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Evaluation of the Academy of Finland

Erik Arnold, Katharina Warta, Kimmo Halme, Gerwin Evers, Amber van der Graaf, Katri Haila, Anne-Mari Järvelin, Juha Kettinen, Peter Kolarz, Raffael Krismer, Kalle Piirainen, Laura Sutinen

Expert Panel: Ben Martin, Sylvia Schwaag-Serger, Dorothea Sturn, Rolf Tarrach

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Abstract

The objective of the evaluation was to produce a comprehensive view of the activities of the Academy of Finland based on international and national expertise and to find means for improving the Academy's impact, operation and structures.

Overall conclusion is that the Academy is working well, given the budgetary and policy constrains within which it functions, but that these constraints need to be addressed if the research and innovation system in Finland is once more to be well governed and can therefore allow the Academy to make a fuller contribution. The government needs a way to regain systemic perspective, and to decide how and to what extent it will tackle the societal challenges by thinking in terms of systemic transitions in addition to stable innovation systems. The current activities in government towards achieving the 4% target and reforming research and innovation funding are encouraging signs that this perspective can be regained, and a new dynamism injected into Finnish research and innovation policy.

Based on the analysis and conclusions the evaluation gives recommendations to the government, to the Ministry and the Academy, and of the future role of the Academy.

Keywords research, science policy, evaluation, innovation environment, Academy of Finland

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Suomen akatemian kansainvälinen kokonaisarviointi

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Tiivistelmä

Arvioinnin tavoitteena oli tuottaa kokonaisvaltainen, kansainväliseen ja kansalliseen asiantuntemukseen perustuva näkemys Suomen Akatemian toiminnasta sekä löytää keinoja Akatemian vaikuttavuuden, toiminnan ja rakenteiden kehittämiseksi.

Laajempana yhteenvetona arvioinnissa todetaan, että Akatemia toimii hyvin ottaen huomioon toiminnan taloudelliset ja toiminnalliset reunaehdot. Reunaehtoja voi kuitenkin olla tarpeen tarkistaa, jos Suomen tutkimus- ja innovaatiojärjestelmän halutaan olla toimivin mahdollinen niin että se mahdollistaa myös Akatemian osalta parhaan kontribuution. Yhteiskunnan tulisi palauttaa toimissaan systeeminen näkökulma ja päättää, miten ja missä määrin tarttua yhteiskunnallisiin haasteisiin ja ottaa huomioon vakaan innovaatiojärjestelmän lisäksi systeemiset siirtymät. Hallituksen nykyinen toiminta 4 % tavoitteen saavuttamiseksi ja tutkimus- ja innovaatiorahoituksen uudistamiseksi on osoitus tämän näkökulman palauttamisesta ja uudesta dynaamisuudesta suomalaisessa tutkimus- ja innovaatiopolitiikassa.

Arviointi antaa analyysin ja johtopäätöstensä pohjalta suosituksia valtioneuvostotasolla, opetus- ja kulttuuriministeriölle ja Suomen Akatemialle sekä Akatemian tulevasta roolista.

Asiasanat	tiede, tiedepolitiikka, arviointi, innovaatioympäristö, tutkimus, Suomen Akatemia

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Internationell utvärdering av Finlands Akademi

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Referat

Syftet med utvärderingen var att med hjälp av internationell och nationell expertis skapa en helhetsbild av verksamheten vid Finlands Akademi och hitta metoder för att förbättra Finlands Akademis genomslag, verksamhet och strukturer.

I utvärderingen konstateras det sammanfattningsvis att Finlands Akademi fungerar väl med beaktande av de ekonomiska och funktionella ramvillkoren för verksamheten. Det kan emellertid vara nödvändigt att se över ramvillkoren om man vill att Finlands forsknings- och innovationssystem ska fungera på bästa möjliga sätt och möjliggöra den bästa kontributionen också för Finlands Akademis del. Samhället bör återinföra ett systemiskt perspektiv i sina åtgärder, besluta hur och i vilken mån det ska åta sig att lösa samhälleliga problem och ta hänsyn till systemiska omställningar utöver ett stabilt innovationssystem. Regeringens nuvarande verksamhet för att nå målet på 4 procent av BNP för FoUI-investeringar och förnya forsknings- och innovationsfinansieringen är ett bevis på ett systemiskt perspektiv och på en dynamisk forsknings- och innovationspolitik.

Utifrån analysen och slutsatserna i utvärderingen läggs det även fram rekommendationer som gäller hela statsrådet, undervisnings- och kulturministeriet samt Finlands Akademi och dess framtida roll.

Nyckelord	forskning, vetenskapspolitik, utvärdering, innovationsmiljö, Finlands Akademi		
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SUMMARY

This evaluation of the Academy of Finland aims to understand the performance and impact of the Academy at a turning point in the way governments internationally approach research and innovation policy. This 'turn' involves placing greater emphasis on addressing societal challenges in addition to promoting scientific, social, and economic development, which have been the priorities in recent decades. Following an open competition, the evaluation has been conducted by Technopolis and 4Front, supported by a panel of leading researchers and practitioners in research policy and funding.

Up to about ten years ago, Finland was admired internationally for the boldness and effectiveness of its research and higher education policy, which was credited with supporting Finland's growth and the completion of its transition from being a resource-based economy to become a leading industrial country. Two pillars of this approach were counter-cyclical investment in research and higher education in times of recession, and the systemic approach to policy taken by government, orchestrated through the predecessors to the current Research and Innovation Council. Based on up-to-date research and theory on the way 'national innovation systems' work, this systemic approach recognised the interdependence of researchers, innovators and different parts of government in generating innovation and growth, and therefore the need to make holistic research and innovation policies.

