien av slike ordninger. Med alle nødvendige forbehold er den korte konklusjonen at den vitenskapelige kvaliteten på forskningen ved SFF-sentrene har vært fremragende. Finansieringen og opprettelsen av sentre for fremragende forskning har endret forskernes tankesett, introdusert konseptet fremragende forskning og lagt til rette for at de beste forskerne har kunnet samarbeide om å designe og utføre banebrytende forskning og prosjekter. De har produsert resultater med langsiktig samfunnsverdi. Sentrene har produsert mer enn 25 prosent av Norges 10 prosent mest siterte artikler, og mer enn 30 prosent av de 1 prosent mest siterte artiklene i Norge.

SFF-sentrene utmerker seg også når man ser på internasjonalt samarbeid sammenliknet med Fri prosjektstøtte (FRIPRO) og norsk forskning generelt. Det er en spesielt stor forskjell når man ser på samarbeid med de 42 beste universitetene i verden. Å være en del av et SFF-senter har gjort det mulig for forskere å etablere samarbeid på høyt nivå som tiltrekker seg toppforskere og som igjen fører til banebrytende forskning og publikasjoner. Samtidig er det nasjonale samarbeidet i Norge opprettholdt eller utvidet. Opprettelsen av sentrene har gjort det mulig å samle de beste forskerne og skape miljøer som har drevet fram fremragende forskning. SFF-forskere har vunnet viktige priser og utmerkelser, inkludert Nobelprisen i fysiologi eller medisin i 2014 som gikk til May-Britt Moser og Edvard Moser, sammen med John O'Keefe, for en oppdagelse som ble gjort i 2005 i deres første SFF-senter. Sjenerøs, langsiktig og fleksibel finansiering, tildelt på grunnlag av internasjonale fagfellers vurdering av vitenskapelig kvalitet, og eminente senterledere har vært avgjørende. Senterlederne har vært

vitenskapelige pådrivere, og deres individuelle kombinasjon av energi, oppfinnsomhet, vitenskapelige ambisjoner og ledelse har påvirket den generelle kvaliteten på forskningen ved institusjonene.

Evalueringskomiteen er overbevist om at SFF-ene har bidratt til å fremme kvaliteten av det norske forskningssystemet gjennom samarbeid i Norge og spesielt med de beste universitetene globalt. Akademisk fleksibilitet, utvikling av talent og samarbeidsrelasjoner, nødvendig infrastruktur og god organisatorisk styring har vært avgjørende for suksessen. SFF-ene har vært fruktbare miljøer for forskeropplæring, og ordningen har helt klart åpnet dører og senket barrierer mellom norsk og internasjonal forskning. Forskeropplæring og rekruttering har holdt høy internasjonal standard. SFF-ene viser kreativitet, robusthet og ambisjoner i sine anstrengelser for å gi unge forskere den best mulige opplæringen, både individuelt og samlet.

SFF-ordningen har utdannet fremtidens forskere. Samarbeid mellom og innenfor institusjoner har blitt påvirket av sentrenes prestisje og funksjon som ledestjerner. Den positive effekten på vertsinstitusjonen sees tydelig fra rektorer og dekaners ståsted, som uttrykker at SFF-ene har bidratt til å endre forskningskulturen ved institusjonene. Det er nå lov å snakke om fremragende forskning, og sentrene er gode eksempler på hvordan man kan organisere og initiere forskning. Det viktigste resultatet av sentrene for universitetene har vært den positive effekten på fakultetenes/instituttenes evne til å produsere pålitelige og robuste forskningsresultater av høyeste kvalitet for å møte sentrale vitenskapelige og samfunnsmessige utfordringer. Dette har manifestert seg i produksjon av imponerende internasjonal forskning på høyeste nivå. Når det gjelder kjønnsbalanse og mangfold er sentrene på nivå med andre forskningssentre og grupper i Norge, men kunne kanskje i fremtiden utvikles til å bli rollemodeller for strategi og politikk for mangfold, inkludert alder og kjønn. En forbedret exit-strategi er etterspurt og bør vurderes.

Sentrene har samfunnsmessig betydning gjennom kommersialisering, patenter og «spin-offs» og involvering i produktutvikling, nye metoder og tjenester, og translasjonsforskning med forbedret klinisk praksis og bedre pasientbehandling på sykehus. Noen sentre har påvirket både norsk og internasjonal politikk gjennom konsulent- og rådgivningsvirksomhet. Sentrene har lagt vekt på formidling av forskningsresultater til allmennheten og politikere gjennom undervisning og museumsutstillinger, populærvitenskapelige bøker, presentasjoner i massemedier og intervjuer i dokumentarer og nyhetsmedier.

De negative effektene av SFF-ordningen har vært få. Noen uttrykker imidlertid bekymring for at SFF-ordningen endrer prioriteringer hos vertsinstitusjonen og dermed reduserer tilgjengelige ressursene for grupper i forskningsmiljøet utenfor sentrene.

Utvelgelseskriteriene for SFF-ordningen har gjennom de første fire sentergenerasjonene utelukkende vært basert på vitenskapelig kvalitet. Det er evalueringskomiteens oppfatning at det er avgjørende for SFF-ordningen at utvelgelseskriteriene i fremtiden fortsetter å være det. Med den nye organiseringen av utvelgelseskriterier er evalueringskomiteen bekymret for at det vil legges mer vekt på virkninger og effekter (impact) og gjennomføring (implementation). En forskyvning i denne retningen bør unngås, og denne problemstillingen bør følges nøye.

Konklusjonen av denne evalueringen er at programmet har vært en enorm suksess for Norge. Komiteen anbefaler derfor på det sterkeste at SFF-ordningen videreføres som hovedmekanisme for å støtte den mest innovative og risikofylte forskningen for Norge. Sentrene har produsert ny kunnskap, katalysert endringer og oppdateringer i utdanning og opplæring av forskere, skapt viktig innovasjon for norsk og global industri og offentlig sektor og har generelt hevet den internasjonale synligheten og statusen til norsk vitenskap. Vitenskapen er global, og mange av sentrene har hatt en bemerkelsesverdig effekt på det globale samfunnet. Banebrytende forskning bidrar til samfunnet, og flere av SFF-ene har påvirket verden med sin kunnskap, kompetanse og innovasjon. For eksempel har forskning i sentrene utviklet metoder som har ført til økt overlevelse for nyfødte med lav fødselsvekt og presisjonsdiagnostikk for kreft. Flere nye spin-off-selskaper er etablert, og næringslivet har adaptert nye prosesser som har forbedret økonomiske resultater. Metoder for å forutsi geologiske naturkatastrofer har reddet hundrevis av liv, redusert økonomiske tap med millioner av euro og forbedret livskvaliteten og motstandsdyktigheten i mange samfunn rundt om i verden. Forskning har påvirket utviklingen av internasjonale anbefalinger og retningslinjer for miljøvern og utslipp av radioaktivitet, og forskning på konsekvensene av krig og fredsbygging har ført til politiske endringer i Verdensbanken og utformingen av FNs bærekraftsmål nummer 16.

Sentrene har vært bemerkelsesverdig vellykkede når det gjelder å trekke ERC-bevilgninger til Norge – et tydelig tegn på fremragende forskning. De har vært medvirkende til å gjøre forskningskulturen i Norge mer internasjonal og til å rekruttere, og til en viss grad beholde, internasjonale toppforskere i landet. SFF-ordningen har konsekvent fulgt prinsippet om å finansiere fremragende, banebrytende grunnleggende forskning i en periode på ti år per prosjekt. Fastholdelsen av disse prinsippene har gitt reelle samfunnseffekter. Ordningen har dekket alle forskningsfelt, fra geologiske trusler og miljøradioaktivitet til gjennombruddstudier om samfunnskonflikter og kriger, marinbiologi og medisinske paradigmeskifter.

Ordningen har utviklet seg gjennom årene og er nå et velutviklet og finjustert instrument. Kvaliteten og forutsigbarheten av SFF-ordningens retningslinjer og mål har vært sentrale for ordningens suksess. Vitenskapelige paneler har vært nyttige i utvelgelsen av nye SFF-sentre, og fremtidig kvalitet på denne prosedyren er avgjørende for fortsatt suksess. For å sikre ordningens suksess også i fremtiden er det viktig å beholde det som er bra og utvikle det som kan forbedres. Rammebetingelsene for forskning i Norge generelt er også viktig for SFF-ene. Arbeidet med kontinuerlig forbedring av norske universiteter og høyere utdanning generelt vil også

være viktig for fremtidige SFF-generasjoner. Det vil være viktig å fremme det banebrytende og derved løfte hele det norske forskningsøkosystemet.

Våre anbefalinger for fremtidens SFF-ordning er:

- Å fortsette SFF-ordningen for fremragende, transformativ og banebrytende forskning som et tiårig program for alle forskningsfelt og bevare kvalitetskriteriene som hittil er brukt for å oppnå banebrytende nysgjerrighetsdrevet forskning.

- Å fortsette å anerkjenne effekten av SFF-ene som rollemodeller for det norske forskningslandskapet i arbeidet med å fremme høy vitenskapelig kvalitet.

- Risikotaking er avgjørende for å fremme den beste forskningen og bør støttes av en ekte bottom-up-prosess med søkelys også på de mest avanserte forskningsmetodene og -prinsippene, internasjonalt og tverrfaglig samarbeid og mobilitet for å tiltrekke seg de aller beste utenlandske forskerne til Norge.

- Mangfold, inkludert kjønnsaspekter, bør styrkes. Det vil være spesielt viktig å identifisere og forberede en yngre generasjon av fremtidige senterledere.

- Midtveisevalueringen kan utsettes til 5–6 år etter oppstart for å redusere insentivet til å gjennomføre mindre banebrytende forskning med fokus på raske resultater og publikasjoner i begynnelsen av senterperioden. Regler og mål for midtveis-evalueringene bør være tydelige, transparente og brukes til å fase ut sentre som er dysfunksjonelle eller ikke holder mål.

- Universiteter bør dele «beste praksis» i håndtering av SFF-er for å oppnå best mulig resultat for sentre, institutter og andre enheter som er vert for sentre og institusjonen som helhet. Fleksibilitet i håndteringen av sentrene er viktig, spesielt for tverrfaglige sentre og sentre som er forankret i mer enn én administrativ enhet. For å sikre rettferdig konkurranse er det avgjørende med en koordinering mellom universitetene av hvordan de støtter forskere i søknadsprosessen.

- Kompetanse i sentre som er i verdensklasse og produserer vitenskapelige resultater av stor betydning for verdenssamfunnet, bør beholdes. Derfor bør en strategi for senteravslutning etter ti år vurderes. En løsning for «de mest fremragende av de fremragende» bør vurderes med midler utenfor den ordinære SFF-ordningen for å unngå kannibalisering på de neste SFF-generasjonene. Innstegsstillinger, integrering ved universiteter etter avslutning og fleksible løsninger kan også vurderes.

- Gruppa i Forskningsrådet som administrerer SFF-ordningen er liten og effektiv og berømmes av alle sentre og universiteter. Fagpanelene som administrasjonen støtter seg på må være pålitelige og bestå av fremragende internasjonale forskere. Det bør vurderes å styrke SFF-ordningen med en internasjonal komite av fremragende forskere for å støtte Forskningsrådet med ytterligere utvikling av SFF-ordningen. Komiteen vil kunne føre tilsyn med evalueringene, sikre best mulig bruk av fagfellevurdering i trinn 2 og fungere som en sterk pådriver for ordningen. Forskningsrådets direktør vil i komiteen kunne fungere som intern pådriver. De regelmessige oppfølgings-møtene med sentrene kunne styrkes ved å inkludere den nye komiteen. SFF-ordningen kunne med fordel utveksle erfaringer med lignende programmer i Norden og resten av verden.

- Alle finansieringsordninger i Forskningsrådet bør være åpne for forskere i SFF-ene.

- SFF-ene bør fortsatt ha full akademisk frihet, inkludert valg av forskningstema, mål, hypoteser, metoder og tilnærminger, samt ubetinget frihet i valg av publiseringskanaler.

Centre for Interdisciplinary Studies in Rhythm, Time and Motion (RITMO): Concert/experiment in RITMO's Motion Lab where data from motion tracking and pupillometry is collected.

1 Introduction

The Norwegian Centres of Excellence (SFF) scheme is a Research Council of Norway (RCN) funding instrument established in 2000 to promote quality in Norwegian research. The SFF scheme's primary objective is to provide support in all fields of research to enable Norway's leading research groups to perform groundbreaking, curiosity-driven research that pushes the international research frontier. Centres funded under the SFF scheme are also expected to facilitate the education of the excellent scientists of the future.

The SFF scheme is administered by the RCN and funded by allocations from the Ministry of Education and Research. Thus far, the SFF scheme has allocated almost NOK 4 billion and is contractually obligated to allocate a further NOK 2 billion. Over four generations of centres, the scheme has funded 44 projects, 23 of which are in operation today, and the SFF scheme is set to announce its next call in autumn 2020.

The SFF scheme has been evaluated once before, culminating in the report Evaluation of Added Value and Financial Aspects – The Norwegian Centre of Excellence Scheme (NIFU STEP, 2010). This evaluation focused primarily on the centres' added value for their host institutions, as well as the more financial aspects of the SFF scheme. However, it did not evaluate the centres' respective scientific merit.

1.1 TERMS OF REFERENCE

In its allocation letter for 2019, the Ministry of Education and Research asked the RCN to perform an evaluation of the SFF scheme. The terms of reference for the evaluation were approved by the Board of the Division of Science in December 2018 (Appendix A).

On behalf of the RCN, a scientific Evaluation Committee (EC) comprising six international professors was invited to evaluate the SFF scheme. The evaluation was to focus on the following areas:

- Has the SFF scheme helped to enhance scientific quality?
- Has the SFF scheme had any impact on the research system?
- Are there recommendations for further development of the scheme?

The findings and conclusions from the evaluation report will primarily be used to further develop the SFF scheme.

1.2 METHODOLOGY

The current evaluation was performed by the EC, which was approved by the RCN Executive Board. Based on the available data, the committee has prepared this independent and consolidated evaluation report.

The committee had its first meeting in Copenhagen in July 2019. This was a preparatory meeting with the RCN administration. In January 2020, the committee met again at the RCN headquarters in Oslo for a two-day meeting. During this meeting, the committee met and interviewed 31 former and current centre directors (Appendix C), leaders of the four largest Norwegian universities, as well as the CEO of the RCN, John-Arne Røttingen.

The RCN has provided a substantial amount of background material, as well as secretarial assistance in writing the main report. The background material provided for the committee includes two sub-reports specifically commissioned by the RCN for this evaluation:

- Bibliometric analysis and career mapping of the SFF scheme, NIFU (2019)
- Impacts of the SFF scheme on the Norwegian research system, NIFU (2019)

The RCN has written a self-assessment report for the evaluation (Evaluation of the Norwegian Centres of Excellence (SFF) Funding Scheme - Self-Assessment report from the Research Council of Norway (2020)) that includes information about the history of the scheme, its finances, selection procedures (including call documents and requirements and guidelines), and information obtained from the centres' progress reports. The RCN has also invited former and current centres to submit impact cases for the evaluation that have been collected and shared with the committee (Evaluation of the Norwegian Centres of Excellence (SFF) Funding Scheme – Impact cases (2020)).

The committee has in addition been provided with

- mid-term evaluation reports for the SFF-I, -II and -III centres
- annual reports for the SFF scheme
- annual reports from the centres from the last year of submission
- final reports for the SFF-I and SFF-II centres
- Evaluation of Added Value and Financial Aspects – The Norwegian Centre of Excellence Scheme (2010)
- Report on Science & Technology Indicators for Norway (versions from 2007, 2012, 2016 and 2018)
- Room for increased ambitions? Governing breakthrough research in Norway 1990-2013, Benner and Öquist (2014)
- OECD Reviews of Innovation Policy – Norway (2017)
- Kvalitet i norsk forskning (2000)
- SFF – Utredning av en norsk ordning (2000)

1.3 LIMITATIONS

This, like other evaluations, has its limitations. These include:

- The challenge of establishing causality between the SFF scheme and the observed performance metrics.
- The difficulty in conclusively identifying the incremental contribution of the SFF programme in terms of centre excellence and output, considering that top-level Norwegian scientists generally lead the centres.
- Difficulties in measuring and comparing quality, and centre performance and standing, in centres that span across many research fields and disciplines.
- The challenge of assessing the objectivity of statements made in interviews, in view of the fact that most people interviewed have personally benefitted from and are strongly engaged in the SFF programme.

The EC acknowledges the existence of these limitations and mitigated their effect by applying experience and judgement, by having group discussions about issues that arose and by juxtaposing different sources of information, e.g. statements made during interviews and in written reports.

Centre for Ecological and Evolutionary Synthesis (CEES): The Sparrow Group conducting fieldwork at the Chokpak ringing station, Kazakhstan. Here they are catching a flock of migrating *Passer domesticus bactrianus.* © Tore O. Elgvin

2 SFF as part of the Norwegian research system

The conception of the SFF Centre of Excellence (CoE) scheme at the turn of the millennium marked a shift in Norwegian research policy towards excellence.

Part of the background was a series of disappointing evaluations of Norwegian research, pointing at a low level of ambition, variable quality and few contributions to the international research frontier (NIFU, 2019b). The shift towards excellence was initiated in 1999 on the basis of a government white paper on research, which made a case for increased investments in world-leading research to support Norway's transition from a resource-based to a knowledge-based economy (Ministry of Education and Research, 1999). The RCN was given the task of proposing how a Norwegian CoE scheme could be set up, and the result was presented in the year 2000 (RCN, 2000). The national budget bill for research for 2001 tasked the RCN with administering the SFF scheme, which was to be funded by yields from a newly established Fund for Research and Innovation. Initially established by the government in 1999 to make the financing of long-term basic research less vulnerable to shifting political agendas, the Fund for Research and Innovation was liquidated in the aftermath of the financial crisis in 2008, resulting in a reintegration of the SFF budget into the yearly allocations received by the RCN from the Ministry of Education and Research.

2.1 RESEARCH FUNDING

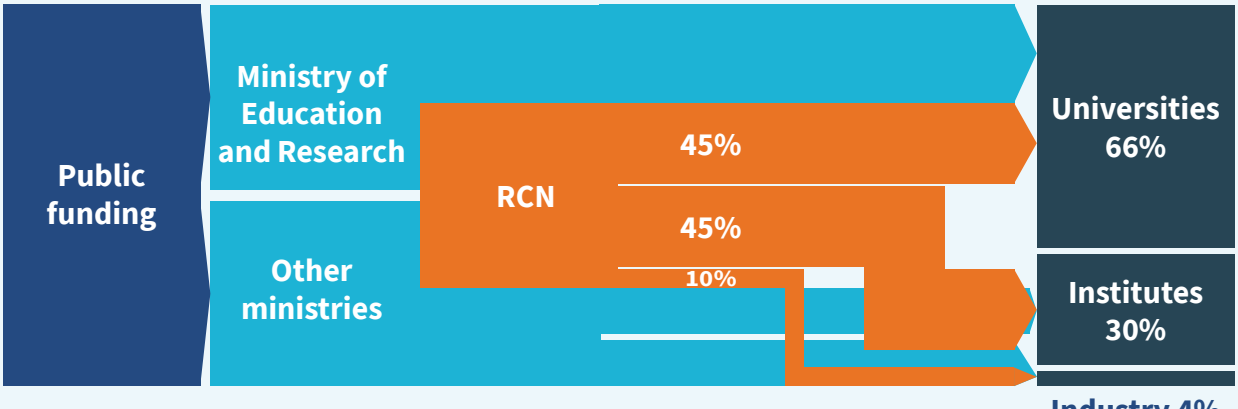
In 2017, Norwegian R&D expenditure was NOK 69 billion, of which 47% was directly funded by public sources (NIFU, 2018). Government funding in Norway is provided by all ministries according to what is known as the 'sector principle', meaning that each ministry takes responsibility for research activities in its sector. The Ministry of Education and Research is by far the greatest contributor to R&D activities, accounting for almost two thirds of the total public funding, with NOK 20 billion.

The Ministry of Health and Care Services, and the Ministry of Trade, Industry and Fisheries come next in funding volume with around five and four billion NOK in annual spending, respectively. Other ministries contribute in varying degrees to research that is relevant to their respective sectors.

Norwegian R&D is performed in three basic sectors; the industrial sector (companies and enterprises aimed at commercial production of goods and services for sale); the institute sector (private non-profit (PNP) research institutes mainly serving industry, research institutes and other R&D-performing institutes (other than higher education) mainly controlled by and funded by the government, and health trusts that do not provide education and PNP hospitals); and the higher education sector (universities, specialised university institutions, state university colleges and university hospitals). The higher education sector is by far the greatest beneficiary, receiving 66% of the public budget for research. The largest part of this funding is channelled directly from the ministry to the higher education institutions (HEI) as core funding, amounting to around 70% of the total public contribution to this sector.

The RCN receives funding for R&D amounting to 27% of the total public funding (NIFU, 2019) and from nearly all ministries. In 2018, the RCN allocated NOK 9.8 billion to R&D with equal shares of 45% to the higher education sector (including university hospitals) and the independent research institute sector (including PNP hospitals). Direct funding of projects in industry accounts for only 10% of RCN spending, but it should be noted that many of the projects funded by the RCN in the institute sector include industrial partners (Figure 1).

FIGURE 1 R&D EXPENDITURE BY SECTOR AND SHARES OF RCN ALLOCATIONS (2018)

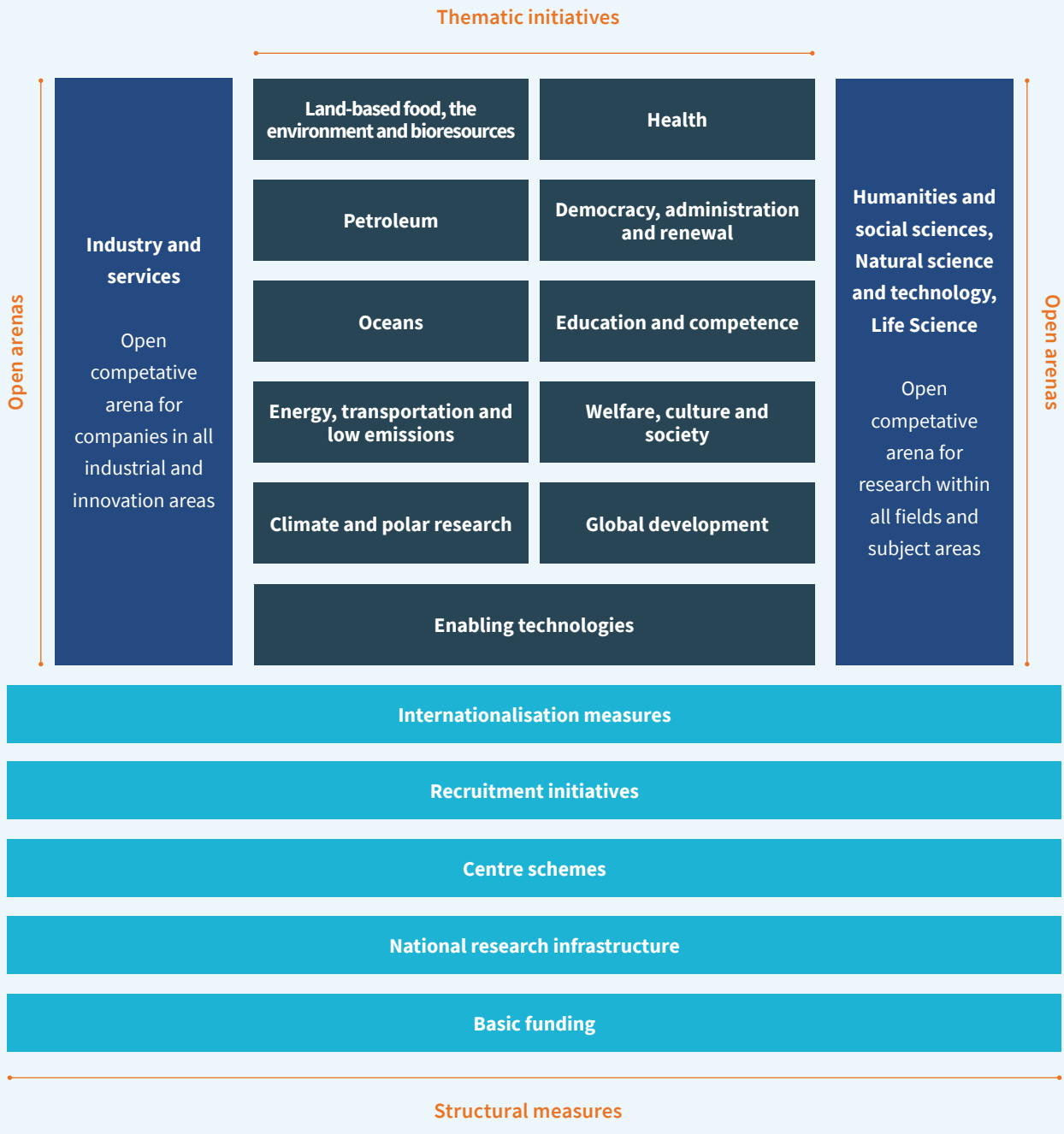


Source: NIFU R&D statistics 2019, calculations by the RCN

During the 20 years of the SFF scheme, the RCN has supported research with a variety of funding programmes. The present organisation (2020) is depicted in Figure 2. The funding opportunities cover the spectrum from curiosity-driven open arenas to thematic or field-restricted arenas. There are two open arenas, one primarily geared towards researchers in the institute and higher education sectors (Figure 2, right-hand side), and the other for business-oriented research (Figure 2, left-hand side). The thematic portfolios (Figure 2, middle) cover research performed in all three sectors. These portfolios correspond to a large extent with priorities set out in the government's Long-term Plan for Research and Higher Education (LTP).

Basic research is funded within both thematic and open funding instruments, albeit to varying degrees. The largest funding opportunity for basic research is within the independent projects scheme (FRIPRO), which is an open arena for research in all disciplines. In 2018, 83% of the independent projects'

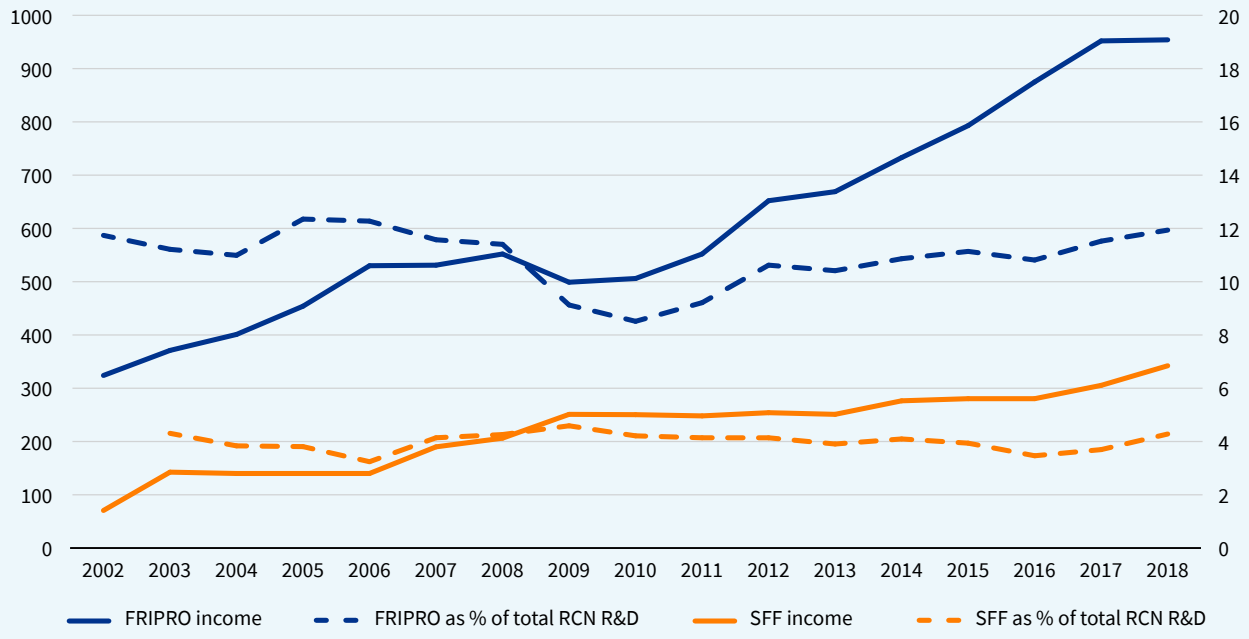
FIGURE 2 RCN FUNDING PROGRAMMES (2020)



Source: RCN

1 From the RCN database Prosjektbanken, total for Store programmer, Handlingsrettede programmer and Grunnforskningsprogrammer (large-scale programmes, action-oriented programmes and basic research pro-grammes).

FIGURE 3 BUDGETS OF SFF AND FRIPRO COMPARED TO THE RCN TOTAL, 2002-2018.



portfolio of NOK 1.1 billion was classified as basic research. The RCN's thematic programmes also fund a significant share of basic research (37%) [1], whereas 15% of the business-oriented BIA programme is classified as basic research. In total, NOK 3.8 billion, or 39%, of the RCN's entire allocation in 2018 was classified as basic research.

The share of RCN funding dedicated to the excellence schemes FRIPRO and SFF have been relatively constant over time (Figure 3). The SFF scheme has been quite stable at around 4% of RCN funding, whereas the open arena for independent researcher projects (FRIPRO) shows a dip between 2008 and 2012, but resurging to its 2002 level of 12% of total RCN funding in 2018.

Whereas FRIPRO is intended to support smaller curiosity-driven research projects, SFF is the only programme in the RCN portfolio that supports large curiosity-driven cooperative projects aimed at scientific excellence; the type of project that is essential to tackle the complex problems facing society. The differences between the two programmes supporting curiosity-driven research is apparent from the following figures: In 2018, FRIPRO made 107 awards with an average of NOK 8 million per award, while in the last call, SFF made 10 awards with an average of NOK 150 million per award.

2.2 RESEARCH PERFORMANCE

According to the OECD's review of Norway's innovation policy, Norway's research output has seen a steady increase from a very low level in the 1980s: 'Norway is ranked far above the world average, but below Switzerland, Denmark and Sweden in terms of the number of scientific articles published per inhabitant' (OECD, 2017). Other indicators such as bibliometrics and subject specific evaluations suggest that 'Norway performs less well in terms of quality measures and lacks world-class environments. Its share of the top 10% most cited publications lags well behind that of the leading countries, including Denmark, the Netherlands, Sweden and Switzerland' (OECD, 2017).

However, as of 2019, Norway is currently on par with Sweden and Finland in terms of citation impact (NIFU, 2019), and thereby among the world leading countries measured per capita.

The OECD review also states that: 'the fragmentation and lack of critical mass in the dominant higher education institutions, both within the organizations and in the overall higher education sector, impede the emergence of more "peaks of excellence"' (OECD, 2017). The Norwegian educational and research landscape is characterised by a substantial number of universities and university colleges, with a few traditional research and higher education institutions located in Oslo, Trondheim and Bergen. A considerable number of smaller institutions initiated in the post-war era are regionally distributed, but the number of HEIs has decreased significantly in recent years, mostly due to mergers in the university college (UC) sector (OECD, 2017). However, it is too early to tell how these mergers will influence research performance.

The OECD review also commends Norway's increased investment in excellent research through the RCN, referring specifically to the SFF scheme and the recent calls for FRIPRO Toppforsk proposals. The latter provides more generous funding lasting up to five years for research projects that have the potential of attaining the highest international standards, but as the OECD review states: '…there is still room to increase the share of large, risky and more fundamental projects in the overall Norwegian (i.e. RCN) funding portfolio, as indicated by the Productivity Commission report and the recent RCN Spending Review' (OECD, 2017).

Objectively, the contribution of the SFF scheme to this improvement in research output cannot be directly quantified. However, some of the most successful and internationally known scientists in Norway are involved in or lead SFFs, and 45% of ERC grants awarded to Norway are linked to the SFFs. As the SFF programme constitutes only 4% of the total RCN R&D expenditure, it can be confidently stated that the programme fulfils its intended roles of raising the quality of research in Norway towards excellence, and increasing international connections and visibility.

2.3 RESEARCH POLICIES

According to the OECD (OECD, 2017), Norway is facing a 'triple transition imperative'. The first transition relates to a shift towards a more diversified and robust economy. A strong research and innovation system will be needed to transform the economy, which is still highly dependent on oil and gas. In the view of the OECD, the higher education sector lags behind those of the other Nordic countries in a number of key research performance indicators, despite a high level of public expenditure. The second transition thus involves moving towards a more competitive, effective and efficient innovation system, with sufficient incentives and checks and balances for better performance in research and innovation. Finally, the third transition imperative is that these transformations must be achieved while supporting research and innovation that can confront an array of societal challenges.

More specifically on the challenge of developing excellent academic communities, the OECD points to the fragmentation and lack of critical mass in the higher education institutions as a structural barrier to the emergence of more 'peaks of excellence'. The universities themselves have an important role to play in enhancing research quality. The OECD points out the need for clearer priority setting within these institutions that could serve as a basis for selection mechanisms at the level of departments, research groups and individual researchers. A more strategic use of internal block funding in order to create critical mass and attract top talent to the institutions' best departments is essential for developing peaks of excellence. One of the aims of the SFF scheme is to stimulate more strategic priorities at the host organisations, of which the large majority are higher education institutions. The OECD thus recommends that Norway continues to fund centres of excellence as an effective external driver of change for the public research sector, but warns at the same time that CoEs cannot substitute for internal priority setting and structural reforms in the higher education sector. Nevertheless, the EC noted that, apart from producing high-level science, the SFF programme also significantly contributed to an increased awareness of scientific excellence in institutions that have so far not been successful in SFF competitions. The committee heard about specific measures at these institutions that aimed to make them more competitive for upcoming SFF generations.

In 2014, the government introduced the LTP with a ten-year planning horizon, including binding budget targets in several areas for the first four-year period (Ministry of Education and Research, 2014). This plan included a clear ambition to increase the funding available for excellent research: 'Norway has many good academic environments, along with a highly developed business community in a number of areas, but we have the potential to be even better. In addition to a general commitment to quality in research and higher education, the Government will prioritize special efforts in world-class science. This is necessary to stimulate more breakthroughs and greater international visibility for Norwegian research, as well as to benefit from the knowledge found among the foremost international experts' (p. 5, English version). The government has followed up on this ambition by increasing the investment in world-leading academic groups. Among other measures, excellence-related programmes at the RCN (SFF and FRIPRO) saw a cumulative budget increase of more than NOK 300 million per year (2014-2018), representing a nominal growth of 33% compared to a 26% increase in the total RCN budget (excluding basic funding for research institutes). NOK 66 million of this increase went to the SFF scheme.

As planned, the government presented a revised LTP in late 2018, this time with greater emphasis on new technology and industrial renewal, and adaptation to a post-carbon society. The revised objectives and strategic priorities of the LTP are intended to inform priorities also within the existing budgets of research performing and research financing organisations. In contrast to the first LTP period, the concrete budgetary targets for the upcoming four-year period are concentrated around two ambitions: the development and use of new technologies (Teknologiløftet), and research for renewal of industries and adaptation to a post-carbon society (Næringsløftet) (Ministry of Education and Reseach, 2018). Whereas the definition of high priority research fields is a necessary and effective measure, the EC strongly emphasises the need for programmes to support curiosity-driven research excellence. The SFF is the main RCN funding mechanism with this aim and is therefore of critical importance to Norwegian science.

Taken together, the SFF scheme positions itself in the Norwegian research and political landscape by funnelling long-term, open and competitive resources into excellent research groups. This pushes the international research frontier and aids the transition from a resource-based to a knowledge-based economy, thus contributing to the government's LTP.

2.4 THE SFF SCHEME

The SFF funding scheme was established in 2000 with the primary objective of providing support that enables Norway's leading research groups to perform ground-breaking research. The research should involve ambitious ideas and complex problems that require coordinated efforts within or across disciplines, and the centres should provide a collaborative environment that educates excellent researchers for the future.

SFF centres are carefully selected through an open, competitive selection process where the main criterion is scientific quality. The process relies on peer review by internationally renowned scientific experts.

It was only in the first generation of SFF centres (SFF-I) that the call for applications included thematic priorities. These were removed from the following announcements (SFF-II, -III and -IV). The selected SFF centres therefore vary greatly across disciplines and thematic areas (RCN, 2020a). However, compared to the Norwegian higher education sector in general, funding from the SFF scheme has to a somewhat larger degree been awarded to the natural sciences (RCN, 2020a).

The SFF scheme is today funded by allocations from the Ministry of Education and Research, and in 2018 had an income of NOK 342 million. This represents approximately 4% of total annual RCN funding. The SFF funding instrument offers generous, long-term and flexible framework financing to a relatively small number of centres. Up to and including 2019, the SFF scheme has allocated approximately NOK 4 billion and is contractually obligated to allocate a further NOK 2 billion, funding a total of 44 centres (Appendix B). The funding is distributed across four genera-tions of SFF centres:

- SFF-I: Thirteen centres started up in 2002/2003 and ended their activities in 2012/2013. Over the project period, these centres each received NOK 60–210 million from the RCN.
- SFF-II: Eight centres started up in 2007 and ended their activities in 2017. Over the project period, these centres each received NOK 77–120 million from the RCN.
- SFF-III: Thirteen centres started up in 2013 and will end their activities in 2023. These centres will each have received NOK 105–175 million from the RCN by the end of the project period.
- SFF-IV: Ten centres started up in 2017. These centres will undergo mid-term evaluation in 2021/2022 and are to be ended in 2027. Contingent on the outcome of the mid-term evaluation, these centres will each receive NOK 129–167 million from the RCN over the project period.

The next generation of centres (SFF-V) is planned to start in 2022.

Each SFF centre is funded for a maximum of 10 years. The funding is awarded for an initial five-year period with the possibility of a five-year extension contingent on the outcome of a mid-term evaluation. However, no centres have been discontinued after mid-term evaluation.

In addition to financial contributions from the RCN, each centre also has funding from its host institution, from exter-nal grants, and, in some cases, from partner institutions. On average, the RCN's SFF contribution constitutes about 23% of the centres' total funding, the host institutions provide about 27% and the RCN provides a further 19% from its other fund-ing instruments. International funding amounts to about 7%

Norwegian Centre for Mental Disorders Research (NORMENT): Magnetic resonance imaging (MRI) of the brain. © NORMENT

of the centres' total funding. The total funding for all 23 active centres (SFF-III and -IV) in 2018 was NOK 1.2 billion. This represented approximately 1.8% of the total R&D expenditure in Norway that year and about 5% of the R&D expenditure in the Norwegian higher education sector (RCN, 2020a).

The centres are led by a centre director and employ a large number of scientific personnel and support staff. In 2018, the 23 active centres reported that 752 professors and researchers, 274 postdocs and 456 PhD students were affiliated to the centres. This represents 4% of senior scientific staff, 14% of postdocs and 8% of PhD students in the country. In addition, 274 people were employed as technical or administrative staff. The centres also have a large number of affiliated guest researchers and collaborators, many of whom are internationally renowned.