Following the 2008 financial crisis and the Nokia crisis, political consensus and commitment to research and higher education broke down. The holistic perspective was lost, gaps started to appear, notably in technology policy, and Finland began to lag behind international thinking about refocusing parts of research and innovation policy towards the societal challenges and the UN Sustainable Development Goals, as the OECD pointed out in its 2017 review of Finnish innovation policy (OECD, 2017).

In the past decade, against a background of reforms in the university and institute sectors, the Academy has taken on major new tasks. These include hosting the new Strategic Research Council, launching the PROFI programme to support research strategy development and renewal in the universities, funding the FIRI committee on research infrastructure, and setting up the Flagship programme that aims to improve the links between fundamental research and innovation in industrial ecosystems. PROFI and the Strategic Research Council were funded from cuts elsewhere in the research system.

Leaving aside these transfers from other budgets, the Academy's grant budget grew little during the period.

The Academy adopted a new strategy in 2015, focusing on quality, impact, and renewal and for the first time (in the strategy update of 2020) identifying a thematic priority – climate change – as central to its work. Its ability to implement the strategy is, however, constrained by budget and the lack of a holistic government policy that would allow it to cooperate fully with other actors. The administration budget has remained at a very low level as a percentage of the grants budget – much lower, in fact, than in other comparable organisations internationally. The Academy had to cope with the inadequacy of this budget via internal reforms and reorganisation.

Despite the budgetary constraints, the Academy's internal processes continue to reflect good international practice. It funds research of international quality and its new tasks have been well executed. However, largely as a result of the lack of administrative budget, there has been too little critical evaluation of its instruments or reflection on their continuing relevance and the need for development. While the overall success rate for proposals to the Academy is about 20%, the success rate in some of the core bottom-up programmes is half that amount – a level internationally regarded as problematic, and which may pose a risk to the Academy's legitimacy in the research community.

The Academy's selection processes are gender-blind, which means that the gender imbalance among funded researchers is roughly the same as that among the applicants, suggesting that the root problem lies in the research community rather than the Academy.

Most research councils struggle with assessing interdisciplinary proposals. This is a problem because many advances in science occur at the boundaries between disciplines. However, the Academy is very friendly to interdisciplinary work, and its organisation is to a high degree consistent with the natural relationships among disciplines.

Our overall conclusion is that the Academy is working well, given the budgetary and policy constrains within which it functions, but that these constraints need to be addressed if the research and innovation system in Finland is once more to be well governed and can therefore allow the Academy to make a fuller contribution. The government needs a way to regain systemic perspective, and to decide how and to what extent it will tackle the societal challenges by thinking in terms of systemic transitions in addition to stable innovation systems. The current activities in government towards achieving the 4% target and reforming research and innovation funding are encouraging signs that this perspective can be regained, and a new dynamism injected into Finnish research and innovation policy.

This means that

- The government needs to re-establish an 'arena' in which it can debate research and innovation policy and governance across government and with key stakeholders. This is a precondition for holistic research and innovation governance, and for the Academy to make its full potential contribution to the national effort

- No matter which way the government decides to shape future R&I organisations and policies, it is important to maintain the Academy, and its legitimacy as the premier funder of research based on independent international based on peer review, within the system and to ensure that the research community as well as wider society feels ownership of it

- There should be substantial increases in both the Academy grant budget and in the technology programme budget of Business Finland, which are complementary means to support the desired growth in Finland's expenditure on R&D to 4% of GDP

- A key component of the Academy's grant budget is for infrastructure. This needs to be raised substantially in order to meet the level of need

- The Academy's administration budget has been kept so low that it has gone beyond encouraging the Academy to be efficient and is preventing it from more radically renewing and developing its activities. It is critical that the Academy receives a substantial increase

- This will inter alia allow the Academy to support the needed further increases in Finland's participation in international research and to review and develop its instrument portfolio

- We cannot second-guess how the government eventually decides to tackle policy for societal challenges, transitions, or missions, and there is no established international 'best practice' to which we can refer. However, it is clear that this must involve a high-level 'platform' approach to the big interventions and a more routine agency-based approach to the rest, probably based on cross-agency cooperation

- The Academy can contribute to these new policy needs d in a variety of ways, from supporting with foresight and needs analysis through running competitions aiming at developing more fundamental research aimed at supporting societal impact and making basic research contributions to cross-agency programmes with societal impact goals. These should be additional to strengthening the resilience of the Academy in its major role, namely quality based funding, and quality assurance of research

- To support these roles, the Academy should become a better networked organisation across the national and international research and innovation system, engaging and cooperating with other actors outside basic research, without at the same time abandoning its roots in basic research and the research community

Table of Contents

Summary 6

1 Introduction 15

2 The context of the Academy of Finland and its evolution 19
2.1 Governance of the research and innovation system 20
2.2 Effects on R&I funding 21
2.3 Finnish R&I policy reforms 25
2.4 Evolution of the Higher Education sector 30
2.4.1 Reforms 30
2.4.2 Funding 34
2.5 Government research institutes 39
2.6 Research and innovation funding organisations in Finland 40

3 The Academy: role, strategy, and operations 42
3.1 Why Finland needs the Academy 42
3.2 Third-generation R&I policy: new needs, international examples 44
3.3 History, governance, and organisational reforms 49
3.4 Strategy 54
3.5 Budget 55

4 Operation: instruments and processes 59
4.1 The Academy's funding instruments 59
4.2 Headline figures and trends over time 67
4.3 Instrument types 68
4.4 Beneficiary organisations 70
4.5 Success rates 72
4.6 Gender balance 74
4.7 Funding processes at the Academy of Finland 77
4.8 The Academy of Finland's involvement in international collaboration 84
4.8.1 The Finnish context of bilateral and multilateral agreements 86
4.8.2 Bilateral agreements 86

5 Quality and impact 91
5.1 Scientific quality of the proposals 91
5.2 Interdisciplinarity and thematic clusters 93

5.2.1 Interdisciplinarity of applications to the Academy of Finland ... 94
5.2.2 Dominant scientific fields in Finland ... 97
5.2.3 Bibliometric analysis undertaken by the Academy of Finland ... 103
5.3 Internationalisation ... 104
5.3.1 Funding of researchers from abroad by the Academy of Finland ... 104
5.3.2 International cooperation at the European level ... 108
5.3.3 International co-publications ... 111
5.4 A change agent in the science system? ... 114
5.4.1 The new requirement of societal impact in research funding perceived by universities ... 115
5.4.2 Flagships ... 116
5.4.3 Profiling ... 118
5.4.4 Infrastructure ... 121
5.4.5 Science communication and policy advice ... 124

6 Conclusions ... 125
6.1 Drivers of change ... 126
6.1.1 The context ... 126
6.1.2 Ministry of Education, Science and Culture, steering of the Academy ... 127
6.1.3 International cooperation ... 128
6.2 Implementation on the organisational level: Academy performance ... 129
6.3 Output, outcomes, impact contribution ... 133

7 Recommendations ... 137
7.1 Recommendations to the government ... 137
7.2 Recommendations to the Ministry and the Academy ... 139
7.3 The future role of the Academy ... 141

Appendix A References and further documentation ... 146
A.1 References ... 146
A.2 Further documentation ... 150
A.2.1 System level evaluations, Finland ... 150
A.2.2 Programme evaluations, Academy of Finland ... 150
A.2.3 Internal studies and evaluations, Academy of Finland ... 151
A.2.4 Scientific field evaluations ... 151

Appendix B Frame of reference of the evaluation ... 153

Appendix C Support group ... 155

Appendix D Expert Panel ... 156

Appendix E Interviews ... 159

Appendix F Supplementary data on portfolio and processes ... 162

Appendix G Business Finland research-related funding instruments 166

Appendix H Dominant scientific fields in Finland – methodology and findings 168
H.1 Data Used 168
H.2 Evolution of AcFin funded publications according to MS Academic top-level fields 171
H.3 Network analysis, top-level fields and international benchmarking 175
H.4 The importance of thematic clusters in Finland based on interconnectedness 178
H.5 Methodological approach of a bibliometric study of the Academy of Finland 184

Tables

Table 1. Timeline of key policy changes and reforms 29
Table 2. Characteristics of three R&I governance paradigm changes 45
Table 3. Development of the Academy of Finland's budget authority in 2012–2021 55
Table 4. Comparable time series of Academy of Finland's appropriations for operating expenditure 2012–2021 56
Table 5. Percentage of expenses in research funding agencies' total research funding volume 57
Table 6. Academy of Finland Funding instruments – overview sorted by share of total funding awarded 66
Table 7. Application numbers and success rates by instrument 73
Table 8. Gender balance of Finland-based researchers 76
Table 9. Process modifications used in the Academy's funding tools 80
Table 10. Funding schemes that promote international engagement and cooperation 85
Table 11. Mobility funding modalities (bilateral agreements) and success rates by country 89
Table 12. Comparison of success rates for interdisciplinary (ID) and non-interdisciplinary applications as well as total funding granted per funding instrument (data for 2020) 96
Table 13. Application and success rates by applicant's nationality 106
Table 14. Comparison of Finland's Horizon 2020 projects with other EU Member States 109
Table 15. Organisations in Finland with the highest participation in Horizon 2020 111
Table 16. Applications and success rates by first research field 162
Table 17. Applications and awards by institution 164
Table 18. Summary of quantitative metrics derived from publication data 180

Figures

Figure 1. The Academy in systemic context 18
Figure 2. Structure of Finnish research and innovation system (with indicative funding flows) 21
Figure 3. Gross expenditure on R&D by sector (€bn) 23
Figure 4. GERD as a percentage of GDP (left) and Government budget appropriations to R&D (right) (constant USD, PPP, 2007=100)........ 24
Figure 5. Development of government budget allocations to R&D per type of organisation 1997–2021 (at current prices, €ms). 26
Figure 6. Universities' funding model from 2021 33
Figure 7. R&D expenditure of Finnish universities by source of funding in 2019 ... 35
Figure 8. Development share of R&D funding by source (in current money) 36
Figure 9. University R&D funding by source and university, 2019........ 37
Figure 10. Development of staff by position........ 39
Figure 11. Decision-making bodies of the Academy of Finland 53
Figure 12. The Administration chart of the Academy of Finland, as from 1.8.2018 ... 54
Figure 13. Evolution of budget authority, operating expenses, Academy staff (FTE) and number of applications, 2012 (=100) to 2021 58
Figure 14. Total funding awarded by the Academy 2011–2020, Academy funding and SRC, in current €m 69
Figure 15. Total funding by instrument type – trends over time 70
Figure 16. Funding by recipient institution type – trends over time........ 72
Figure 17. Application success rates of the largest one-stage funding instruments, 2011–2020........ 73
Figure 18. Application and success rates by gender........ 76
Figure 19. The Academy's main 'one-stage' application assessment process 79
Figure 20. Modification options used in the Academy's application assessment process........ 80
Figure 21. Considerations for award process design 84
Figure 22. Academy funding for bilateral research projects in total (€k)) in total in 2011–10/2021........ 88
Figure 23. Academy of Finland funding for bilateral research projects (€k) by co-operation country in 2011–10/2021........ 89
Figure 24. Interdisciplinary applications – headline figures........ 96
Figure 25. Distribution of top-level fields: relative total share in publications comparing Academy of Finland and MS Academics Database........ 99
Figure 26. Top 3rd of research fields with fastest growing shares in publications 100
Figure 27. Lowest 3rd of research fields with fastest declining shares in publications........ 101
Figure 28. Visualisation of the main clusters (dendrogram) from a high-level........ 102
Figure 29. Percentage of foreign applicants in selected programmes of the Academy of Finland 106
Figure 30. Application and success rates by applicant nationality 108