2.5 TERMINOLOGY AND APPROACH

In this report we use the term research output for publications, books, catalogues, inventories etc. In addition to lists of publications, such research output can generally be characterised by citations, Journal Impact Factor (JIF) and other bibliometric parameters. Research outcome is used for new products, theories, methods or procedures etc. derived from research. Research impact is used to describe the effect of the research output and outcome on society. Research output can be measured, but it is more difficult to perform outcome and impact analyses. This has come to constitute a whole research area in itself, with new methods such as IRIS, Researchfish, the UK RAE etc., and has led to much debate. It is difficult to measure quality and excellence in research, as the concept of quality varies between research fields, cultures and traditions. For this reason, we have tried to apply the concept with a great amount of humility and inclusiveness. We have used publications of all kinds, citation counts where relevant, patents, and information about research outcome and impacts. We also look at education in terms of teaching and supervision, including master's degree and PhD studies. We have reviewed collaboration with national and international groups, international summer schools, master classes and conferences, and we look at funding aside from the SFF scheme, as well as prizes. We do not compare the SFF centres, and we try to look at the overall achievements for each centre in relation to other research groups within the same field. In doing this, we seek to describe the SFF scheme in Norway in relation to the international research landscape, and to answer the question: Has the SFF scheme stimulated excellent and groundbreaking research, and in effect contributed to the development of the Norwegian science system?

A further challenge concerns the ultimate value of such schemes. This report aims to provide a number of answers to this challenge in the context of Norway in general and the SFF scheme in particular. However, before that, a few general remarks may be in order.

Research can be described as a delicate ecosystem with basic research, translational research and applied research and technology characteristically forming a continuum and progressing concurrently. There is no sharp distinction between these concepts, and in fact, science and innovation policies, and even individual policy instruments, often demonstrate a mix of these. In addition, interdisciplinarity, or convergence among research specialisms, is more prevalent than ever, and modern research technologies utilising big data, AI and digitalisation are on the increase in almost all fields of research. All investments from the public purse must be motivated by arguments about some sort of ultimate societal value, and investments in scientific achievements are not necessarily different. Yet, for different stages of scientific inquiry, the demonstration of societal value differs. Whereas the value of translational projects can often be measured objectively, the eventual societal impact of curiosity-driven research is frequently delayed and may not be directly measurable. Yet, the innovations that provide the strongest transformation frequently arise from curiosity-driven projects carried out at a high level of excellence. The ecosystem notion described above is therefore closely connected to the expectation that scientific research offers a spectrum of outcomes, including new industrial products, methodologies, new clinical knowledge, and a variety of other beneficial effects for society, but also fundamentally new knowledge with the potential to become disruptive.

Innovation can be derived from research, as in the case of many new drugs and medical procedures, and it may lead to new methods e.g. for fish farming, or even for international courts. Innovation can of course also arise without any kind of research whatsoever. However, without a sustained long-term, basic science effort, the level of innovation and societal impact of research will inevitably decrease. In addition, research is the basis for novelty in and improvement of education, which is important for universities and secondary education, and not least for an enlightened public discourse, as the new graduates carry their knowledge into society, be it the public sector or industry. Research is also fundamental for evidence-based decision-making in all parts of society.

It is a complex task to assess research output, outcome and societal impact, as it may take many years to unfold the full potential of research results, particularly those of curiosity-driven research programmes. However, it has been demonstrated in several studies that investments in research pay off. The MRC, NIH and Welcome Trust analysis from the UK 'Medical Research, what's it worth?' reports an impressive revenue on research investments in terms of 33% perpetually every year after the funding/investment was given (Health Economics Research Group, Office of Health Economics, RAND Europe, 2008). Investments in curiosity-driven basic research have huge innovation impact as demonstrated in the inventory from the DNRF Centre of Excellences 'Curiosity pays off' (Danish National Research Foundation, 2013).

3 SFF in the international landscape

The SFF scheme is an example of a type of research policy instrument that has been increasingly applied internationally to further excellence in science.

The current report focuses on one type of research policy instrument that has been increasingly applied internationally to further excellence in science, namely Centres of Excellence. In essence, the typical CoE can be described as an organisational environment that strives for and typically achieves an internationally high level of research quality in a particular area of science, innovation or even socio-economic improvement, e.g. such as those related to grand challenges. International examples of CoEs include those that focus on either one of these three missions or combine them to various extents.

Typical examples of basic science-focused CoEs are the Swedish Linnaeus Centres of Excellence, the Swiss NCCR programme and the Danish National Research Foundation's CoE programme; the innovation-oriented CoE can be exemplified by the Norwegian SFI scheme; and the socio-economic impact CoEs by the Australian Cooperative Research Centres Programme. In addition, there is a type of CoE that ties together research activities in networks, for example the Canadian Networks of Excellence. The Norwegian CoE programme, SFF, is an example of a basic science-oriented CoE scheme that aims to create unitary, localised, 'under one roof' organisational platforms for research that aspires to achieve new discoveries and scientific breakthroughs. It is therefore an instance of the first kind of CoE. In that sense, it shares a common ambition with other types of individual-based excellence initiatives such as the European Research Council Advanced Grants or the Swedish Distinguished Professor Grants, but with the essential difference that the SFF-type scheme aims to achieve these outcomes by creating and fostering a new local social environment, or organisation, as a platform for the research. Another difference is that the SFF centres do not focus on a single Principle Investigator (PI) but are operationally governed by a centre director who may coordinate several sub-project PIs. It is therefore more like the Swiss NCCR programme or the Swedish Linnaeus programme than, say, the ERC Advanced Grants or the Swedish Distinguished Professor Grants. An additional typical feature of the Norwegian SFF scheme, shared by many other CoE initiatives, is a strong geographical and institutional concentration of the participating centres.

This type of CoE has become a significant part of the policy mix for the higher education and research sector across the world. In many ways, it is possible to identify a global model or blueprint for these excellence schemes, in terms of topics (highly competitive, discovery-oriented global research programmes), selection systems (multi-stage international peer review), funding (large, long-term funding commitments) and evaluations (high-impact publishing, awards, organisational capacity and visionary leadership). Even though many successful CoEs tend towards certain topics, e.g. nanotechnology, neuroscience, biomedical and life sciences, information technology and computer science (aka STEM subjects), the instrument has also been successfully applied to support research from the social sciences and humanities. A typical observation, however, is that the instrument is most commonly and successfully employed where there is a potential to utilise a highly skilled scientific workforce, advanced research infrastructure, a mature high-tech industrial system and above all, the presence of scientists with high international standing. On the other hand, several countries have utilised the CoE instrument successfully for its ability to revitalise the science system through creating platforms that enable focus on certain desirable topics, to stimulate collaboration/interdisciplinarity among specialisations and that enable universities and scholars alike to develop priorities and engage in new research programmes, and to attract talent into new emerging areas of research. In this way, apart from stimulating and furthering already excellent research, the CoE instrument can also be utilised for overcoming 'capability gaps' in a research system by building up critical mass, as well as for bridging 'credibility gaps' vis-à-vis governments, industry and other interest groups by clearly demonstrating strength and commitment in a specific area of science deemed important.

4 Interviews by the Evaluation Committee

4.1 DIALOGUE WITH CENTRE DIRECTORS, RECTORS, PRO/VICE-RECTORS AND THE RCN DIRECTOR

This chapter summarises the interviews conducted with the centre directors, rectors, pro/vice-rectors and the RCN director by the EC in Oslo in January 2020. The names of the interviewed persons are listed in Appendix C. The EC members carried out the interviews and their overall impressions are given here. When different groups were interviewed in parallel by subsets of the EC, the same questions were used for all groups of invited persons, for reasons of consistency. This chapter presents a summary of the main messages as interpreted by the EC.

The overall feedback was overwhelmingly positive, and it was emphasised that the SFF programme had had an important and positive influence on Norwegian research, both in terms of the research production in itself, but also in being a role-model for transforming the Norwegian research landscape, using the same mechanisms as those of the ERC throughout Europe. The SFF has raised the acceptance of excellence and groundbreaking research as a necessity for solving the present extensive societal problems. The centre directors were positive about the SFF programme, and they all agreed that its main distinguishing feature is scientific excellence. The following summarises the answers to the specific questions put to the interview subjects.

Can anything be done to strengthen the programme?
There was consensus that the RCN handled the SFF programme effectively. It was added that some universities and departments could improve their handling of the SFF programme through exchange of 'best practice', with focus on flexibility, freedom and fast solutions to overcome bureaucracy. Organisational matters for the centres, especially those with interdisciplinary research topics and those anchored in different places, was also said to have room for improvement in some centres.

Better possibilities for submitting applications for funding in addition to the SFF programme would strengthen the SFF centres' research abilities, and they recommended not setting any limitations to SFF researchers who wished to apply to the other RCN programmes.

No hindrance whatsoever of the free right to publish was stressed as a very important element. Similarly, they recommended keeping the modest requirements for reporting to the RCN, postponing the mid-term evaluation for 1-2 years and considering a time span longer than 10 years. Increasing the provision of teaching in those centres where it was restricted, either due to the centre itself or a lack of flexibility in university teaching programmes, was also stressed.

Is there an 'A team and B team' feeling?
The NIFU report (NIFU, 2019a) describes that in some university departments, a number of researchers perceive the SFF centres to be the 'A teams' and the other researchers outside the SFF centres to be the 'B teams'. Generally, the A/B distinction was not acknowledged in the group of SFF centre directors. For those who did acknowledge the concern, it was not found to be a major issue. To alleviate any A and B team perception, they suggested sharing 'best practice examples', including an open-door policy for the SFF centre to the outside world, to avoid the feeling of the SFF being 'an island' within the department, and to secure 'soft borders', so that colleagues outside are encouraged to collaborate with the centre. It was considered important to ensure that the culture of the SFF centres resonated and enriched that of the host department and institution in general. Several pointed to the inevitable – that the concept of excellence includes both collaboration and competition. Sharing of infrastructure and fairness in teaching was proposed as a way of alleviating an eventual A and B feeling, and good leadership from the department heads, deans, vice-rectors and rectors were mentioned as being essential. In all aspects of centre administration and leadership, the necessity of transparency was underlined.

Exit strategy – What is best?
For some centres, 10 years is a perfect period, while others have developed competences of importance for society, both in the public sector and industry in Norway and beyond, and some centres have developed into 'the most excellent of the excellent'. All of these attractive competencies should be preserved for the sake of future societal strength. Flexibility is therefore recommended for the exit strategy, including funding provided by the university to institutionalise the research field after the 10-year period. Some centres have and some will continue to pursue new visions and give birth to new centres, and 'the most excellent of the excellent' may need special arrangements.

Some centre directors considered the mid-term evaluations to be ineffective and inconsequential, and they also experienced the review as a constraint on their ability to achieve breakthrough results, because they needed to generate tangible results very early on in the centre's lifetime. Some directors suggested abandoning the mid-term review, but all agreed that the rules for the mid-term review should be more clearly communicated, and that it should lead to clear-cut consequences, including the discontinuation of underperforming centres. Big is not necessarily better, but a prolongation of centres with special competences and/or centres considered 'the most excellent of the excellent' needs to be considered.

Gender and diversity – How is it best supported?

The centres and the RCN have made considerable efforts to increase gender diversity, and with some success. The new proposed model for SFF-V, where the universities must assure a balanced distribution of gender among the applications, appears to promote gender diversity. However, it was mentioned that areas with very few women may experience a negative bias in the initial steps of preparations for new centres of the fifth generation (if universities send four or more applications, at least 40% must have a female as the proposed centre leader). The centre directors also suggested focusing on increasing other types of diversity, including age diversity. The average age of centre directors is quite high, and a proactive involvement of younger centre scientists in leadership positions should be considered. Positioning the brightest young scientists to lead high level research efforts should be encouraged. The diversity of nationalities was also found to be important, and the SFF programme is probably the best vehicle to achieve mobilisation in attracting the very best scientists from abroad and vice versa.

New criteria for SFFs focusing on impact and implementation – Consequences?

There was unanimous support for the present criteria of research excellence as the only prevailing metric. It was further commented that the predictability and periodicity of calls for new generation centres is very important for the scheme, and the period of 4-5 years between generations is viewed as optimal. Universities and the whole research ecosystem spend a considerable amount of time preparing for the next generation of SFFs, and so the selection criteria should not be changed just before the announcement of a new generation of SFFs. It is well recognised internationally that in ex-ante evaluations, subsequent impact and implementation is very difficult, if not impossible, to predict, and that the long-term importance for society will be best obtained by focusing on research excellence, as it is the best predictor of transformative research.

There was strong consensus that the key assessment criteria of excellence has the strongest potential to develop outstanding, fundamental and pioneering research. There was encouragement to recognise the potential for research-driven innovation emerging from such science, and that such outputs may be game-changing for society, in addition to the top-quality scientific publications produced.

Centre for Early Sapiens Behaviour (SapienCE): Archaeologists work systematically to document everything they find as they dig out new cultural layers, so as to not miss important clues that can tell us about the behaviour of early humans. The photo shows the inside of Blombos Cave. © Ole Unhammer

5 Scientific quality

The research from the centres is highly cited and the researchers internationally competitive. Some of the centres are world leaders in their fields. Several features of the scheme enable this success.

5.1 QUALITY OF RESEARCH AT THE SFF CENTRES

Over the past decades, the SFF scheme has had a strong impact on the quality of basic science in Norway. The funding and creation of centres of excellence has changed the mindset of researchers, introducing the concept of excellence and allowing the best researchers to come together to design and perform groundbreaking research and to support groundbreaking projects with sustained, long-term funding. To obtain funding from this attractive scheme, researchers were expected to collaborate and design more ambitious projects using state of the art techniques. This has not only led to more international collaboration with prestigious universities worldwide and high impact publications, it has also led to the 2014 Nobel Prize in Physiology or Medicine, awarded to May-Britt Moser and Edvard Moser, together with John O'Keefe, for their discovery of an internal positioning system in the brain.

The following details summarise the EC's assessment of questions related to scientific quality.

Do the centres produce highly cited articles?

An analysis based on 37,000 articles that were produced by the first three SFF generations shows that the centres have produced more than a quarter of Norway's top 10% cited articles in the same period (NIFU, 2019b). Not enough time has passed to be able to evaluate the publication impact of the SFF-IV centres, but a similar pattern is expected. All of the first three generations not only performed much better than the rest of the world, they also outperformed the host institutes and FRIPRO grantees in terms of publication metrics. The number of highly cited publications seemed to increase while the centres were active, compared to the years before, which is a good indication of the scheme's success. The same patterns are also visible when looking at the 1% most highly cited publications, with the centres producing more than 30% of the top 1% cited papers in Norway. These data indicate the value of the excellence scheme in creating centres where top researchers can attract top talent and together produce groundbreaking research that is recognised across the world. An analysis of the citation index also picks up on the fact that there is a wide range of citations between different centres. In each generation, a group of centres far outperforms the other centres and a few centres perform below the Norwegian average. This variation is to be expected of course, as innovative, groundbreaking projects also carry high risks. When aiming to achieve excellence, testing novel concepts carries a risk of failure.

Do the centres produce publications of high international quality?

Publications from the centres are not only highly cited, they are also published in the most prestigious international journals. SFF-II and SFF-III performed well above the world average, and FRIPRO and Norwegian averages, while SFF-I was on par with FRIPRO. The SFF centres also excel when looking at international collaborations, again outperforming FRIPRO and the Norwegian average. There is an especially strong difference when it comes to collaborations with the top 42 universities in the world. All three generations of SFF centres established a much larger network of high calibre international collaborations after the centres became active, indicating the success of the funding scheme. Publications based on international collaboration, particularly with the world's leading research organisations, are more frequently cited. Being part of a Centre of Excellence has allowed researchers to establish high level collaborations, attracting top researchers and leading to groundbreaking research and publications.

Have the centres' research activities had long-term scientific impacts in their respective fields internationally?

The increase in the number of highly cited publications in prestigious journals, as well as the increase in the calibre of international collaborations, indeed indicate international long-term scientific impact. The SFF centres have established international collaborations with the world's most influential research institutions, achieving the goal of bringing the quality of research in Norway closer to the top 42 universities in the world while maintaining the same level of national collaboration. Some of the centres have become world leaders in their fields.

To what extent do the centres themselves act as the driving force in groundbreaking research?

The centres have brought together the best scientists, creating a working environment that further drives excellence. The centres have attracted the best researchers and students. New teaching programmes at master's degree and PhD level have created a new generation of students taught by experts who are at the forefront of their fields. Secondly, the creation of a funding source that specifically funds innovative groundbreaking research has allowed the centres to design more ambitious research projects and to become the driving force in innovative basic research.

5.2 RECOGNITION AND COMPETITIVENESS OF THE SFF RESEARCHER

An extensive survey has been produced of the output from the SFF programme over the three first cycles of funding, and this has included a detailed assessment of the quality and competitiveness of the SFF researchers in terms of quantifiable measures (NIFU, 2019b). It is valuable to review these measures, as well as to stand back and assess the longer-term contribution of the researchers from the SFFs in terms of their scientific legacy.

Four indicators that are of particular relevance are the citation rate of papers, prestigious awards and invitations to give lectures, awards from the ERC and other national and international funds, and the quality of the competition for positions in the SFFs. In addition, a further measure relates to collaborations with research groups in the top institutions worldwide.

Citation rates

In terms of the citation rate, the SFF researchers have a documented major positive impact in Norway. Two measures that have been introduced include measuring the fraction of papers produced by a centre that are in the top 1% or the top 10% of papers, by citation, in a given field. In 18 of the 30 centres that have been assessed, either

(a) More than 20% of the papers produced by the centre were in the top 10% of papers in the research field of the centre, or
(b) More than 3% of the papers produced by the centre were in the top 1% of papers in that field.

Of these 18 centres, 10 centres achieved both criteria (a) and (b) (NIFU, 2019a). Although caution is needed with citation rates, this suggests that the research performed in the centres attracts considerable international attention.

From a different perspective, the research outputs from the SFFs account for about 21.5% of the research papers produced in Norway, although the total funding of the active SFF centres corresponds to only about 2% of the total Norwegian research budget (RCN, 2020a). The centres were also responsible for 27.5% of articles published by Norwegian researchers that are in the international group of papers with the highest 10% of citations in that field. Similarly, they were responsible for 31.4% of papers produced based on Norwegian research that are in the group of papers with the top 3% of citations in that field. These measures indicate extremely successful research outcomes for many of the SFFs. In addition to these data, a survey carried out led to a series of interesting perceptions about publications and research dissemination outside academia, with 40% of the researchers perceiving that there was greater dissemination of the research as a result of being conducted within the SFF structure (NIFU, 2019a). Overall, the bibliometric analyses indicate that the SFF programme attracts the most successful scientists in Norway and, based on the increase in their metrics during the centres' activities, further increases their research output.

Awards and international collaboration

A number of prizes and awards have been won by SFF scientists, including the Nobel Prize as described above. In 2018, all the centres were involved in active international collaboration, including 21 centres who worked with academics in the UK, USA or Germany, and over 30 of the centres collaborated with researchers from countries including Brazil, Russia, India, Japan and China. Since 2006, the centres have in fact had collaborations with over 93 countries.

Awards from the ERC and other funding

The SFFs have attracted high calibre scientists to contribute to their research activity. Many of these people have been successful in attracting international and national funds in addition to the resources associated with the SFFs. For example, in the period 2007-2018, 34 ERC Advanced Grants were awarded to Norwegian institutions, and 17 of these had a PI employed at an SFF before or when they received their grant. A further seven PIs with ERC Advanced Grants became involved with SFFs after receiving their ERC award, including several who have later become centre directors. Examining the evidence from a different perspective, in 2018, 20 of the 23 SFFs had foreign income, which accounted for nearly 12% of the total foreign income in Norwegian higher education institutions. This included income from 14 ERC grants, including five Starting Grants, three Consolidator Grants and six Advanced Grants. This is very strong evidence that the SFFs have scientists that compete successfully at the very highest international level.