Figure 31.	International comparison, participation in H2020, Net EU Contribution per country, total success rate	111
Figure 32.	Percentage of scientific publications involving international collaboration	113
Figure 33.	Percentage of scientific publications among the world's 10% top-cited publications (fractional)	114
Figure 34.	Academy of Finland in 2021	115
Figure 35.	Total research funding (over 6 years) and the percentage of PROFI funding from total research funding	120
Figure 36.	Evaluation Framework	155
Figure 37.	Data retrieval pipeline	170
Figure 38.	Distribution of top-level fields: relative total share in publications comparing Academy of Finland and MS Academics Database	172
Figure 39.	The number of distinct publications (by unique doi's) by AcFi grant year	173
Figure 40.	Top 3rd of research fields with fastest growing shares in publications	174
Figure 41.	Lowest 3rd of research fields with fastest declining shares in publications	175
Figure 42.	Network of research fields from Academy of Finland-funded publications	176
Figure 43.	Percentage of scientific publications among the world's 10% top-cited publications, selected fields, Finland, OECD and EU-27, 2011-2020	178
Figure 44.	Clustering of research fields based on the relative distances to each other	183
Figure 45.	Visualization of the main clusters (dendrogram) from a high-level	184

1 Introduction

This evaluation of the Academy of Finland was commissioned by the Finnish Ministry of Education and Culture (MEC), based on an open competition. It was done by members of the Technopolis Group and 4Front Oy, supported by a panel of experts in research policy, funding and evaluation (Appendix D).

The previous evaluation (Arnold, et al., 2013) focused on the operation of the academy: its success in performing the tasks allocated to it by the Ministry of Education and Culture (MEC); its role in the Finnish research and innovation system; its role in developing the strategic development of research organisations in Finland; internationalisation; and its internal structure.

The remit of this evaluation is over the past decade or so to consider:

1. The role of the Academy of Finland in the RDI system – The contribution of Academy's structure, the Ministry's (performance) steering and the operating practices in serving the overall development of the Finnish RDI system and the strategic development of key research actors, in particular universities and research institutes

2. The role of the Academy of Finland in promoting international scientific cooperation

3. The organisation and operations of the Academy of Finland: the roles of the Board, the Research Councils and the Administration Office, including the impact of changes in the organisation of the Academy of Finland to its performance as well as facilitation of the Strategic Research Council and the Finnish Research Infrastructure Committee

This new evaluation is being done in a very different context. The Academy has taken on new funding roles; the former generous funding from Tekes for applied and collaborative research has been greatly reduced through a combination of Tekes management decisions and government funding cuts, opening up a technology funding gap; the effectiveness of national research and innovation (R&I) policy governance via the Research and Innovation

Council has been reduced; and at the same time both societal pressures and the direction of international R&I policy has shifted towards the societal challenges.

Figure 1 sketches at a high level the 'system' in which the Academy works. External change drivers interacting with the Academy include:

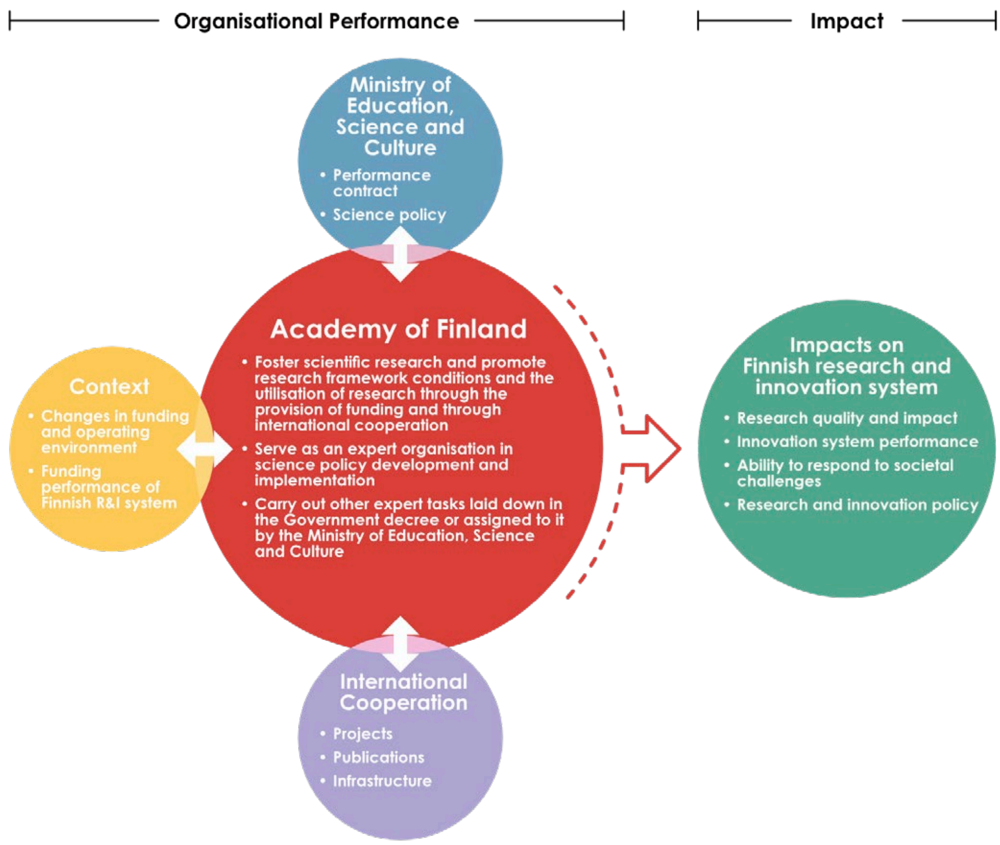
- Government Research and Innovation (R&I) policy and the steering relationship between the Ministry and the Academy
- Contextual changes such as the growing policy importance of the societal challenges, as well as changes in the performance of the Finnish research and innovation system
- Opportunities for Finland to participate in international research (such as the Framework Programme, Nordic cooperations, bilateral programmes and internationally shared research infrastructures)