Competition for positions and international profile

The SFFs have a history of engaging foreign students, postdocs and senior research staff. The proportion of international PhD students has been steadily rising since 2011 and from 2016-2018 reached levels of over 40%, suggesting that the research programmes are internationally competitive and attractive. A similar trend can be seen at the postdoc level, where over 50% of postdoctoral researchers are foreign. Similarly, foreign senior scientists represent a share of nearly 30% of the senior scientists employed by the SFFs (RCN, 2020a). Taken together, these data point to the international attractiveness of the SFF scheme, and the diversity of talent being drawn into the research base of the country. This is strong evidence of the SFFs' ability to draw in a competitive and international research talent base. One element of the data on nationality relates to data from 2014, which identifies 39% of Norwegian PhD students, 59% of postdocs and 23% of professors as immigrants or descendants of immigrants (RCN, 2020a).

Where there are senior scientists employed in centres, especially those drawn in from abroad, there may be opportunity to diversify the international profile of the university faculty where appropriate through the appointment of these scientists to permanent positions following the SFF programme.

5.3 EFFECT OF THE SFF SCHEME ON QUALITY

In bibliometric terms, each generation of SFFs as a group performs above comparable groups at their host organisation, and above the Norwegian average. They also perform above the highly competitive FRIPRO average. In line with the reasoning presented in the previous section, this suggests that the SFF scheme has managed to attract Norway's most talented researchers, as well as top-level talent from abroad. In addition, although there are large variations among the SFFs, a majority (21 out of 30) showed positive trends during the period of funding (NIFU, 2019b, p. 60) This suggests that the participants were able to improve on research production/quality by partaking in the scheme. The main purpose of this section is to identify which aspects of the SFF scheme are likely to have had these effects. We do this by identifying certain aspects of the SFF scheme that are likely to promote research practices that have an affinity to research quality, and then observing to what extent the SFF centres display such characteristics.

Quality promoting aspects of the SFF scheme

The SFF scheme is designed to promote research quality in ways that show some similarities to traditional project funding, but that also deviate from such smaller scale instruments in important ways. The primary objective of the Norwegian SFF scheme has been to support research groups so that they can perform at, and advance, the international research front in their respective fields, as well as to promote future excellence in research by transferring skills e.g. to younger researchers (RCN, 2020a). In addition, the SFF encourages scientists to address big questions using research methods and approaches that span disciplines. Furthermore, there are a number of other motivating aspects of the SFF scheme that have been proposed in previous reports, including to counteract fragmentation in the Norwegian research system, and to increase the attractiveness of Norwegian researchers to international collaboration. This is expected to be achieved by certain features including:

- generous, long-term and flexible funding
- a coherent and co-localised organisational base for the research
- funding on the basis of international peer assessment adhering to a high standard of scientific quality (including the potential of centres to produce groundbreaking results)
- mid-term evaluations focusing on both research quality and organisational aspects, e.g. the centre's organisation and collaboration
- a centre director who leads the centre
- a scientific advisory committee attached to the centre

The quality-promoting aspects of the scheme would be, firstly, that the availability of substantial and long-term funding enables risk-taking as well as more sustained investment in research programmes. Secondly, the organisational platform based on colocalisation would promote collaboration across research disciplines, thereby promoting novelty. Thirdly, leadership under a centre director facilitates a coherent research trajectory and counteracts fragmentation. Fourthly, excellence-oriented assessment criteria stimulate practices that promote quality in research.

Which features play the greatest role in achieving scientific quality at the centres?

Previous evaluations have suggested that centres promote quality in research typically through enabling collaboration and interaction across organisational boundaries and academic fields. In this regard, the most important enabling features of the centres were scientific vision and strategic focus; the ability to exploit possibilities for interdisciplinarity, e.g. by defining new territories between disciplines; strong but dynamic leadership and team management that creates 'interaction within a framework'; and the ability to attract top international and national talent thereby creating international environments. These qualities also make the centres exceptionally well-adapted for training new researchers. The vast majority of SFF participants report that the scheme increased involvement in interdisciplinary research by connecting multiple fields compared to their previous activities (NIFU, 2019a; 2019b). The sharing of facilities, joint seminars and other social arrangements contributed to this outcome. New research trajectories stimulated by centre involvement tended to continue after the SFF had been concluded (NIFU, 2019a, p. 46). According to participants, the two main factors that advanced research in the SFF context were new collaborations and long-term funding (NIFU, 2019a, p. 46). Other quality promoting aspects of the centres included enhanced visibility afforded by the organisation as a CoE, which often led to new funding and new research collaborations.

Are there other forms of added value from organisation as a centre, and if so, what?

The NIFU bibliometric and career impact study (NIFU, 2019b) suggests that the SFFs have helped advance the quality of the Norwegian research system through, among other things, collaboration with top universities globally. At the same time, national interactions remain intact, which suggests that the international collaborations may have an important spillover effect on local actors. Such spillovers seem to have taken place locally, between SFFs and host organisations. The mid-term evaluations suggested that many, if not most, of the centres had fostered interaction across departments and faculty borders. This is likely an effect of many factors, including that of encouraging participation from several fields in the centre. It is also likely that the agglomeration of academic competence, international talent and organisational capacity in project attraction and leadership represent vital opportunities for spillovers into the host organisations. According to the NIFU survey, the SFFs contributed to capacity building in the host organisation, typically with respect to grant applications and procedures, recruitment and integration of new staff. The SFFs tended to contribute to building strong researcher trajectories/programmes in the host departments and increasing their prestige, thereby attracting international talent to the host (NIFU, 2019a, pp. 63-65). Not only SFF participants, but also deans and vice-deans have reported these types of impacts, by referring to SFFs as a form of 'institutional innovation' that facilitates intellectual and organisational boundary crossing. The SFF becomes a resource for the host to use strategically, for example when setting priorities. In terms of the impact

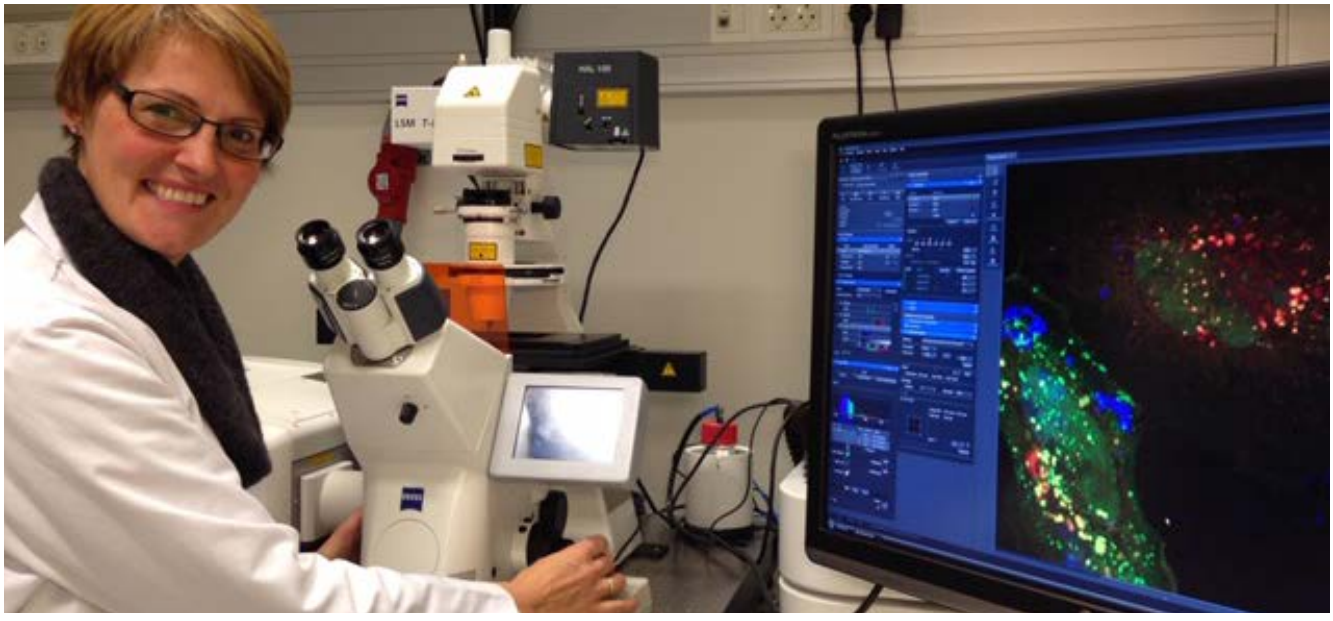
of the SFF scheme on training future researchers, 80% of the PhD students connected to the scheme believe it has been important to their career trajectories, research contacts and national/international collaboration (NIFU, 2019a, p. 35). This may be explained by the privileged position of centre trainees who could advance their education in a research environment where high-level internationally competitive science is the norm.

What characterises the centres that are particularly successful?
The majority of the SFFs (18 out of 30) can be considered very highly cited, in that they have a high proportion of their articles among the top 1% or top 10% most cited. These centres also seem to have had the majority of the value added from SFF funding in terms of combining different fields, advancing knowledge on key questions in their fields, participating in collaborations and having access to research infrastructures. At the same time, those SFFs that increased their top-university collaboration during the SFF period do not report any substantial impact on their research performance. This may be related to the fact that these researchers already had a high publication output (NIFU, 2019a, p. 87). Participants in the SFFs that received top scores in the mid-term evaluations reported that their participation increased their opportunities to draw on multiple fields. When looking at the top-scorers across the board (bibliometric, collaboration and mid-term evaluation), we find a group of 12 SFFs that all report significant benefits in terms similar to the expected goals of the SFF scheme, viz. participation in interdisciplinary and international collaboration, contribution to key international research questions, career opportunities, external research dissemination, and increased time for research (NIFU, 2019a, p. 88). In order to capture key characteristics of the top-performing SFFs with regard to scientific quality, we looked more closely at the 10 centres that scored the highest on the Nordic Level 2 list, Nature Index Journals and proportion of top 10% and top 1% cited articles overall. The mid-term and self-evaluations of these centres reveal some common denominators, in that such centres tended to be characterised by the following features:

Academic flexibility: The ability to expand into adjacent fields to support the core research programme, and to adjust research trajectories to follow up on new trends or leads.

Management of talent and collaboration: A high level of national and international collaboration, including mobilisation of international top-level researchers in the field. This includes international recruitment of both young and senior scholars, as well as mobilisation of local researchers to focus their research efforts in the direction of the centre. It also involves mentoring and in-house PhD training as a recruitment base. Recruitment of international talent in turn critically depends on the standing of the centre scientists, particularly the centre director and the quality and relevance of the research topic.

Necessary infrastructure and good organisational governance: This includes the ability to expand into new facilities, and to improve infrastructure when necessary. It also involves creating a favourable infrastructural environment with direct access to core research equipment. As regards organisational governance, these centres typically have strong, visionary leadership, where leadership and organisational structure promote discussion and interaction, and provide an enabling research culture/environment for young scholars. It also characteristically involves a sub-group structure where groups display a complementary vision with organised collaboration between groups, for example in the form of seminars and meetings centred on research communication, e.g. data sharing, joint authoring and analysis. Finally, the top centres typically have a very good relationship with their host organisation.



Centre for Cancer Cell Reprogramming (CanCell): Scientist Camilla Raiborg at the fluorescence microscope. © Øystein Horgmo.

6 Has the SFF scheme had any impact on the research system?

The centres have extensive international collaborations and create dynamic environments for PhDs and postdocs. University leaders see the scheme as strategically important for their institutions.

6.1 RESEARCHER TRAINING AND RECRUITMENT

The SFFs are fertile hotbeds for researcher training. The centres have recruited a considerably larger proportion of young scholars than the overall level in the Norwegian research system. In the group of scholars below the age of 35, about 50% of the scholars in the SFFs are in this group against 23% in the core Norwegian system. As a considerable subsection of this group, the proportion of PhD students and postdocs is also higher in the SFFs than in the core Norwegian system. The SFFs have furthermore seen increasing internationalisation among young scholars. The period 2012-15 saw a surge in the share of postdocs reported as foreign from 19 to 57%, and this share has been relatively stable since. In the period 2012-16, the share of PhD students reported as foreign increased from 21 to 43%.

There is also vivid activity in terms of recruitment and career movement relating to the SFFs. Young SFF researchers seem more likely to pursue careers outside Norway and outside the core research system than their peers in the core Norwegian system, but a substantial number of researchers with foreign degrees also choose to stay in the Norwegian research system (NIFU, 2019b, pp. 86-87).

It seems to take postdoctoral researchers from SFFs longer to obtain a permanent position in the HEI sector than is typical for researchers from the core Norwegian system. NIFU suggests that this might be owing to pickiness or desire for a position with more research than teaching (NIFU, 2019b, p. 80). Several representatives from host institutions mention that the SFFs have given a general lift to their host institution in terms of research quality, internationalisation, research infrastructure and training. This lift applies to researcher training as well.

The contribution of SFF centres to the educational mission

In general, the SFFs have a spillover effect on their host institutions and this is also the case when it comes to researcher training. The centres develop new methods and initiatives to educate their young researchers and, in many cases, invite scientists and students who are not affiliated with SFFs in their host environments to partake in these activities, just as there is osmosis to teaching and other forms in the wider educational work of the institutions. The SFF staff contribute to the teaching, but it can be a challenge to integrate scholars involved in interdisciplinary work into a traditional core disciplinary teaching programme.

The vast majority of the staff in the SFFs have stated that their teaching duties at bachelor's degree level have not changed with the SFF status. Among those who reported a decreased level (16%), the majority comes from the social sciences and humanities (NIFU, 2019a). A major impact on undergraduate teaching at the University of Oslo has been reported by three previous SFFs that have renewed their science education by integrating computer modelling and programming from the beginners' courses. The result of this effort is a new generation of science graduates that are highly skilled in using computers to solve scientific and engineering problems and have been trained in solving far more complex and realistic science problems than are part of a traditional curriculum. The initiative has been recognised by numerous prizes and awards (RCN, 2020b).

How do the doctoral students and postdocs at SFF centres benefit?

The SFF centres have shown immense benefits for doctoral students and postdocs. These benefits come in three forms:

- Specific initiatives: Most centres have dedicated initiatives aimed at the career development of young researchers such as courses relevant for career building and research schools for PhD students, as well as centre-specific initiatives such as regular one-on-one mentoring or the praxis of including a young scientist in the executive group on a yearly basis.
- Research environment: PhD students and postdocs benefit from the SFFs' dynamic international environment. They learn on a daily basis from the centres' high research standards, international horizon, network and collegial breadth, and often get the opportunity to publish with prominent international scholars.
- The SFF brand: Many SFFs have considerable international clout, and young scholars from the SFFs benefit from this status when they present their research at conferences. Coming from an SFF means benefits in terms of international attention and networking possibilities.

What impact does the SFF scheme have on the careers of students and other employees of the centres?

The SFFs' pronounced striving for the highest international quality has an impact on the involved researchers. Many former SFF PhD students and postdocs end up establishing their own research groups. It is difficult to prove a direct causality between the SFF scheme and these developments, but reports and interviews support the impression that such causality exists. However, the interdisciplinary nature of SFFs, which makes for research breakthroughs, can also create challenges for the individual researchers in terms of teaching opportunities and possibly also employment in more traditional monodisciplinary contexts. It is possible that this factor contributes to the relative delay for young SFF researchers in finding permanent

employment compared to their peers in the general Norwegian system. Many SFFs are aware of this risk and take active mentoring measures to remedy it.

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

The SFFs have been instrumental in focusing research teams towards complex questions, attracting researchers nationally and internationally and securing a quality of research of high, and in some cases the highest, international standard. This has entailed a general lift in the surrounding research environments and institutions, as well as in the broader HEI landscape. The SFFs have increasingly hired international researchers. Some of these scholars stay in Norway, contributing to the internationalisation of Norwegian research, as well as other sectors. In addition, researchers from the SFFs have found employment internationally, serving as ambassadors for Norwegian research abroad and often forging bonds between Norwegian and international research environments, which may, in turn, benefit future recruitment.

In terms of disciplinary distribution, the SFF scheme has funded more mathematical and natural science, slightly more medical science, a similar proportion of research in the humanities and less social sciences compared to the Norwegian higher education sector as a whole (RCN, 2020a). A few SFFs from across the disciplinary spectrum are at the very forefront of international research, putting Norway and Norwegian research firmly on the international research map. Many SFFs have reached the highest standards. This general high quality is beneficial for Norway. The disciplinary breadth of the SFF scheme is one of its particular strengths, especially when it comes to tackling complex issues that require a subtle and long-term interdisciplinary approach. Several centres expand their expertise in areas that are of importance to Norway today. The disciplinary breadth, convergence and scientific quality of the SFF scheme also makes it possible for centres to expand their expertise in areas that will be of importance to Norway in the future.

Overall observations

The reports and interviews give rise to a set of overall observations concerning researcher training and recruitment in the SFFs:

Internationalisation of Norwegian research: The SFFs have decisively opened the gate and lowered the hurdles between Norwegian and international research. The flux goes both ways, which seems ideal for cultivating a Norwegian research profile that is dynamic and meets the highest international standards. Scholars from the SFFs who are recruited outside Norway are not scholars lost to Norway. On the contrary, such recruitments help forge connections and exchanges between Norwegian and international research environments, supporting research collaboration, and leading to international recruitment to Norway and recruitment of Norwegian scholars abroad.

The standard of researcher training and recruitment: The SFFs strive to reach the highest international standards. The

Centre for Neural Computation (CNC): May-Britt Moser and her rat colleagues. © Rita Elmkvist Nilsen / Kavli Institute for Systems Neuroscience / CNC

centres' intense drive for scientific quality spills over into all areas covered by the centre, including researcher training and recruitment. The SFFs show creativity, robustness and ambition in their endeavour to provide the optimal researcher training for their young scholars individually and collectively.

The centre leaders as scientific drivers: The SFF centre directors have been scientific drivers through their dynamism, and when their specific individual blend of energy, ingenuity, scientific ambition and leadership is plugged into institutions, it spills over into the general quality of research, early career scholars' training, education, interaction with colleagues and interaction with the wider society. One of the most important aspects of the researcher education at the SFFs is the opportunity to work in this kind of environment and learn from the best – also when it comes to taking original and groundbreaking paths.

Researchers for the future: The SFF scheme through its long-term substantial funding is fit to tackle big and complex issues, and many centres are exploiting this potential to the full. Educating the next generation of researchers to be original, ambitious and well-connected across disciplines and in the wider world is one of the most important – and possibly one of the most enduring – effects of the SFF scheme.

6.2 SCIENTIFIC COLLABORATION

The SFF programme has allowed researchers to study new, important research topics, which has produced advanced scientific knowledge on key international research questions to a greater extent than previously. The SFF scheme has secured better access to research facilities, equipment, data registers or biobanks, technical staff and other infrastructure.

For about half of the researchers, the ability to attract international research grants has increased markedly. Although the RCN's SFF allocation (NOK 342 mill. in 2018) corresponds to about 4% of the RCN budget, and the active SFF centres today together manage (through the RCN's SFF contributions, the host institutions' own financing and additional external grants) roughly 2% (NOK 1.2 billion) of the total Norwegian research budget, the 44 SFFs have also been involved in more than 300 EU projects. About half of the ERC grants that have gone to Norway are linked to SFFs, which is a remarkable sign of excellence and a quality stamp. The SFF programme has advanced the scientific knowledge on key international research questions through new collaborations and new partners, including with the very best in the world. Overall, Norway's participation in core EU programmes has seen a positive development. However, Norway generally performs well in the societal challenges pillar and less well in the excellence pillars ERC and Marie Curie. Notably, the profile of the SFF researchers shows the opposite pattern. In each of the SFF generations, two or three centres have been responsible for more than half of all the EU projects. The centres seem to have been able to attract a large number of researchers with sufficient competences and capacities to be successful in the competition for prestigious EU grants and projects (NIFU, 2019b).

More resources in terms of time, staff or facilities were important to varying degrees for this increase and the key words visibility, increased ambitions and increased risk-taking have been important for the leap forward for Norwegian research anchored in the SFFs. The basis of this success has been long-term funding, but also the size of the funding and the flexibility. The competence of the centre leader has also been important, as has the working environment characterised by teamwork, sharing of ideas and research results (NIFU, 2019a).

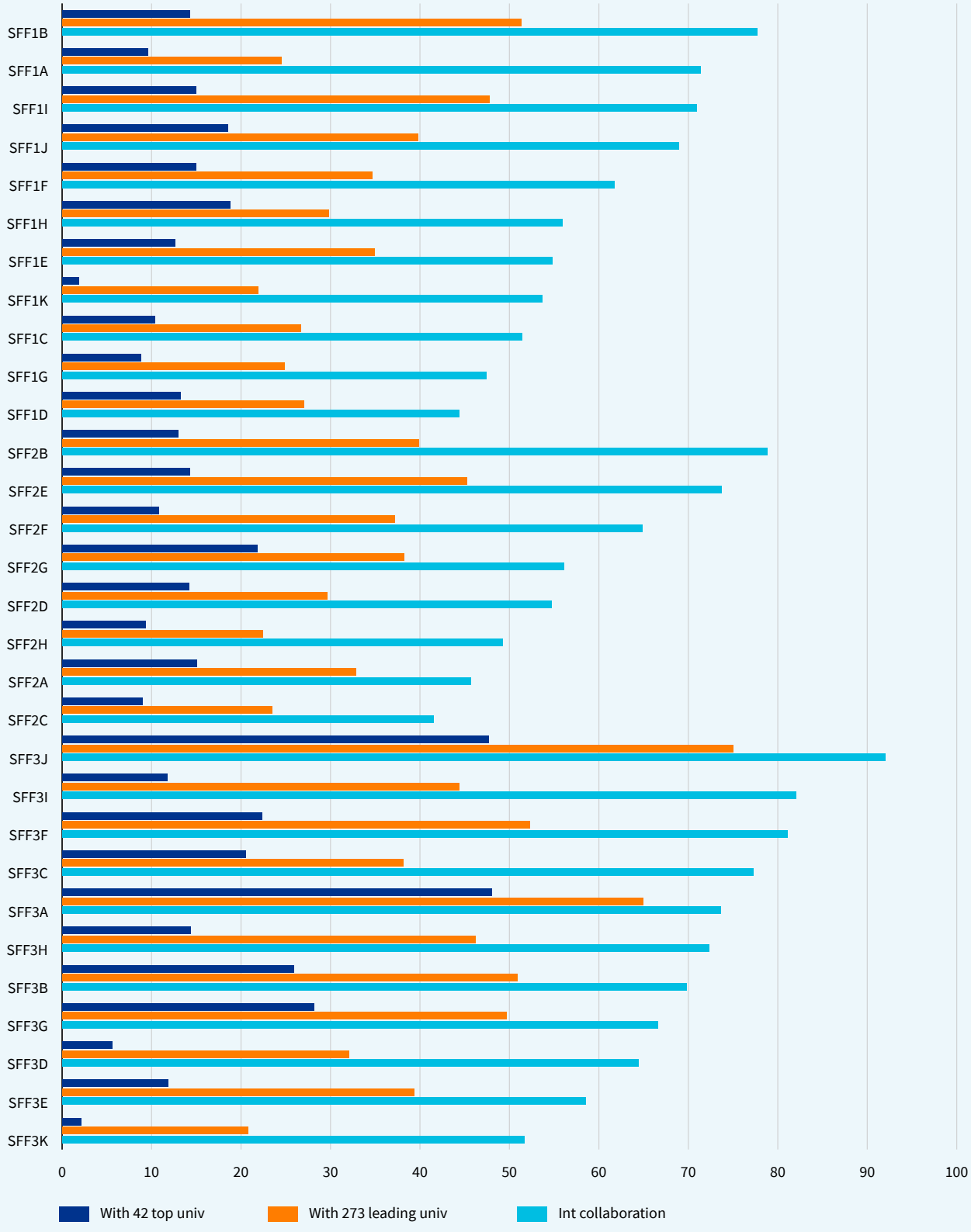
We saw differences in terminology in this respect between the science and technology disciplines, which used 'teamwork' and 'interdisciplinarity', and the social sciences and humanities, which referred to it as the sharing of ideas. Whether this reflects a true difference is difficult to establish as terms can be interpreted differently in the different research milieus. The daily facilities in the centres, which have strengthened the research, have included shared physical facilities, joint scientific seminars, workshops and social arrangements (NIFU, 2019a).

As regards national and international collaboration outside the centres themselves, the SFF centres have collaborations within their own university or institution, and collaborations with other institutions in Norway and internationally. As depicted in the bibliometric analysis and the career mapping, more than half of the articles from the SFFs are published with a non-centre co-author at the host institution, showing that the centres are not secluded 'ivory towers' (NIFU, 2019b). The collaboration among researchers in Norway has developed through the SFF instrument. In around 20% of the articles published, they collaborated with other Norwegian institutions, while another 20% have co-authors in other centres. The increase in international collaboration has been even more marked between the centres and the very best international institutions, as listed by the CWTS Leiden Ranking. In general, there was a clear trend towards relatively more collaboration with leading universities abroad in Norwegian research in the time period. There was a steeper increase for the SFFs from 2010 onwards followed by a stabilisation four years later. As regards collaboration with the 42 top universities, a steep increase was seen in the share of articles dedicated to collaboration with universities after the SFF scheme was introduced, and all three generations of SFFs reached a higher level than the general trend for FRIPRO and the host institutions. This trend has been on the decrease after 2013. There are, as expected, large variations among the SFFs in the degree of international collaboration (Figure 4). Some of these variations are probably related to differences in thematic research profiles, and the SFF-III generation stands out with more collaboration, relatively speaking, with leading and top universities (NIFU, 2019b).

The SFFs have demonstrated national and international collaboration and the large majority report that the extent of their international research collaboration increased after joining the SFF scheme. The highest increase in international collaboration was found among the participants of social sciences and humanities research programmes, and the

FIGURE 4 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 share of articles with international collaborations within each generation. Each SFF is represented by an anonymous code.



Source: (NIFU, 2019b).

highest increase in national collaboration was found among the participants in the science and technology-oriented centres. The very top-level centre researchers already had a high level of co-authorship with leading universities internationally before joining the SFFs, which is of course a logical consequence of the selection process.

Interdisciplinary collaboration and the opportunity to draw on multiple academic fields were increased in most cases, and unchanged in about a quarter of the centres, where either multi-disciplinarity was not relevant or already present.

6.3 IMPACT ON THE HOST INSTITUTIONS

Overall, the SFF scheme has paved the way for the acceptance of excellence in research as the norm. The centres facilitate research of the highest quality in the host institutions and render high prestige. This is important for the branding and self-esteem of the institution, with subsequent spillover effects to researchers outside the centres. The model of meritocracy where the best is acknowledged now prevails in Norway, and the SFFs have played an important contributing role in this respect.

The SSF scheme has also had success in applications in the excellence pillar from the EU, the ERC grants and Marie Curie, where they have had a changing effect on their host institutions as such.

The universities have chosen to support and strengthen all stages of the SFF scheme, starting from the application phase to the allocation of resources and prioritisation, co-funding during the lifetime of an SFF centre (Table 1), and have given support also in the afterlife or exit phase of the centres (NIFU, 2019a). The large institutions with many centres during the four generations have of course developed more detailed means than those who have had few. In interviews, the EC observed excellent cooperation and communication between the leadership of the universities and an active exchange of 'best practices' on the implementation and operation of the SFFs.

Prior to and during the application phase, the universities, represented by their rectors, vice-rectors, deans and heads of department, provide strong support for prospective applicants, focused on identifying potential centre directors and stimulating their interest. These measures also include buying out time to develop the application, administrative support for the application, recruitment of external consultants, networking with potential partners, in-house experts, previewers and helpers, interview training for applicants and internal budgets (NIFU, 2019a). During the four generations, the internal preparation process has perhaps drifted somewhat from being driven solely from the bottom-up towards the situation where some faculties/ universities organise internal selection processes etc. This could constitute an area of concern, since those who are either very young, daring, audacious or creative might be overlooked by such a mainstream top-down process. As the calls for SFFs are only every five years and predictable, the universities have had schemes to support young researchers to develop into mature, realistic applicants, which has thus created a balance.

TABLE 1 CO-FUNDING, HOST INSTITUTIONS

HOST	TOTAL NUMBER OF CENTRES	SUPPORT FROM RECTOR	SUPPORT FROM FACULTY/DEPARTMENT
UiO	17	2 mnok pr year in the centre period	PhD positions, in-kind, facilities, infrastructure and administrative resources
NTNU	9	2 mnok pr year + continuously 2 PhD + 1 postdocs in the centre period	Approximately 50% of the Rector. Facilities and infrastructure, PhD./postdocs, administrative resources may also include other in-kind*
UiB	8	12.5% of the RCN funding to be used for PhD positions, alteration of buildings or as cash	Postdoc and PhD positions. Varies between the faculties. Facilities, infrastructure and administrative resources
UiT	3	1/6 of the RCN funding to be used towards recruitment positions and running costs	Match the funding from the Rector. Infrastructures and in-kind (department)
NMBU	2	1,4 mnok pr year dedicated to administrative support + continuously 2 PhD (or postdocs) during the centre period	Ideally a matching of the support from the Rector but has turned out to be challenging. Infrastructure, facilities

Source: (NIFU, 2019a)

*The Central Norway Regional Authority also contributes cash to SFFs involved in translational research

After allocation of a centre grant, the universities have developed a range of schemes for co-funding (Table 1).

There are of course differences between research areas, and some deans and rectors claim that the SFF grants may sometimes be too large in the humanities. However, there seems to be a culture for applying for the upper limit of the grant, in contrast to e.g. Denmark where the Danish National Research Foundation experienced that some of the centres in the humanities applied for a lower grant sum.

NIFU's work for its report on the impact of the SFF scheme on the Norwegian research system (NIFU, 2019a) included a careful evaluation, in which researchers from the centres and from outside the centres in the various institutions were asked about their viewpoints on the centres' impact on their host institutions. Generally, those who are from the centres are more positive towards the impact of the centres than those from outside. This discrepancy is of course expected. Those who reported less positive impact on host institutions claim that the centres take away resources from research groups outside the centres. Others see this as a prioritisation of the most excellent. Given limited funds, some departments/ organisations may find it a challenge to strike the right balance.

The same divergent attitude was demonstrated towards resource allocation, where those within are more positive than those outside (NIFU, 2019a). The terms of organisation and governance in the first generation of centres were anchored with the faculty leadership or even rector, whereas it is now the norm that the centres are anchored within the departments to ensure collaboration and also integration during the exit phase. Regarding organisation of the centres themselves, the first centres placed much emphasis on a very strong centre of excellence leader, whereas it has now been established that interdisciplinary centres anchored in several faculties must have their own board. A few of the centre leaders see this as a formally required 'necessary evil', since the scientific leadership is often anchored in a science advisory board comprising international and top-level participants. Having the anchor in the departments seems to function well, but the benefit of such a new additional local bureaucracy layer in terms of a board could be debated. Furthermore, some centres also implemented mechanisms of shared leadership, where a senior centre director works closely with a younger colleague with a view to develop her/his skills and profile towards that of a future centre leader. This mechanism ensures the development of future leaders and, in some centres, the continuation of centres in the event of the original centre director's retirement.

Collaboration between and within institutions is influenced by the centres' prestige, which serves as a beacon, and the considerable positive activity with a high level of excellence taking place attracts other external funding. As such, the scheme is very attractive for faculties and departments. However, it requires considerable resources in terms of funding, administration and leadership time. The benefits, however, are clearly seen as greater than the negative consequences. Several departments involved in the same centre makes matters even more complex. However, the rectors and deans emphasised that the SFF scheme is the prerequisite for real interdisciplinary collaboration. The research areas may have different traditions for administration and economy, and cross-faculty projects have been complex. In the life sciences, collaboration between universities and hospitals have been strengthened and the translational research aspects have clearly benefitted, although lack of space in some university hospitals has been an obstacle to a seamless collaboration. The hosts and centre leaders have reported a positive collaboration overall. However, within the social sciences and humanities, good relations with the head of department and faculty leadership seem far less common than in life science and science and technology. On the other hand, the SFF leaders within life sciences and science and technology are more critical about the financial and administrative university support (NIFU, 2019a).

The positive impact on the host institution is clearly seen from the viewpoint of the rectors and deans, who claim that the SFFs have contributed to changing the research culture at the institution; talking about excellence is now accepted, and the centres are seen as beacons demonstrating how to organise and initiate research activity that inspires and contributes to stronger ambitions – also in the surrounding environment (NIFU, 2019a).

As regards gender policy and diversity, the centres are on par with other research centres and groups in Norway, but could in the future become role models for gender and diversity strategy and policy.

The SFF scheme's exit policies or embedment strategies are critical points. The different institutions have different exit policies, as seen in Table 2. Some universities argue that it is important to ensure continuation of the competence developed in the centres, while others claim that it is the responsibility of the centres to secure their scientific legacy. In the life sciences, department heads seem to experience more limited possibilities to ensure the continuation of the centre's research compared to the social sciences, humanities and science and technology. Deans and rectors alike have underlined that exit is not easy. They acknowledge that the RCN wants the institutions to take responsibility, and although the centres should be self-sustained when grants ends, a 'best practice' solution has been difficult to develop. This dilemma is universal for centres of excellence.

The centres' most important contribution to the universities has been the positive impact on the departments' ability to produce reliable, robust research results of the highest quality to address key scientific challenges and important societal challenges, with an impressive international and excellent research production (NIFU, 2019a).

6.4 SOCIETAL IMPACT

It is well known internationally that performing a thorough and robust outcome analysis of investments in research is a difficult task. It takes a long time before the full potential of research breakthroughs are realised. For example, from Niels Bohr's presentation of the atom model in 1913, it has taken every year since to reach the present beneficial outcomes, and the gains are steadily growing: It has been claimed that Bohr's atom model together with the research that followed is responsible for about 35% of the world GDP (University of Copenhagen, 2013). There are international collaborations between research councils and research foundations that aim to improve the quality of research outcome analysis, and various programmes and scales are under development. In NIFU report I (NIFU, 2019a), the SFFs' interactions and impact on society outside academia have been mapped and analysed according to modes of interactions (Table 3).

The traditions for how to report dissemination of research to society outside academia probably varies between the different scientific fields and centres among the SFFs. Overall, the centres have had a strong focus on societal impact outside academia (Figure 5).

As concerns the life sciences, policy influence is not emphasised in the self-evaluations from the reports. Instead, their main impact has been through commercialisation, primarily with patents and spin-offs and involvement in product development, new methods and services, translational research with improved clinical practice and better patient treatment in hospitals. In science and technology, the centres have engaged broadly in policy through consultancy and advisory work to establish an evidence base for decision-making through contract research. They have also filed patents, and have engaged in networking, teaching, commercialisation and dissemination of knowledge to the public. In the social sciences and humanities, the emphasis has been on dissemination of research results to the general public and policymakers, through teaching and, to a lesser degree, commercialisation. The centres from all science areas have been involved in museum exhibitions, popular science books, presentations in mass media, and interviews in documentaries and mass media outlets (Figure 5). The centres combined have published hundreds of popular science articles and contributed to thousands of mass media publications (RCN, 2020a; NIFU, 2019a).

As regards industrial innovation, the SFF programme has led to 78 applications for patents and nine licensing agreements have been signed. The centres have started new companies/business ventures employing approximately 100 people (RCN, 2020a). There is great variation across the centres on how industry collaboration has been organised. Some areas have had a close collaboration with already existing, well renowned industry partners. The SFF programme has had a positive pedagogic function for the departments in which they are anchored. However, the attitude of those from outside the centres in relation to the SFF programme's impact is not quite as positively judged, as described above, due to both conscious and unconscious bias from the outside in and vice versa. Overall, the attitude towards research has been strengthened by the SFF scheme and, again, with the interesting observation that those who describe a less positive impact were from the social sciences and humanities (perhaps signifying a different culture within social sciences and humanities with more critical attitudes among different 'schools', compared to science, technology and life science, where teamwork was more pronounced) (NIFU, 2019a).

TABLE 2 HOST INSTITUTIONS' EXIT STRATEGY

HOST	SUPPORT FROM FACULTY/DEPARTMENT
UiO	Had previously a policy of granting centres 2 mnok each year. This skewed funding from social sciences and humanities to life science and science, and was therefore stopped. The faculty has the responsibility; hence support may vary. Expectation that the research activity should be self-sustained. Policy for SFFs and similar instruments established in 2019.
NTNU	Expect the research groups to be self-sustainable. Takes responsibility for technical and administrative personnel.
UiB	Expect the research groups to be self-sustainable. Potential support depends on the performance of the individual centres.
UiT	Policy for exit since 2013. The SFFs may continue as a research group and apply to the university board for 'transitional funding' – three PhD positions from Rector and three from the faculty. Adjustments can be made based on the distinctive centres.
NMBU	NMBU considers the possibility for the further granting of each Centre. A continuation is based on an external evaluation, and the decision is made by the host faculty and partners and is time limited.

Source: (NIFU, 2019a)

Some centres have had a strong tradition for research and dissemination in relation to schools in Norway, the healthcare sector to patient groups, with non-governmental organisations and museums, and of course the general public.

In the self-evaluation, the centres with a more applied profile have placed a lot of emphasis on describing their scientific excellence in the societal impact case report (RCN, 2020b), while the centres with a strong basic research profile have underlined their societal contributions, with each seeking to demonstrate a balance including both output and outcome.

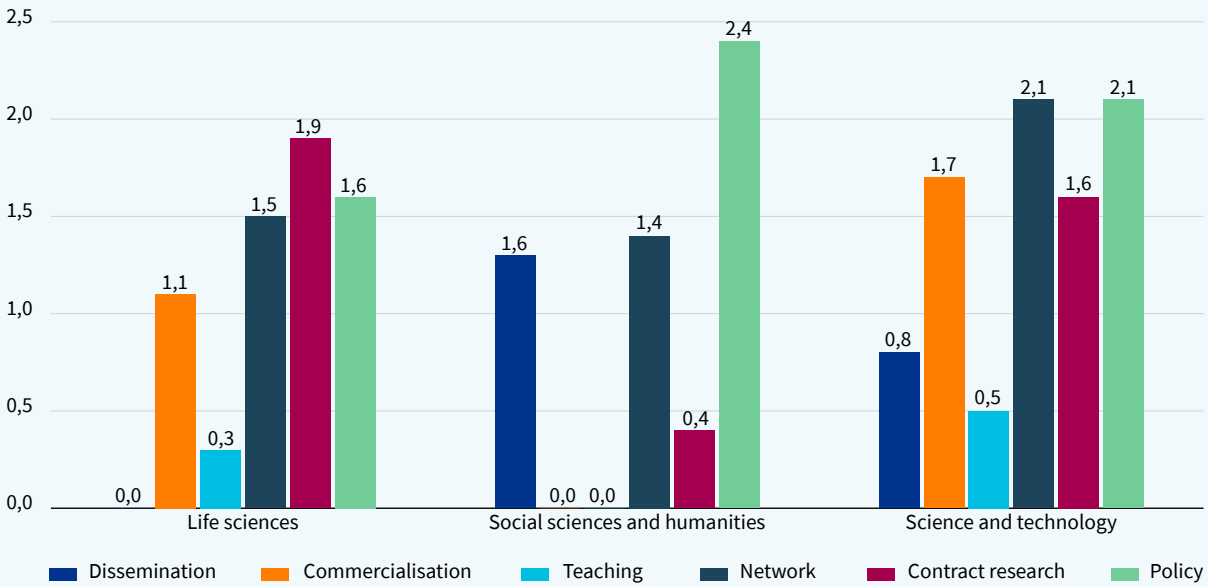
Documenting the second order effects of research is extremely challenging or even unrealistic, as described above, but compared to the international average from centres of excellence, the SFF scheme seems to have worked across the spectrum. The societal impact profile in the individual centres could typically be attributed to specific individuals, and it has also been these special few who have been prominent expert advisers in policy organisations and in public roles. The policy roles have been prominent also internationally in settings such as the World Bank, WHO and IPCC, and the impact on society internationally has generally grown alongside the four generations of the centres. For the centres themselves, there is no doubt that the scientific output in terms of publications, citations and patents has been the most important outcome, which is a sign of their wish to pursue the highest level of new knowledge and creativity in the most pertinent research areas.