The Academy is in the middle of the diagram, with the three functions defined for it in the Academy Law.[1] The effects of the Academy's work should be to support and improve the performance of the Finnish national research and innovation system, including R&I policy itself.

Recognising the role of research funders not only as funders of the status quo but also as change agents supporting the health of the research system and its relevance to wider national needs, the evaluation needs to pay special attention to changes in both the external and the internal drivers of change, in the Academy's behaviour and performance, and in its impacts. This evaluation therefore uses a framework spanning organisational performance and impact evaluation approaches.

1 Laki Suomen Akatemiasta, 20.11.2009/922, section 2 of the law has been amended in 6.4.2018 (213) and it concerns the task of the Academy.

Figure 1. The Academy in systemic context



Our methodology involved an inception phase, where we reviewed available documents, conducted pilot interviews with people from the Academy, the MEC and the stakeholder organisations, met with our panel of experts and a support group organised by the MEC, whose members have kindly helped us throughout the process. We asked the Academy to produce a self-evaluation report, which provided us with useful information and data and was a basis for several of our discussions with the Academy. We identified and reviewed further documents, collected, and analysed data from the Academy on its activities and other aspects, did a bibliometric analysis of the research areas the Academy funds, held in-depth interviews with a wider range of stakeholders including university rectors, institute heads, representatives of industry, and other government agencies as well as workshops with leading researchers holding ERC grants in order to understand their experience and perceptions of the Academy.

Our expert panel met key people from the Academy, MEC and the research community so that its members could directly form their own views on the Academy's operations and performance. This final report presents a fusion of the expert panel's and the evaluation team's findings, conclusions, and recommendations.

The next Chapter of this report presents the context of the Academy, describing its role in the national research and innovation system, the other key actors and developments in policy and funding over time.

Chapter 3 focuses on the Academy, explaining the importance of its role in research funding and how the international R&I policy context is changing. It then discusses the history, organisation, strategy, and budget development of the Academy.

Chapter 4 focuses on the instruments and processes the Academy uses in its work while Chapter 5 discusses their effects in relation to interdisciplinarity, internationalisation, quality, and careers and in relation to the structure and performance of the research community.

The last two Chapters provide conclusions and recommendations.

2 The context of the Academy of Finland and its evolution

This Chapter explores issues in the governance of the Finnish R&I system over the last decade and the way these have impacted in R&I funding. It describes relevant policy reforms in reseach and in the higher education system. It explains the changes in the research institute sector and among research and innovation funding organisations in inland

In the past, Finland was viewed internationally as a role model for policies for higher education, research and innovation, generating growth in the face of difficult economic circumstances, and for its holistic governance of research and innovation via the Science and Technology Policy Council (now called the Research and Innovation Council – RIC), under the leadership of the Prime Minister. The unhappy coincidence of the 2008 financial crisis with the difficulties of Nokia, which had been something of a standard-bearer for Finnish R&I Policy, was a big blow both to the national economy and to national confidence in R&I policy (OECD, 2017). Finland experienced a particularly sharp shock in the financial crisis, due to the loss of ICT exports associated with Nokia's restructuring.

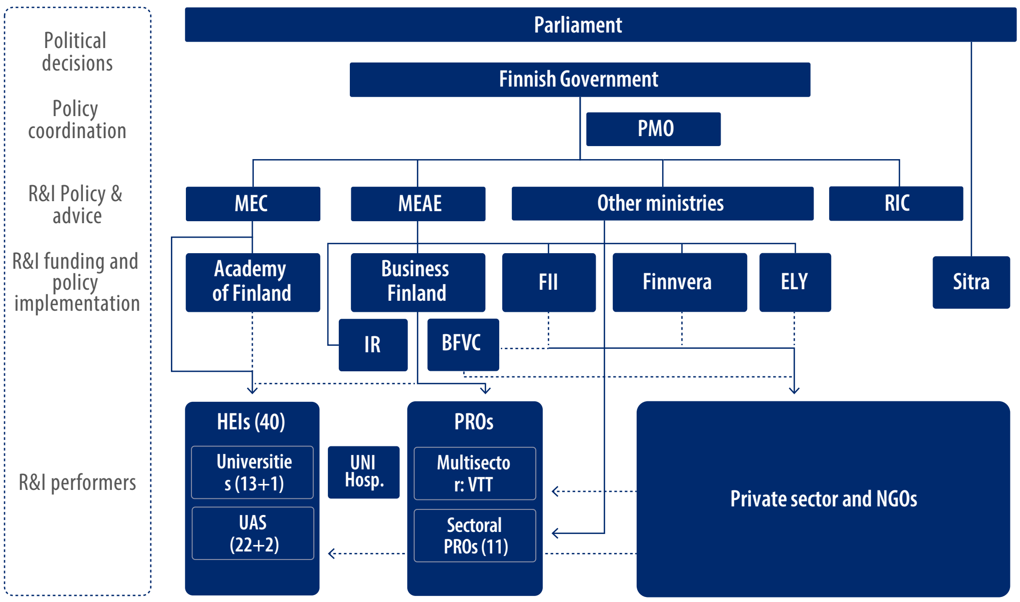
The consequences of these two events included government austerity but also a breakdown in the previously holistic R&I governance. The volume of research funding in both business and the research system has since stagnated, opening a major gap in applied research and technology funding. R&I policy has become more fragmented, making it hard to take strong national positions on addressing the societal challenges that have increasingly been a focus of policies in other European countries.