TABLE 3 MODES OF INTERACTIONS OUTSIDE ACADEMIA

MAIN MODES	INCLUDES
Policy	Consultancy, advisory work
Contract research	Contract and joint research with non-academic partners
Networks	Networking activities with non-academic actors
Teatching	Bachelor and master level
Commercialisation	Patents, spin-offs, products, services, methods and monetary partners
Dissemination	Information advice, lectures for the community, communication activities

Source: (NIFU, 2019a)

FIGURE 5 AMOUNT OF REPORTED INTERACTION
Average score for each mode of interaction by field



Source: (NIFU, 2019a)

6.5 NEGATIVE EFFECTS AND CHALLENGES ASSOCIATED WITH THE SFF SCHEME

'Every rose has its thorn'

The SFF scheme has been successful, boasting high scientific activity with groundbreaking results, international collaboration and the achievement of excellence in Norwegian research. It has had an impact on academia and society beyond, and the scheme has been important in the transformation of Norwegian research from the previous below OECD average to the present high-end position.

This transformation has of course led to challenges. Norway was previously a very equal society in academia and the notion of excellence was previously only acknowledged in sports and the arts. The international notion of excellence as defined by the ERC and all the international rankings emphasising the very best as acknowledged by Plato and Aristotle's 'meritocracy' have constituted a transformative process for Norway.

In the institutions, the SFFs have been seen, particularly by those outside the centres, as creating A and B teams, where those not participating in the SFF have felt left out and less privileged. This is the way things are in sports, arts and science, with the excellence notion prevailing all over the world, but perhaps the Norwegian tradition has made the necessary transformation more difficult. In the first generations of the SFF scheme, the centres were very prominent and anchored in the organisation directly under the rector or deans. In the later generations, they are now embedded in the departments and the impression of A and B teams has been reduced – at least to some extent. The combination of competition and collaboration in research is essential and demands good leadership, and it is important to allow the centres to flourish. The accepted international concept of excellence must be the norm.

One special area of interest is the possibility of the centres to buy themselves out of other obligations such as teaching. In the Danish National Research Foundation scheme, which is parallel to the SFF scheme, it has been emphasised in recent years that top-level researchers should participate in teaching, as it is important for the new generations to be stimulated by the very best, as is also the tradition among leading universities across the world.

The same goes for the education of bachelor's and master's degree students, which to some extent has been lower than expected in the centres. This should also be remedied in the future.

The postdoc challenge is of international concern: The very best young people in international research have insecure career prospects and they themselves choose to be postdocs for several periods in the very best research centres around the world. It is their own personal choice to work with the research they are most interested in rather than choosing a more secure career in industry etc. However, the balance between tenure track and temporary positions should be considered in the future, with permanent positions planned on a more long-term basis.

To our surprise, it has not been the case that any of the centres have been discontinued after the mid-term evaluation, in spite of the strong emphasis placed on this mid-term evaluation process. The mid-term evaluation has been used to strengthen all the centres, but not to terminate centres with inappropriate research production, as is the case internationally. This may be difficult in small countries, and also if the centres have produced a certain level of research output.

The SFF scheme creates temporary pockets of excellence, as do centre of excellence programmes all over the world. It is a challenge to sustain the research activities after the centres have been concluded, which is also experienced at the international level. The groups that stand out in excellence at the very top will be able to attract international and national funding further on, and this should be planned well in advance before the exit phase and in close collaboration with heads of department, deans and rectors. If centres are very exceptional, a permanent institution, like the Broad Institute in Boston, could be a solution, but again, after a few generations, the 'star quality' might vanish. Such a model should be carefully considered especially in Norway with its many institutions and universities in relation to the size of the country (in spite of mergers in recent years). Research excellence is often the result of special individuals carrying the torch. It is all about people driven by curiosity.

The main selection criterion of the SFF scheme has been scientific excellence. It is the EC's opinion that it is of utmost importance for the scheme that the selection criteria continue to maintain this singular focus. With the new organisation of selection criteria, the EC is concerned that there will be a drift towards considerations of impact and implementation. A drift in this direction would lead to less focus on scientific excellence and could change the kinds of centres that are funded, something that should be avoided.

7 Conclusion

The Norwegian SFF programme was initiated in 2000 and comprises a total of 44 centres that are either presently active or have ended their activities. The performance and the legacy of these centres provide a broad and rich basis for the evaluation of the SFF programme.

The central conclusion of this evaluation is that the programme has been a tremendous success for Norway and that its continuation as the main mechanism to support the most innovative, risky research is critical for Norway. The centres have produced new knowledge, catalysed changes and updates in the education and training of scientists, created important innovation for the Norwegian and global industry and the public sector, and have generally raised the international visibility and standing of Norwegian science.

Science is global and many of the centres have had a remarkable effect on the global society. Groundbreaking research has produced benefits for the community, and several of the SFF centres have had worldwide influence with their knowledge, expertise and innovation. The research results have saved lives, increased economic performance, reduced losses, and improved quality of life and resilience around the world.

The centres have been remarkably successful in terms of attracting ERC grants to Norway – a clear sign of excellence in research. They have been instrumental for making the research culture in Norway more international and for recruiting, and to some extent retaining, top international scientists to the country. Importantly, by instilling a general culture of excellence in research, the SFF programme has transformed the Norwegian research community far beyond the actual centres themselves. Overall, the SFF programme has, together with the ERC, lifted 'all the boats' and induced competitiveness for the sake of society.

The SFF programme has consistently adhered to the principle of substantially funding excellent, groundbreaking basic research for a period of 10 years per project. The consistent adherence to these principles has produced real societal impact. The programme has covered all fields of research, from geohazards and environmental radioactivity to breakthrough studies on societal conflicts and wars, marine biology and paradigm shifts in medical science.

The programme has evolved over the years and is now the principal refined and fine-tuned instrument that supports Norway's top-level basic science. Excellence and predictability of SFF policies and objectives have been instrumental for the programme's success. Scientific panels have been useful in the process of selecting new SFF centres, and the future quality of this procedure is essential for continued success. To ensure the success of the programme also going forward, its continued evolution will depend on the ability to retain what is good and develop what can be improved. Also, the framework conditions for research in Norway at large are important as they form the basis for the SFFs. The continued improvement of the Norwegian universities and higher education landscape will be important for future generations of SFFs. It will also be important to advance the cutting edge and thereby leverage the whole Norwegian research ecosystem. The EC's specific recommendations for SFF going forward are given below on the basis of the analysis described in this report.

8 Recommendations

- To continue the SFF programme for excellent, transformative and groundbreaking research as a 10-year programme for all research fields and preserve the criteria of excellence used hitherto to achieve groundbreaking curiosity-driven research.

- To continue to acknowledge the impact of the SFFs as a role-model for the Norwegian research landscape in the pursuit of excellence in Norwegian research.

- Risk-taking is crucial to foster the best research and should be supported by a true bottom-up process with focus also on the most advanced research methods and concepts, international and interdisciplinary collaboration and mobility to attract the very best researchers from abroad to Norway.

- Diversity, including gender aspects, should be strengthened. It will be particularly important to identify and prepare a younger generation of future centre leaders.

- The mid-term evaluation could be postponed until after 5-6 years to minimise the incentive to carry out mainstream research with a focus on rapid results and publications at the beginning of a centre's life. The rules and objectives of the mid-term evaluations should be clear, transparent and used to phase-out dysfunctional or underperforming centres.

- Universities should share 'best practice' in managing SFFs to achieve the best results for centres, the departments' hosting centres and the institution as a whole. Flexibility in handling the centres is important, especially for interdisciplinary centres and centres anchored in more than one department. To ensure fairness, coordination among the universities on how to support researchers in the application process is considered crucial.

- The competences of world-class centres with scientific knowledge of importance to the whole world should be retained. Therefore, a strategy for the final exit after 10 years should be considered. A solution for 'the most excellent of the excellent' should be considered with funding from outside the traditional SFF scheme to avoid cannibalising the next SFF generations. Tenure track, embedment in universities after exit and flexible solutions could also be considered.

- The RCN section that manages the SFF programme is small and efficient, and praised by all of the centres and universities. Panels established to assist procedures must be trustworthy and comprise eminent international scientists. Strengthening the SFF scheme with an international committee of eminent scientists should be considered to assist the RCN in further developing the scheme. This committee could oversee the evaluations, secure the best use of peer review in round two and act as a strong advocate for the programme. An internal 'champion' on the committee could be the director of the RCN. The regular follow-up meetings with centres could be strengthened by inviting this new committee to the meetings. The SFF programme could share best practice with similar excellence programmes in the Nordic countries and the rest of the world.

- All RCN funding programmes should be open to researchers within the SFFs.

- Academic freedom in all respects should be continued for the SFFs, including freedom of choice in relation to research subjects, aims, hypotheses, methods, approaches and an unconditional freedom of choice for where to publish.

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12 Appendices

Ecological and Evolutionary Synthesis (CEES): Stockfish (dried cod) in Ballstad, Lofoten. Samples collected in this area has played an important role in CEES' research on the Atlantic cod (*Gadus morhua*). The sequencing of the cod genome, from the cod stock that is referred to as "skrei", revealed a striking discovery that fundamentally changed our understanding of the functionality and evolution of the immune system in vertebrates.

Appendix A: Terms of reference

EVALUATION OF THE SFF SCHEME AS A FUNDING INSTRUMENT – TERMS OF REFERENCE – DECEMBER 2018

BACKGROUND

The Norwegian Centres of Excellence (SFF) scheme is a Research Council of Norway funding instrument established in 2002 to promote quality in Norwegian research. The SFF scheme's primary objective is to provide support to Norway's leading research groups so that they can achieve research results that advance the international research front. Centres funded under the SFF scheme are also expected to educate top scientists for the future.

Several subject-specific evaluations conducted in the early 2000s pointed to the considerable fragmentation within the Norwegian research system as the main reason why the level of scientific quality was too low. The SFF scheme was established to concentrate resources around research groups that were already achieving a high international standard. The SFF scheme was intended to promote and reward high quality, help to encourage longer-term scientific perspectives and more autonomy for the country's top researchers, encourage closer cooperation with leading international research groups, enhance recruitment, and provide the necessary professional standing for Norway's best research groups.

The SFF scheme is administered by the Research Council and funded by allocations from the Ministry of Education and Research. Each SFF centre receives funding for maximum 10 years (an initial five-year period with the possibility of a five-year extension). A mid-term evaluation of each centre is conducted about 3.5 to 4 years after it is established and forms the basis for determining whether the individual centre receives funding for the final five-year period.

This funding instrument offers generous, long-term and flexible framework financing to a relatively small number of centres. Thus far the SFF scheme has allocated approximately NOK 3.6 billion, and is contractually obligated to allocate another NOK 2.4 billion, to 44 projects. This funding is distributed over four generations of SFF centres:

- The first SFF generation (SFF-I) comprised 13 centres that started up in 2002/2003 and were terminated in 2012/2013. SFF-I received a total of NOK 1.6 billion, and over their project periods each of these centres received NOK 60–210 million from the Research Council.
- The second generation (SFF-II) comprised eight centres that started up in 2007 and were terminated in 2017. SFF-II received a total of NOK 0.9 billion, and over their project periods each of these centres received NOK 77–120 million from the Research Council.
- The third generation (SFF-III) comprises 13 centres that started up in 2013 and are to be terminated in 2023. SFF-III has been allocated a total of NOK 2.1 billion, and over their project periods each of these centres will have received NOK 105–175 million from the Re-search Council.
- The fourth generation (SFF-IV) comprises 10 centres that started up in 2017. These centres will undergo mid-term evaluation in 2021 and are to be terminated in 2027. SFF-IV has been allocated a total of NOK 1.5 billion, and over their project periods these centres will each receive NOK 129–167 million from the Research Council.

The next funding announcement (SFF-V) is planned to be issued in autumn 2020 for centres with start-up in 2022.

Selection of the centres to be awarded SFF status and funding is carried out by international referees and is based on an open competitive process. Specific thematic guidelines were only stipulated in the first funding round (SFF-I). These stipulations were removed from the scheme starting with the SFF-II funding announcement. As a result, the various SFF centres extend across the entire range of disciplines and thematic areas.

The SFF scheme has been evaluated once before. The evaluation was carried out by NIFU STEP in 2010 and culminated in the report Evaluation of Added Value and Financial Aspects – The Norwegian Centre of Excellence Scheme. The evaluation focused in particular on the centres' added value for their host institutions as well as financial aspects of the SFF scheme but did not evaluate the centres' respective scientific merit.

The Research Council now wishes to have another evaluation of the SFF scheme. Substantial funds have been allocated under the scheme, and the Ministry of Education and Research requested an evaluation in its allocation letter to the Research Council for 2019.

PURPOSE OF THE EVALUATION

The evaluation is to assess the degree to which the scheme has had the expected impact on scientific quality among the research groups granted funding. Furthermore, the Research Council is seeking an evaluation of other impacts of the scheme, such as on the training of young researchers, on research collaboration, and on universities' organisation, priorities and strategies. The Research Council also seeks to document examples of long-term scientific and societal impacts of the centres' research activities. Findings from the evaluation will primarily be used to further develop the scheme.

EVALUATION QUESTIONS

The evaluation will mainly focus on exploring the following:

- Has the SFF scheme helped to enhance scientific quality?
- Has the SFF scheme had any impacts on the research system?
- Recommendations for further development of the scheme.

Has the SFF scheme helped to enhance scientific quality?
In light of the scheme's objective to facilitate groundbreaking research, the Research Council is primarily interested in mapping the extent and quality of the best research produced by the centres. The committee is asked to evaluate the overall impact of the SFF scheme on scientific quality. The evaluation is not meant to be an assessment of each centre's scientific merit.

The following topics should be highlighted:
- To what extent do the centres produce groundbreaking research (compared to e.g. Nor-wegian researchers in general or other relevant comparisons)?
- To what extent are the researchers at SFF centres internationally recognised and competitive (e.g. in terms of applications for grants and positions) (compared to e.g. Norwegian researchers in general or other relevant comparisons)?
- Has the SFF scheme helped to enhance scientific quality, and if so, how?

Has the SFF scheme had any impacts on the research system?
- What impact has the scheme had on researcher training and recruitment?
- What impact has the scheme had on scientific collaboration (locally, nationally and internationally)?
- What impact has the scheme had on the host institutions?
- Has the SFF scheme had impacts on society outside academia?
- Has the scheme had any negative impacts on the research system, and if so, how?

Recommendations for further development of the scheme

ORGANIZATION AND PROCEDURE

The evaluation is to be conducted by an international scientific committee. With the assistance of a secretary, the committee is to draw up a consolidated evaluation report.

The committee will base its assessment on written material provided by the RCN. Among this material will be two sub-reports that the RCN will commission through a tender process. The sub-reports will encompass e.g. bibliometrics, the impact of the SFF scheme on participants' career development (career mapping), and an analysis and assessment of the impacts of the SFF scheme on the research system overall. The committee will be consulted underway regarding the content of the sub-reports. In addition, the Research Council will commission scientific and societal impact case studies on the research activities from selected centres, and the committee will have access to these studies. The Research Council will supply the committee with other material as well, including a description of the SFF scheme, the mid-term evaluations of the SFF-I, SFF-II and SFF-III generations, the previous evaluation of the SFF scheme, annual reports for the SFF scheme, annual reports from the centres and the final reports for the SFF-I and SFF-II centres.

The Research Council will quality-assure the information in the evaluation report with the institutions/centres involved. The Research Council will also maintain a dialogue with the committee underway and may contribute comments and data. The final evaluation report is to be written in English and must include a summary in Norwegian. The evaluation report and (possibly anonymised) sub-reports will be made publicly available. The deadline for submission of the final report to the Research Council is 1 April 2020.

The committee's tasks
The committee is asked to draw up an overall report based on the findings of the sub-reports and other factual material made available by the Research Council. The report is to contain an overall evaluation of how well the SFF scheme has achieved its objectives and should in addition provide recommendations to the Research Council regarding ways in which the scheme may be improved.

The committee tasks are to:
- Obtain an overview of the scheme by examining and evaluating the background material.
- Become familiar with and evaluate methods and findings of the sub-reports.
- Write a report that contains:
  - an evaluation of the extent to which the SFF scheme has contributed to greater scientific quality at the centres.
  - an evaluation of the impact of the scheme on the Norwegian research system.
- recommendations for further developing the scheme.
- The chair of the scientific committee is expected to participate in the formal presentation of the evaluation report when it is submitted.

TARGET GROUPS

The Research Council of Norway
Norwegian government ministries (primarily the Ministry of Education and Research)
The host institutions
The SFF centres themselves
The general public

DATA SOURCES

- Externally produced sub-reports (to be obtained through a tender process). These may contain e.g.:
  - Bibliometric data and career mapping;
  - Analyses of the scheme's impacts on the research system (based on, among other things, financial data and interviews of centre representatives (centre directors, group leaders, students, board chairs, centre partners), the host institutions (university administrators, faculty administrators, department heads), other research groups (applicants, competitors, colleagues) and individuals involved in the selection of SFF centres and/or mid-term evaluations (committee members, etc.).

- Internally available materials (Research Council administration)
  - The previous SFF evaluation (Evaluation of Added Value and Financial Aspects – The Norwegian Centre of Excellence Scheme, 2010);
  - The mid-term evaluations of the SFF-I, SFF-II and SFF-III centres;
  - Annual reports for the SFF scheme (starting in 2006);
  - Annual reports from the centres;
  - The final reports for SFF-I and SFF-II centres;
  - Requirements and guidelines for SFF;
- Description of the SFF-IV assessment procedures

- Materials the Research Council will prepare internally or in cooperation with the cen-tres:
  - Lists of centre employees (containing name, position and year hired)
  - Impact case studies from selected SFF centres;
  - Description of the SFF scheme
  - Other (e.g. centre's own reports)

Appendix B: Previous and existing SFFs

FROM 2002-2019 THE RESEARCH COUNCIL OF NORWAY HAS ESTABLISHED 44 CENTRES OF EXCELLENCE

Aquaculture Protein Centre (APC)
Professor Trond Storebakken / Professor Margareth Øverland

The centre has given important expertise in the development of novel fish feeds, including new methods to measure amino acid requirements, knowledge of use and limitations of new ingredients, including impact on fish health, and new methods for processing of fish feed. The centre has given us an important foundation for future work on fish feed with high relevance for the aquacultural sector, and has created a knowledge platform that has led to a new centre for research-based innovation.

Bjerknes Centre for Climate Research (BCCR)
Professor Eystein Jansen

The ambition of the Bjerknes Centre for Climate Research is to be a world-leading centre on the dynamics of climate change with an emphasis on the oceans and high latitude climate change. It investigates past, present and future climate changes and provides frontier science with relevance to societal responses to the risks from climate changes. The centre includes interdisciplinary groups that integrate empirical studies and dynamical modelling of the climate system. Originally funded through the SFF scheme, the centre has become one of the key climate research centres globally and comprises 234 scientists from 37 countries.

Centre for Advanced Study in Theoretical Linguistics (CASTL)
Professor Curt Rice / Professor Marit Westergaard / Professor Peter Svenonius

CASTL had great impact on linguistic theory – in syntax, semantics, phonology and language acquisition. The success of much current work in these fields, both at UiT and beyond, stands on the shoulders of CASTL.

Centre for the Biology of Memory (CBM)
Professor Edvard I. Moser

During its lifetime from 2003 to 2012, investigators at the Centre for the Biology of Memory discovered the neural ele-ments of a position-coding circuit in the mammalian brain. These elements encode our current position but are also parts of episodic memories. The key discovery of grid cells - cells that map the local environment in a lattice-like manner, serving as a universal coordinate system for space - was recognised with the Nobel Prize awarded to the Mosers in 2014.

Centre for Ships and Ocean Structures (CeSOS)
Professor Torgeir Moan

The Centre for Ships and Ocean Structures addressed basic research in marine hydrodynamics, structural mechanics and control to develop mathematical methods and quantify their uncertainty by combined use of numerical and experimental methods. Examples include innovative efficient methods for predicting the fluid motions and pressure in tanks under severe motions, and the vortex induced vibrations (VIV) in a complex interaction between a structure and fluid. Particular focus has been on combining two of the three main disciplines in integrated dynamic analysis of complex marine systems with a focus on emerging technologies for ships, offshore platforms, wind turbines and aquaculture facilities based on technological visions and use of enabling technologies. An example is methods for hydro-aero-servo-elastic analysis of floating wind turbines under environmental loads as well as fault conditions, by properly accounting for the properties of the individual sub-systems (rotor, drivetrain, tower, support structure and mooring system).

Centre for Integrated Petroleum Research (CIPR)
Professor Arne Skauge

By describing and modelling processes occurring in oil and gas fields, CIPR developed fundamental knowledge used to optimise extraction rates. The centre has been crucial for developing new world-leading research activity in geological carbon storage, geothermal energy research, and image analysis and visualisation.

Mathematics for Applications (CMA)
Professor Ragnar Winther

The most important long-term effect of the centre was the strengthening of the research groups in partial differential equations and stochastic analysis, two areas of mathematics that are vital for applications in science and engineering.

As a result of the ten-year centre period, the Department of Mathematics, University of Oslo, currently have research groups in these fields at the highest international level.

Center of Molecular Biology and Neuroscience (CMBN)
Professor Ole Petter Ottersen / Professor Tone Tønjum

By coupling molecular biology to basic neuroscience, CMBN has helped unravel the molecular basis of essential physiological and pathophysiological processes in the brain, thus providing a platform for improved therapy and prevention of neurological disease.

Centre for Medieval Studies (CMS)
Professor Sverre Bagge / Professor Leidulf Melve

In CMS's original application, the point of departure was Robert Bartlett's book 'The Making of Europe', dealing with the 'colonisation' of the European periphery. The book has served as a source of inspiration as well as a challenge to develop different interpretations, notably to look at the process as an interaction rather than a colonisation. Christianisation and state formation in Northern and Eastern Europe not only meant an export of culture and institutions from west to east but changed the whole continent, making the territorial state the normal political unit and leading to cultural interaction, not only from west to east but also in the opposite direction.

Center for the Study of Civil War (CSCW)
Professor Scott Gates

The Center for the Study of Civil War (CSCW) fundamentally altered the way civil war was studied. We now have a much better understanding of why civil wars break out, how they are sustained, and what it takes to end them and to preserve a civil peace. CSCW blazed new pathways of research on global trends in conflict, geography, political institutions, inequality, demographics, and shifting public opinions about civil armed conflict. CSCW research on the consequences of war and post-conflict peace led to policy shifts at the World Bank and the construction of Sustainable Development Goal 16 at the United Nations.

International Centre for Geohazards (ICG)
Professor Farrokh Nadim

Through their knowledge and expertise, the geohazard specialists trained at ICG have saved hundreds of lives, reduced economic losses due to natural hazards by millions of euros and improved the quality of life and resilience of many communities around the world.

Physics of Geological Processes (PGP)
Professor Jens Gottfried Feder / Professor Bjørn Jamtveit

The Centre for Physics of Geological Processes (PGP) introduced concepts and methods from physics and complex systems science to understand patterns and processes of the Earth. PGP research emphasises the role of rapid, far-from-equilibrium processes in shaping the evolution of our planet on all scales.

Center for Quantifiable Quality of Service in Communication Systems (Q2S)
Professor Peder Johannes Emstad / Professor Svein Johan Knapskog

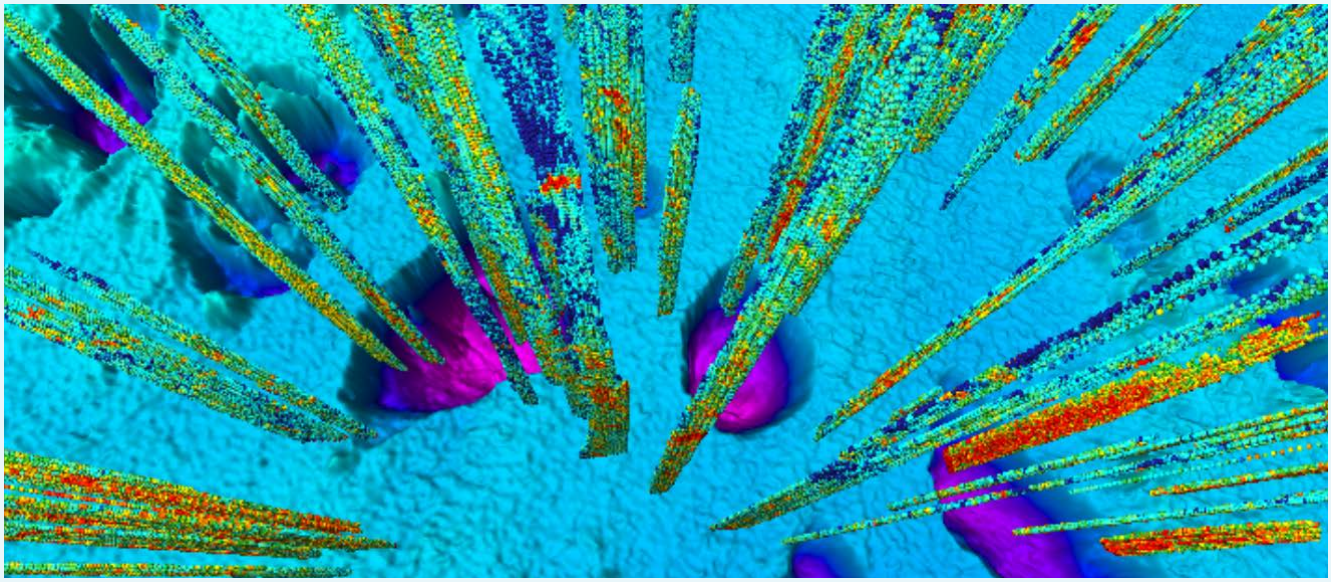
Q2S conducted research in the fields of information security, dependability, network performance, and audio-visual signal processing. The many external activities, such as EU financed research projects and Networks of Excellence and visiting scholars contributed to a unique setting. A number of PhDs were awarded and master's degree students educated for the benefit of the university and industry.

Center for Biomedical Computing (CBC)
Professor Hans Petter Langtangen

The Center for Biomedical Computing has brought advanced scientific computing tools into medical research and towards clinical applications. The most important contributions from the centre have been made in three different areas: by developing award-winning open source computational software with a large user base, addressing clinically important applications in cardiovascular- and neuro-medicine, and by pioneering a major shift towards increased use of computing tools in undergraduate science education.

Centre for Cancer Biomedicine (CCB)
Professor Harald Stenmark

The Centre for Cancer Biomedicine identified novel cellular pathways that are dysregulated during cancer development and utilised these to develop novel prognostic and diagnostic cancer biomarkers.



Centre for Arctic Gas Hydrate, Environment and Climate (CAGE): In a study published in Science, scientists at CAGE mapped over 100 blow-out craters on the Barents Sea floor.
© Illustration: Andrea Plaza-Faverola/CAGE

Centre for Ecological and Evolutionary Synthesis (CEES)
Professor Nils Christian Stenseth

The processes of ecological-evolutionary feedback loops are at the core of the CEES's research. CEES combines a broad range of disciplines such as population biology, genomics, and statistical and mathematical modelling to understand evolutionary processes in a variety of systems, including marine, terrestrial, arctic, and microbial, as well as using theoretical approaches. CEES has tackled questions such as: Under what conditions, both in human and animal systems, will disease outbreaks occur? Why and how have some fish species ended up with surprisingly simple immune systems? What are the implications of these immune systems for medical and fish farming industries? What are the ecological drivers for hybridizations and speciation? With reference to these and other questions, CEES members have published a large number of high-profile papers.

Centre for Geobiology (CGB)
Professor Rolf-Birger Pedersen / Professor Ingunn Hindenes Thorseth

The Centre for Geobiology discovered the first hydrothermal vent fields along the Arctic Mid-Ocean Ridge in the Norwegian-Greenland Sea and documented unusually large mineral deposits and unique ecosystems and environments. This knowledge will be critical for the potential future exploration of mineralogical and biological resources in this region. Furthermore, the discovery of a new species has led to a major breakthrough in evolutionary biology.

Centre for Immune Regulation (CIR)
Professor Ludvig Sollid

Researchers at the Centre for Immune Regulation (2007-2017) made fundamental new discoveries in immunology. The biological mechanism responsible for the long serum half-life of albumin was revealed, and this finding opens new avenues for therapeutic applications of albumin, albumin derivatives and IgG variants. Novel aspects of gut plasma cells were identified; that these cells express surface IgA and IgM and that they can be long lived. These findings have implications for effective vaccination and for the understanding of immunological disorders of the gut. Researchers at the centre also discovered that T-cell immune responses directed towards Idiotypes presented on the surface of B cells can induce B cell cancer as well as autoimmunity.

Centre for the Study of Mind in Nature (CSMN)
Professor Christel Fricke / Professor Olav Gjelsvik

CSMN contributed world leading research, published by Oxford, Cambridge and Harvard university presses, in philosophy and related disciplines: work on global justice and especially on gender aspects of global justice, work on communi-cation, herein issues in semantics and world-word relations, work on the understanding of human action and rationality, and on how to improve and assess the concepts we employ. From a low starting point, philosophy in 2019 had the highest Times' rating of any discipline at the University of Oslo.

Centre for Theoretical and Computational Chemistry (CTCC)
Professor Kenneth Ruud / Professor Trygve Ulf Helgaker

The Centre for Theoretical and Computational Chemistry developed new methods for understanding chemical, physical, and biological systems based on the laws of quantum mechanics. These methods allowed us to discover a new chemical bonding mechanism created by magnetic rather than electric forces, unravel the molecular mechanism of human infrared vision by two-photon absorption, and understand how cold-adapted enzymes work.

Equality, Social Organization and Performance (ESOP)
Professor Kalle Moene

ESOP's goal was to understand the connection between equality, social organisation and economic development, both in rich and poor countries. ESOP also used the experience from the Nordic countries to challenge economic theory. The basic insights from the research emphasise the need to consider inequality in a broad context and to combine theoretical and empirical insights. Much of the research can only be described by including more specific details. In sum, three broad lessons stand out:

i) a country can achieve a competitive advantage in the world market by sustaining a low inequality at home;
ii) politics and economics reinforce each other, as countries with small wage differentials generate high support for large welfare states, while countries with large welfare states generate a market economy with small wage differences before taxes and transfers;
iii) institutions and organisations complement each other, as it is the countries most exposed to international competition that have the most comprehensive organisations in the labour market.

In this perspective, depending on the initial situation, both inequality and equality can multiply. The dispersion of income and power leads to equilibrium outcomes where small economic differences can produce persistently low inequality, and large differences can produce persistently high inequality.

Centre for Autonomous Marine Operations and Systems (AMOS)
Professor Asgeir Johan Sørensen

The Centre for Autonomous Marine Operations and Systems contributes fundamental and interdisciplinary knowledge in marine hydrodynamics, ocean structures, marine biology, marine archaeology and control theory. The research encompasses: technology for mapping and monitoring of the oceans, marine robotics platforms and risk management and max-imised operability of ship and ocean structures. The research results are being used to develop intelligent ships and ocean structures, as well as autonomous unmanned vehicles for operations under water, on the sea surface, in air and space.

Birkeland Center for Space Science (BCSS)
Professor Nicolai Østgaard

The Birkeland Centre for Space Centre focuses on how the Earth is coupled to space. At the moment, we are organised into three research groups; two instrumentation groups (one for space instrumentation and one for ground-based instruments) and an Education and Public Outreach group. The three research groups focus on:

1. Dynamics of the asymmetric geospace:
   When and why are the auroras in the two hemispheres asymmetric?
   What are the important temporal and spatial scales of geospace dynamics?
2. Particle Precipitation
   What are the effects of particle precipitation on the atmospheric system? This includes the possible effect on climate.
3. Hard radiation from thunderstorms:
   What is the role of energetic particles from thunderstorms on geospace? In the enormous electric fields in lightning discharges both relativistic electrons and gamma-rays are produced.

Our focus is to explain how this happens and what effects this hard radiation has.

Centre for Arctic Gas Hydrate, Environment and Climate (CAGE)
Professor Jurgen Mienert / Professor Karin Andreassen

Our research has highlighted that ice sheets store large amounts of methane, which are released on retreat. Such discharges represent a threat that is unaccounted for in climate models for the future: rapid melting of Arctic and Antarctic ice sheets, may not only cause damaging sea level rise, but also release enormous amounts of the potent greenhouse gas methane.

Centre for Biodiversity Dynamics (CBD)
Professor Bernt-Erik Sæther

The Centre for Biodiversity Dynamics produces theoretical and empirical analyses of the dynamics in time of genes, populations and communities in a fluctuating environment. These analyses have generated insights that have identified general principles for how biological diversity at different organismic levels change as a response to variation in the environment.

Centre for Cancer Biomarkers (CCBio)
Professor Lars Andreas Akslen

CCBIO has uncovered novel biological properties of the cancer organisms by which tumour cells can programme the surrounding microenvironment to support their own growth and spread, and how such processes can be monitored locally and systemically. Molecular biomarkers have been translated to the clinical context to improve precision diagnostics and therapy for cancer patients in a cost-effective and responsible way. Projects are performed in a reflective environment supported by strong educational programmes. CCBIO has integrated ethics, economics and social science into its venture in order to promote a sustainable style of cancer research.

Centre for Earth Evolution and Dynamics (CEED)
Professor Trond Helge Torsvik / Professor Carmen Gaina

The Centre for Earth Evolution and Dynamics performs interdisciplinary research on the broad connections between Earth and planetary interiors and their surfaces, through geological time. CEED pioneers a unified theory linking the structure and dynamics of the Earth mantle with plate tectonics through large magmatic events.

Centre of Molecular Inflammation Research (CEMIR)
Professor Terje Espevik

The vision of the Centre of Molecular Inflammation Research (CEMIR) is to find out how sensors in the innate immune system initiate and regulate inflammatory responses. Impacts of CEMIR research include the identification of new drug targets and host-directed therapeutic strategies to treat infections and cardiovascular disease.

Centre for Environmental Radioactivity (CERAD)
Professor Brit Salbu

The Centre for Environmental Radioactivity has improved the ability to assess radiological impact and risks associated with environmental radioactivity, also in combination with other stressors. By focusing on key factors contributing to the uncertainties, state of the art tools and methods have been developed to better manage those risks. CERAD research has documented the impact of source term and particle releases on radionuclide transfer and effects, developed a multispecies toolbox to assess mechanisms underlying biological responses, and demonstrated the societal and ethical aspects of radiation risks. Research has been recognised at the highest international level, and according to the international mid-term evaluation committee, 'CERAD is a global Centre of Excellence and a flagship for Norwegian science with an agenda that is also highly relevant for society'. An exit strategy has been developed to secure the sustainability of the CERAD CoE.

Centre for Intervention Science in Maternal and Child Health (CISMAC)
Professor Halvor Sommerfelt

CISMAC is a consortium based at the University of Bergen. It undertakes intervention research to improve maternal, neonatal and child health and development in low and middle income countries in sub-Saharan Africa and South Asia. In 2019, its research (The Lancet 2019; 394:1724-36) showed that community-initiated Kangaroo Mother Care reduces mortality in low birth weight neonates by 30% and improves their growth.

Centre for Neural Computation (CNC)
Professor May-Britt Moser

The Centre for Neural Computation is taking the discoveries of neural cell types for position coding to a mechanistic level. Investigators at the Centre have identified mechanisms by which location is encoded in large neural networks, and they are developing new tools for deciphering neural codes embedded in networks of hundreds to thousands of neu-rons consisting of grid cells and other types of space and time-coding neurons. The Centre is expanding its activities and a number of neural coding principles have been uncovered in a variety of neural circuits across a variety of species, including humans.

Center for Multilingualism in Society across the Lifespan (MultiLing)
Professor Elizabeth Lanza

Through an innovative interdisciplinary approach, the Center for Multilingualism in Society across the Lifespan generates cutting edge research on the knowledge and use of more than one language by the individual and in society, addressing crucial issues in our contemporary world.

Norwegian Centre for Mental Disorders Research (NORMENT)
Professor Ole A. Andreassen

NORMENT has discovered a series of genetic variants involved in mental disorders, identified patterns of brain abnor-malities, and shown how risk factors affect illness course and outcome, thus providing unique transdisciplinary insight into disease mechanisms and clinical outcomes of mental disorders.

Centre for the Study of the Legitimate Roles of the Judiciary in the Global Order (PluriCourts)
Professor Geir Ulfstein / Professor Andreas Føllesdal

International courts and tribunals face growing criticism: states challenge the WTO, the International Criminal Court and the regional human rights courts. Yet some also consider establishing a new international investment court. PluriCourts asks why and when states do and should establish such international courts, and why and when ICs can legitimately claim that states should defer to their judgments.

Centre for Cancer Cell Reprogramming (CanCell)
Professor Harald Stenmark

The Centre for Cancer Cell Reprogramming will identify the Achilles' heels of cancer and target these for reprogramming cancer cells into harmless cells.

Centre for Fertility and Health (CeFH)
Professor Per Magnus / Siri Håberg

Our main aim is to disentangle the biological and social components of the causes and consequences of low fertility in modern societies. We use the rich national registries and cohort studies in Norway and combine medicine, genetics, demography, and advanced statistical methods to approach the complexity of the fertility changes seen in the last dec-ades.

Centre for Experimental Research on Fairness, Inequality, and Rationality (FAIR)
Professor Bertil Tungodden

FAIR is a hub in Europe for experimental research on fairness, inequality and rationality. We conduct groundbreaking research on how to address inequality in society through innovative methodological approaches and promote transparency in social sciences.

Hybrid Technology Hub (HTH)
Professor Stefan Krauss

Development and validation of organ-on-a-chip technology could lead to its adaptation by the pharmaceutical industry, hospitals and authorities as alternatives to animal experimentation and for personalised drug testing. The Hybrid Technology Hub Centre of Excellence is developing organ-on-a-chip technology for organs that control energy metabolism. Towards this goal, the centre combines research in stem cell technology, organoid development, microfluidics, sensor technology, chemical biology, bioinformatics and ethics.

Hylleraas Centre for Quantum Molecular Sciences (Hylleraas)
Professor Trygve Ulf Helgaker / Professor Kenneth Ruud

The Hylleraas Centre of Quantum Molecular Sciences develops and applies new theoretical methods for describing complex molecular systems and their interactions with strong electromagnetic fields, such as those that are now becom-ing available in modern experimental facilities. Early work has unravelled the complexity of the fundamental Grignard reaction of organic chemistry and allowed unusual nuclear magnetic resonance signals to be observed in organometallic complexes.

Porous Media Laboratory (PoreLab)
Professor Alex Hansen

Our current understanding of flow in porous media is scattered over many disciplines. The aim of PoreLab is to unite this knowledge, fill in the blanks and thereby produce a unified description and a new unified field of science.

Center for Low Dissipation Quantum Spintronics (QuSpin)
Professor Arne Brataas

QuSpin´s vision is to trigger a revolution in low-power information and communication technologies in an energy-efficient society. We will develop the basic science that uses quantum entities such as the electron spin in radically different ways. We aim at groundbreaking basic research that is crucial to the development of fast, high-capacity, material systems and tools for smaller and more power-efficient electronic devices.