There have been major reforms of the universities, the universities of applied sciences, government research institutes, and funding agencies, followed by significant changes in budgets, but these have resulted from rather separate decision-making processes in the education and research sphere on the one hand and in industry and innovation policy on the other. While there appears to be a revival of interest in pursuing a more active R&I policy at the level of parliament and the government, the Academy of Finland finds itself in a very different and much less certain context than a decade ago. The future role of the Academy depends to a great extent on whether and how it proves possible nationally to refocus on R&I as a driver not only of economic growth but increasingly of sustainability, and to adopt more holistic R&I Policies across government.

2.1 Governance of the research and innovation system

Figure 2 shows that the structure of R&I governance in Finland is quite typical for a Western European country. In Nordic R&I policy discussions, Finland has been described as having a 'two-pillar' system, resting on strong industry and education ministries and their agencies. Over the past 20–30 years, R&I policymakers have increasingly understood the importance of involving not only finance ministries but also several other 'sector' ministries in R&I policy. Until about a decade ago, Finland's system of R&I governance with an effective high-level advisory council was widely admired, and many attempts have been made internationally to imitate it (OECD, 2009) (Schwaag-Serger, et al., 2015).

Figure 2. Structure of Finnish research and innovation system (with indicative funding flows)



BF = Business Finland
BFVC = Business Finland Venture Capital Ltd
ELY = Centres for Economic Development, Transport, and the Environment (Elinkeino-, liikenne- ja ympäristökeskukset)
FII = Finnish Industry Investment Ltd
HEI = Higher Education Institutions (Universities and Universities of Applied Sciences)
MEAE = Ministry of Economic Affairs and Employment
MEC = Ministry of Education and Culture
NIY = Young Innovative Enterprises funding service of Business Finland (Nuoret innovatiiviset yritykset -rahoituspalvelu)
PMO = Prime Minister's Office
PRO = Public Research Organisations
RIC = Research and Innovation Council
Sitra = the Finnish Innovation Fund
IR = The Finnish Climate Fund Ltd
VTT = Technical Research Centre of Finland – VTT Ltd
Source: 4Front

However, the effectiveness of the Council in fostering the development of R&I policy for the national innovation system in a holistic way depended crucially on the impetus given to it by the chairmanship of successive Prime Ministers. More recent Prime Ministers have given the Council less priority. The RIC in its original form held its last meeting in December 2014, soon after it adopted its final extended STI policy review.

The RIC was restructured in 2016 and again in 2019. It is still chaired by the Prime Minister, the Minister of Science and Culture and the Minister of Economic Affairs are Vice-Chairs, and it contains three additional ministers appointed by the government. In addition to the ministers, the Council has six to seven other members appointed by the government based on proposals from the Ministry of Education and Culture for the duration of the parliamentary term. The members of the Council are required to have broad expertise in research, development, and innovation. The seven appointees currently comprise three people from business, three university professors (of whom, one rector) and the president of VTT[2]. The Council's independent secretariat and two subcommittees have been abolished, and preparatory work assigned to civil servants within the Ministry of Education and Culture, the Ministry of Economic Affairs and Employment, the Prime Minister's Office, Tekes/Business Finland, and the Academy of Finland (OECD, 2017). Most of the recommendations of the independent evaluation of the RIC published in Spring 2014 (Pelkonen et al., 2014) were not put into practice and the RIC activities in 2016–2019 were not as intensive or independent as earlier (Lemola, 2020) (RIC, 2020). As a result, the RIC is inherently less powerful than before. This has resulted in a loss of systemic perspective and, in particular, the emergence of a 'technology gap' in funding (OECD, 2017). While the Prime Minister's Office has taken on a greater role in funding research to support policymaking, no other body has been allocated the leading role in R&I policy that would make it possible to set clear strategic directions. While statements of Finnish R&I policy increasingly connect with societal and environmental issues and the societal challenges, these changes in tone have not triggered policies that cut significantly across the existing silos or involve major new types of programmes or funding instruments.

2.2 Effects on R&I funding

Finland has in the past fared well in international comparisons of the R&I system, while it has more recently been overtaken in the EU by Belgium, Sweden, Denmark, Austria, and Germany. Historically, R&D intensity in Finland grew steadily between 1981 (1.15% of GDP) and the 2008–09 financial crisis (Figure 3), driven by a policy of state investment in higher education and research. During the last decade, the system has stagnated and total R&D

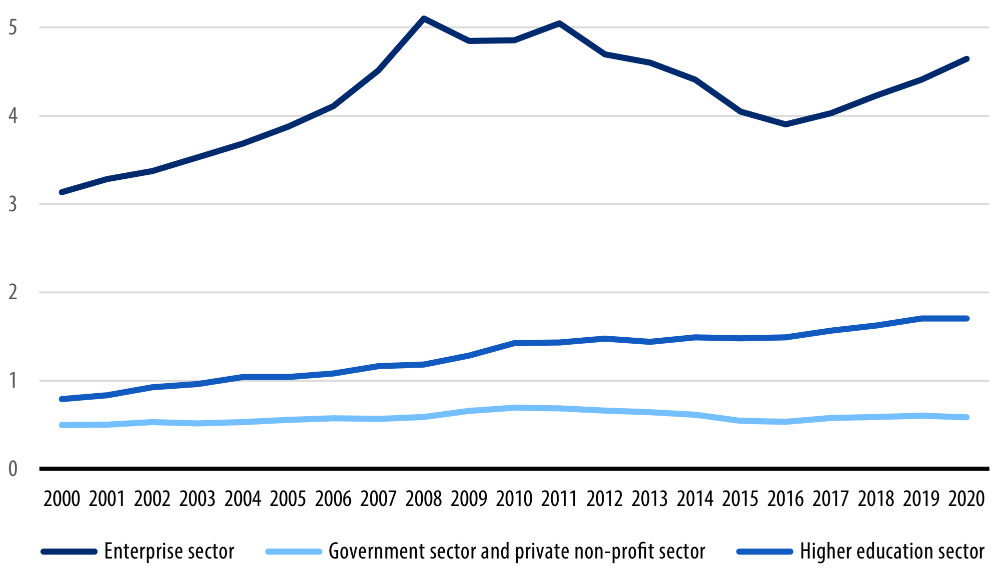
2 https://valtioneuvosto.fi/en/-/1410845/tutkimus-ja-innovaationeuvosto-asetetti-2

investment (GERD) as a share of GDP has declined after reaching a peak in 2009 (3.73 % of GDP). Only during the last few years, the R&D intensity levels has been rising again.

The ICT equipment, electrical equipment and machinery, and information and communication services sectors account for the lion's share of business R&D expenditure in Finland. In 2000 Nokia represented 29.4 % of all R&D investments in the country (Ali-Yrkkö & Hermans, 2002). By 2008, Nokia produced 2.6% of GDP and was responsible for 36.9% of total R&D expenditures in Finland (Ali-Yrkkö, 2010). While the role of Nokia remained stable until 2009 a rapid decline took place from 2012, and following the takeover of the Nokia Mobile Phones activities by Microsoft in 2013 Nokia's R&D had more than halved from its 2008 level to 17% of Finnish BERD (Ali-Yrkkö et al., 2013). Despite this, however, Finnish BERD as a proportion of GDP remains well above the OECD average.

Figure 3 shows that there has been some recovery in business R&D, following the Nokia shock. Higher education expenditure on R&D (HERD) has been growing slowly but consistently for the past 20 years, while that in the government sector (mainly the institutes) has almost been flat as a proportion of GDP. This pattern is common to many countries, making state investment in HERD increasingly important in economic performance.

Figure 3. Gross expenditure on R&D by sector (€bn)

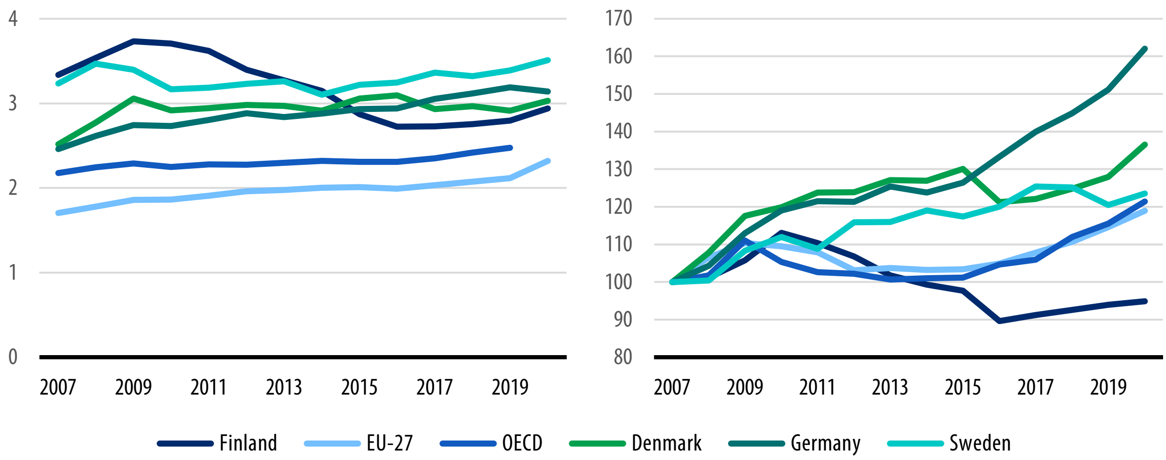


Source: Research.fi

In 2020, Finland's gross domestic expenditure on R&D accounted for 2.94% of GDP (estimate 2.88% for 2021), which is still above the OECD average (2.47%) and the average for the EU-27 area (2.32%). The Finnish business sector accounted for 67.0% of total R&D expenditure, higher education sector for 24.6% and government sector 8.4%. The total sum of R&D expenditure was € 6,932 m, which is €217m more than in the year before. The overall expenditure grew by 3.2%.

Unlike the previous two Figures, Figure 4 shows expenditures in **real** terms and has been published by the OECD in a Finnish case study about its R&D intensity target (Deschryvere et al., 2021). The study focused on the period from 2005 when the current 4% R&D intensity target was set for the first time and the present. In practice, after the peak at 3.73% in 2009, R&D intensity has declined until it reached 2.72% in 2016. No major change has occurred since then. Finland was the only country in the EU that invested less in R&D in absolute terms in 2017 than in 2007, while most EU Member States (21/27) have increased their R&D intensity over the same period.