Rosseland Centre for Solar Physics (RoCS)
Professor Mats Carlsson

The vision of the centre is 'Understanding the workings of the energetic Sun'. The activity is stepping up in phase with the rising activity of the new Solar Cycle; new methods and algorithms are being developed for numerical simulations of the whole Sun in anticipation of Exascale computing, and groundbreaking observations are being collected at solar ob-servatories and from satellites.

Centre for Interdisciplinary Studies in Rhythm, Time and Motion (RITMO)
Professor Anne Danielsen / Associate professor Alexander Refsum Jensenius

RITMO has within only two years of operation established itself as an international powerhouse for the study of rhythm as a means of structuring and predicting temporal events, facilitating human- and human-machine interaction, and enhancing experiences of pleasure and absorption. One of the centre's unique assets is the truly interdisciplinary nature of the research programme, bridging such diverse fields as musicology, psychology, and informatics.

Centre for Early Sapiens Behaviour (SapienCE)
Professor Christopher Stuart Henshilwood

The origins of our own species and the development of cognitive and behavioural 'modernity' are among the most profound of research issues in the behavioural and life sciences. Interdisciplinary research conducted at the University of Bergen SFF Centre for Early Sapiens Behaviour (SapienCE) demonstrates that human populations living in southern Africa successfully faced environmental challenges and developed complex technologies and symbolic artefacts 100,000 years ago. Our eclectic mindset combined with state-of-the-art analysis has refined the interpretations of the earliest known instances of complex human behaviour and justifies the term 'groundbreaking'.

Centre for Autonomous Marine Operations and Systems (AMOS): The AMOS/NTNU-boat 'Gunnerus' during installation of Norway's deepest underwater lab. © NTNU

TABLE 1 PREVIOUS AND EXISTING SFFS
Planned future centre directors are shown in parenthesis

ACRONYM	CENTRE NAME	HOST INSTITUTION	PROJECT MANAGER(S) (IN CHRONOLOGICAL ORDER)	GENERATION
APC	Aquaculture Protein Centre	Norwegian University of Life Sciences (NMBU)	Trond Storebakken/ Margareth Øverland	SFF-I
BCCR	Bjerknes Centre for Climate Research	UNI Research AS	Eystein Jansen	SFF-I
CASTL	Centre for Advanced Study in Theoretical Linguistics	Univ. of Tromsø – The Arctic University of Norway	Curt Rice/ Marit Westergaard/ Peter Svenonius	SFF-I
CBM	Centre for the Biology of Memory	Norwegian University of Science and Technology (NTNU)	Edvard Ingjald Moser	SFF-I
CESOS	Centre for Ships and Ocean Structures	Norwegian University of Science and Technology (NTNU)	Torgeir Moan	SFF-I
CIPR	Centre for Integrated Petroleum Research	UNI Research AS	Arne Skauge	SFF-I
CMA	Mathematics for Applications	Univ. of Oslo	Ragnar Winther	SFF-I
CMBN	Center of Molecular Biology and Neuroscience	Univ. of Oslo	Ole Petter Ottersens/ Tone Tønjum	SFF-I
CMS	Periphery and Centre in Medieval Studies	Univ. of Bergen	Sverre Håkon Bagge/ Leidulv Melve	SFF-I
CSCW	Center for the Study of Civil War	Peace Research Institute (PRIO)	Scott Gates	SFF-I
ICG	International Centre for Geohazards	NGI - Norwegian Geotechnical Institute	Farrokh Nadim	SFF-I
PGP	Physics of Geological Processes	Univ. of Oslo	Jens Gottfried Feder/ Bjørn Jamtveit	SFF-I
Q2S	Center for Quantifiable Quality of Service in Communication Systems	Norwegian University of Science and Technology (NTNU)	Peder Johannes Emstad/ Svein Johan Knapskog	SFF-I
CBC	Center for Biomedical Computing	Simula Research Laboratory AS	Hans-Petter Langtangen/ Joakim Sundnes	SFF-II
CCB	Centre for Cancer Biomedicine	Univ. of Oslo	Harald Stenmark	SFF-II
CEES	Centre for Ecological and Evolutionary Synthesis	Univ. of Oslo	Nils Christian Stenseth	SFF-II
CGB	Centre for Geobiology	Univ. of Bergen	Rolf-Birger Pedersen/ Ingunn Hindenes Thorseth	SFF-II
CIR	Centre for Immune Regulation	Univ. of Oslo	Ludvig M. Sollid	SFF-II

ACRONYM	CENTRE NAME	HOST INSTITUTION	PROJECT MANAGER(S) (IN CHRONOLOGICAL ORDER)	GENERATION
CSMN	Centre for the Study of Mind in Nature	Univ. of Oslo	Christel Fricke/ Olav Gjelsvik	SFF-II
CTCC	Centre for Theoretical and Computational Chemistry	Univ. of Tromsø – The Arctic University of Norway	Kenneth Ruud/ Trygve Ulf Helgaker	SFF-II
ESOP	Equality, Social Organization and Performance	Univ. of Oslo	Karl Ove Moene	SFF-II
AMOS	Centre for Autonomous Marine Operations and Systems	Norwegian University of Science and Technology (NTNU)	Asgeir Johan Sørensen	SFF-III
CEMIR	Centre of Molecular Inflammation Research	Norwegian University of Science and Technology (NTNU)	Terje Espevik	SFF-III
CBD	Centre for Biodiversity Dynamics	Norwegian University of Science and Technology (NTNU)	Bernt-Erik Sæther	SFF-III
CNC	Centre for Neural Computation	Norwegian University of Science and Technology (NTNU)	May-Britt Moser	SFF-III
CCBio	Centre for Cancer Biomarkers	Univ. of Bergen	Lars Andreas Akslen	SFF-III
BCSS	Birkeland Center for Space Science	Univ. of Bergen	Nikolai Østgaard	SFF-III
CISMAC	Centre for Intervention Science in Maternal and Child Health	Univ. of Bergen	Halvor Sommerfelt	SFF-III
CERAD	Centre for Environmental Radioactivity	NMBU	Brit Salbu	SFF-III
MultiLing	Center for Multilingualism in Society across the Lifespan	Univ. of Oslo	Elizabeth Lanza	SFF-III
CEED	Centre for Earth Evolution and Dynamics	Univ. of Oslo	Trond Helge Torsvik/ Carmen Gaina	SFF-III
NORMENT	Norwegian Centre for Mental Disorders Research	Univ. of Oslo	Ole A. Andreassen	SFF-III
PluriCourts	PluriCourts - Centre for the Study of the Legitimate Roles of the Judiciary in the Global Order	Univ. of Oslo	Geir Ulfstein/ Andreas Føllesdal	SFF-III

ACRONYM	CENTRE NAME	HOST INSTITUTION	PROJECT MANAGER(S) (IN CHRONOLOGICAL ORDER)	GENERATION
CAGE	Centre for Arctic Gas Hydrate, Environment and Climate	Univ. of Tromsø – The Arctic University of Norway	Jurgen Mienert/ Karin Andreassen	SFF-III
QuSpin	Center for Low Dissipation Quantum Spintronics	Norwegian University of Science and Technology (NTNU)	Arne Brataas	SFF-IV
PoreLab	Porous Media Laboratory	Norwegian University of Science and Technology (NTNU)	Alex Hansen	SFF-IV
SapienCE	Centre for Early Sapiens Behaviour	Univ. of Bergen	Christopher Henshilwood	SFF-IV
FAIR	Centre for Experimental Research on Fairness, Inequality, and Rationality	Norwegian School of Economics and Business Administration (NHH)	Bertil Tungodden	SFF-IV
CFH	Centre for Fertility and Health	Norwegian Institute of Public Health	Per Magnus/ (Siri Håberg)	SFF-IV
CanCell	Centre for Cancer Cell Reprogramming	Univ. of Oslo	Harald Stenmark	SFF-IV
HTH	Hybrid Technology Hub	Univ. of Oslo	Stefan Krauss	SFF-IV
Hylleraas	Hylleraas Centre for Quantum Molecular Sciences	Univ. of Oslo	Trygve Ulf Helgaker/ (Kenneth Ruud)	SFF-IV
RoCS	Rosseland Centre for Solar Physics	Univ. of Oslo	Mats Carlsson	SFF-IV
RITMO	Centre for Interdisciplinary Studies in Rhythm, Time and Motion	Univ. of Oslo	Anne Danielsen/ (Alexander Jensenius)	SFF-IV

Appendix C: People interviewed by the Evaluation Committee

TABLE 2

NAME	INSTITUTIONAL AFFILIATION	CENTRE
Alex Hansen	NTNU	PoreLab
Alexander R. Jensenius	UiO	RITMO
Andera Føllesdal	UiO	PluriCourts
Anders Solheim	NGI	ICG
Anne Borg	NTNU, rector	
Anne Danielsen	UiO	RITMO
Asgeir J. Sørensen	NTNU	AMOS
Bernt-Erik Sæther	NTNU	CBD
Bjørn Jamtveit	UiO	PGP
Brit Salbu	NMBU	CERAD
Carmen Gaina	UiO	CEED
Dag Rune Olsen	UiB, rector	
Deborah Oughton	NMBU	CERAD
Elizabeth Lanza	UiO	MultiLing
Halvor Sommerfelt	UiB	CISMAC
Harald Stenmark	UiO	CCB, CanCell
Ingrid Melle	UiO	Norment
Joakim Sundnes	Simula	CBC
John-Arne Røttingen	RCN, CEO	
Jon Storm-Mathisen	UiO	CMBN
Karin Andreassen	UiT- The Arctic University of Norway	CAGE
Kenneth Ruud	UiT- The Arctic University of Norway, prorector for research	CTCC, Hylleraas
Marit Westergaard	UiT- The Arctic University of Norway	CASTL
May-Britt Moser	NTNU	CNC
Nikolai Østgaard	UiB	Birkeland
Nils Christian Stenseth	UiO	CEES
Per Magnus	Public Health Institute	CFH
Ragnar Winther	UiO	CMA
Scott Gates	PRIO	CSCW
Siri Håberg	Public Health Institute	CFH

Continued next page

NAME	INSTITUTIONAL AFFILIATION	CENTRE
Stefan Krauss	UiO	HTH
Sverre Bagge	UiB	CMS
Trygve Helgaker	UiT- The Arctic University of Norway	CTCC, Hylleraas
Unn Røyneland	UiO	MultiLing
Åse Gornitzka	UiO, vice-rector	

Appendix D: Gender balance

The first SFF call (SFF-I) did not include measures aimed at improving gender balance.

Of the applications, 3% had female project leaders and among the centres that were funded, none had female centre directors at the start of the project period. When the centre period ended, three centres had, or had previously had, a female centre director for a period of time.

The gender distribution among other employees at the centres is known from 2004, which was the first year that the centres were required to submit progress reports. In 2004, 17% of the senior scientific staff (professors, associate professors and researchers) were female, 27% of the postdocs and 35% of the PhD students.

In the SFF-II call, several measures were taken to improve gender balance:

- Institutions were 'invited to encourage the research communities to nominate women as CoE directors and leading researchers'
- 'All factors otherwise being equal in terms of scientific quality', priority would be given 'to applications with female centre directors and centres with a strong percentage of women in leading positions' (moderat kjønnskvotering).
- Applicants were also asked to specify target figures for gender balance that were to be eval-uated in the mid-term evaluation, and in the selection of SFF-II centres, the assessment of scientific quality listed a criterion entitled 'The environment, ethics and equal opportunity'.
- NOK 30 million was set aside for two special calls for proposals from the SFF-II centres for measures to promote gender balance.

In the end, 14% of the applications and 1 of 8 (13%) of the funded SFF-II projects had a female centre director. The directorship at this centre was later transferred to a male. At a different SFF-II centre, a female took over as director during the centre period.

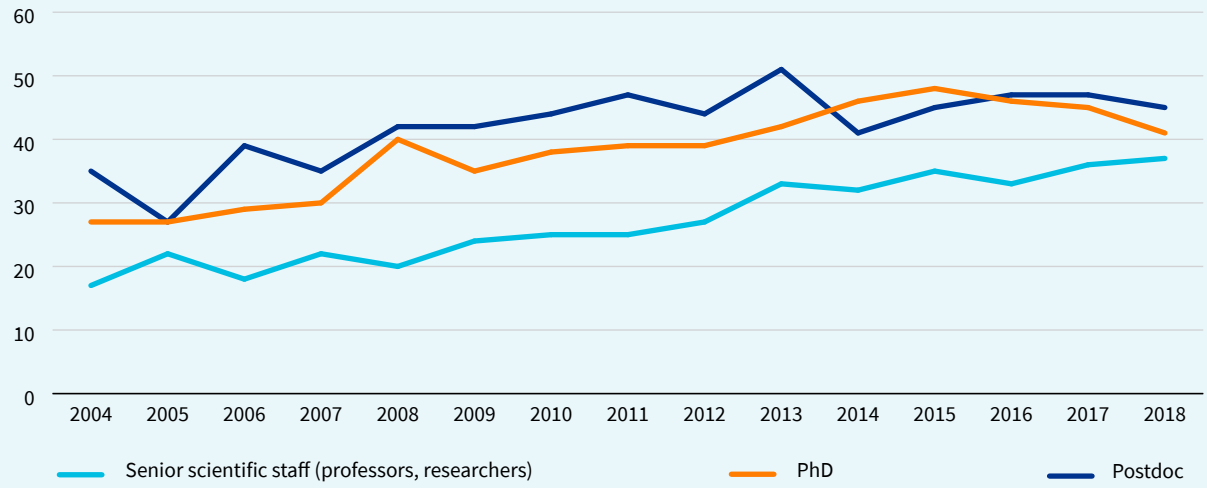
Among the senior scientific staff at the SFF-II centres, 23% were female, among the postdocs 38%, and among the PhDs 53% at the start of the centre's period of operation.

In SFF-III, similar efforts were made to promote gender equality to those of SFF-II, except that there was no earmarked funding for later gender equality calls. The percentage of female centre directors increased to 24% in the SFF-III applications and to 23% among the funded centres.

In SFF-IV, the selection procedures also gave priority to female centre directors, all else being equal, and included an assessment criterion to evaluate the appropriateness of 'plans to support development of research talents of the under-represented gender towards qualification to more senior-level positions' in scientific fields characterised by a gender imbalance. Among the SFF-IV applications, 21% were led by a female director and 1 of 10 (10%) of the funded projects had a female director.

Today, 6 of the 23 active centres (SFF-III and -IV) have female directors (26%). This is partly due to transfers of leadership during the project periods. Among the senior scientific staff in the active centres, the share of females is 37%, among postdocs 41%, and among PhD students 45%.

FIGURE 1 PERCENTAGE OF FEMALES AMONG SENIOR SCIENTIFIC STAFF, POSTDOCS AND PHDS
Percentage distribution of females in senior scientific (black), postdoc (red) and PhD positions (brown) as reported to the RCN from active SFFs in the period 2004-2018.



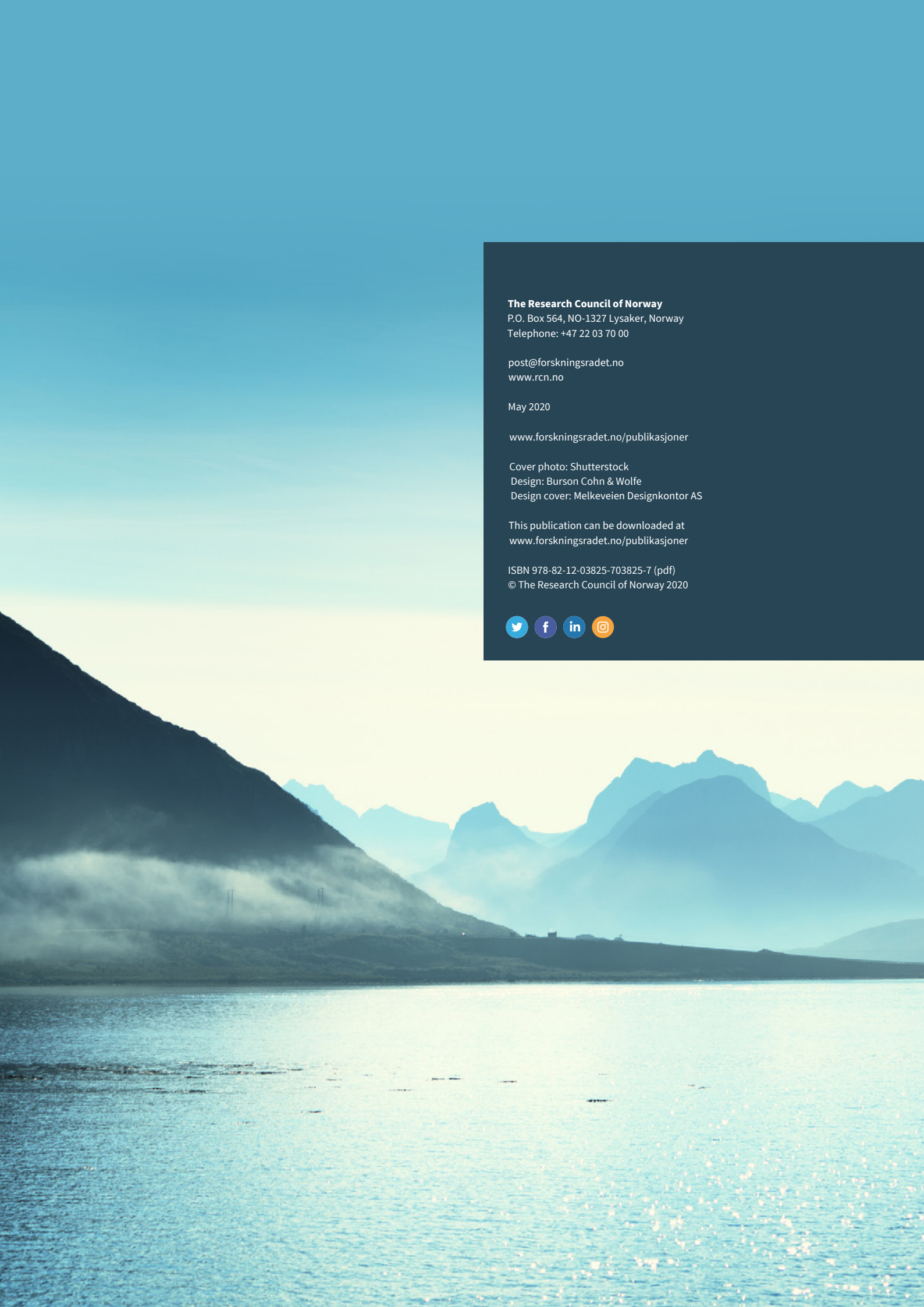
Source: RCN

TABLE 3 GENDER BALANCE AMONG PROPOSED AND ACTUAL SFF CENTRE DIRECTORS (NOT COUNTING TRANSFERS)

GENERATION	PHASE	TOTAL # APPLICATIONS	MALE PROJECT LEADER	FEMALE PROJECT LEADER
SFF-I	Phase 1	129	125	4 (3.1%)
	Phase 2	40	39	1 (2.5%)
	Funded	13	13	0 (0%)
SFF-II	Phase 1	98	84	14 (14.3%)
	Phase 2	26	23	3 (11.5%)
	Funded	8	7	1 (12.5%)
SFF-III	Phase 1	139	106	33 (23.7%)
	Phase 2	29	23	6 (20.7%)
	Funded	13	10	3 (23.1%)
SFF-IV	Phase 1	150	118	32 (21.3%)
	Phase 2	34	27	7 (20.6%)
	Funded	10	9	1 (10%)

Appendix E: The Evaluation Committee

Professor Liselotte Højgaard, University of Copenhagen, Denmark (chair)
Professor Dr. Ruedi Aebersold, ETH Zurich, Switzerland
Professor Mette Birkedal Bruun, University of Copenhagen, Denmark
Professor Tomas Hellström, Lund University, Sweden
Associate Professor Mathilda Mommersteeg, University of Oxford, UK
Professor Andy Woods, University of Cambridge, UK



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