Figure 4. GERD as a percentage of GDP (left) and Government budget appropriations to R&D (right) (constant USD, PPP, 2007=100)



Source: OECD/MSTI; Source for 2020: OECD & Eurostat, data for 2020 is provisional

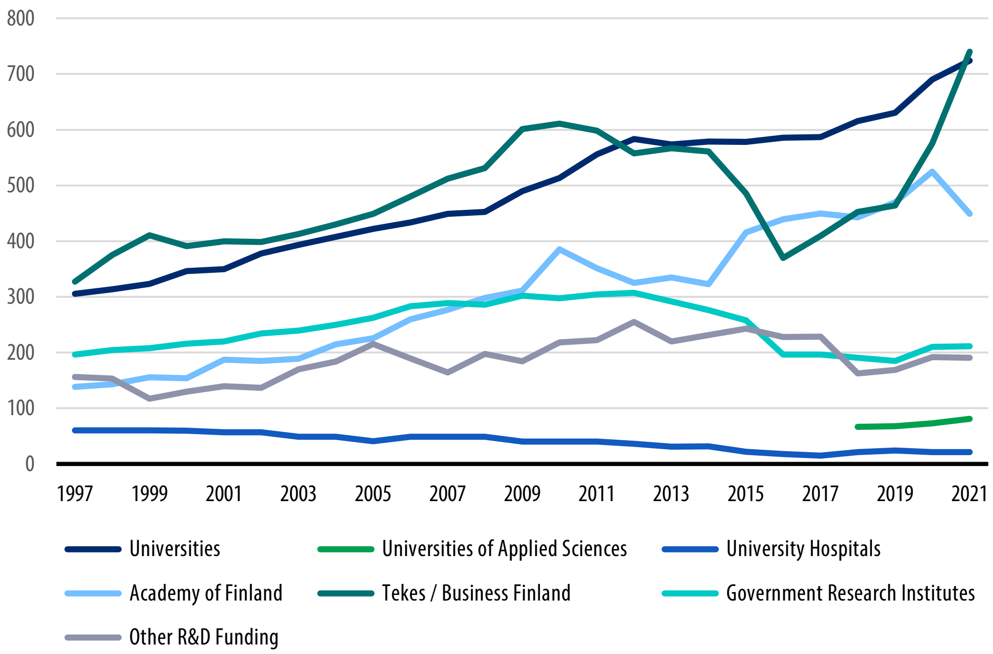
Survey data indicate that Finnish companies more generally responded to the financial crisis by refocusing their R&D on existing businesses and markets rather than on new ones, at least in the period up to 2014 (Ormala et al., 2014). The share of the ICT sector in total GERD has fallen from 43% in 2008 to 20% in 2018 (Deschryvere et al., 2021), confirming that Finland is falling back on more traditional, often more slowly growing industries. There is anecdotal evidence from our interviews that business R&D has become less adventurous and is tending to move abroad. Much of VTT's most adventurous research is now done with firms abroad. Survey data from industry suggests that the level of state R&D support is an important factor for Finnish industry in deciding both the amount and the location of its R&D (Ormala et al., 2014).

Recovery in terms of GDP, jobs and productivity has been slow, as the crisis revealed an underlying need for economic restructuring besides recovery from the financial crisis. These factors led to cuts to public RDI subsidies and contraction of private investment at the same time. The public budget cut particularly affected Tekes (and therefore Business Finland), while the basic research funding as provided by the Academy of Finland has been fairly stable (see Figure 5). The 2020–2021 figures for Business Finland are severely distorted by the distribution of additional Covid-related funding – the underlying numbers are likely to be similar that for 2019. The Academy's figures are also inflated by Covid funding, but only to a very small extent.

A major consequence of the cuts has been a sharp fall in R&D collaboration between research organisations and enterprises. Company funding of university R&D also decreased by some 40% between 2010 and 2017.[3]

3 The share of HERD financed by the business sector dropped from 5.71% in 2010 to 3.09% in 2019.

Figure 5. Development of government budget allocations to R&D per type of organisation 1997–2021 (at current prices, €ms).



Source: Statistics Finland. NB These figures include extraordinary funding for the Academy and Business Finland related to Covid. The Covid funding component included in these figures may be incomplete

On our reading, these trends underscore the importance of high-quality, dynamic R&D funding across both fundamental and more applied research, in support of economic and social welfare. The need for restructuring and increased dynamics in industry and across the wider research and innovation system is urgent, while the reduced effectiveness of governance discussed above is a significant impediment to achieving this.

2.3 Finnish R&I policy reforms

Unlike in some countries, where research policy receives limited political attention, successive Finnish governments have played a visible role, not only in budgeting science and research but also in the development and focus of publicly funded research. Key reforms in the past decade (Table 1) have included restructuring the research institute sector, increasing the autonomy of the universities and the universities of applied sciences, encouraging university mergers and the development of clearer research strategies through profiling, creating a new Strategic Research Council (SRC), closing the major SHOK innovation centre programme, and merging the Tekes innovation agency with the Finpro business development agency to form Business Finland. However, these reforms have taken place at the same time as an austerity programme that has severely constrained government spending.

The university system reform in 2010 made the universities more autonomous from government, gave them control over both human resources and their finances, brought more societal representatives into their governance, and ended the practice of the faculty electing the rectors. Correspondingly, it increased the importance of funding – both via the performance-based funding system that was developed and via external funding – as well as the need for the universities to develop their own strategies.

A national reform (TULA) of state research institutes and research funding (Valtioneuvoston, 2013) that merged 20 institutes into 12 was approved by the government in 2013 and conducted between 2014 and 2017. This aimed to improve the coordination, efficiency, and effectiveness of public research as part of the larger research and innovation ecosystem. Decisions on reductions in research funding were made, including on research appropriations of the Academy of Finland. Finland's stability programme 2014 stated that that annual funding authorisation would be reduced by € 20m in 2015 and 2016, as well as by €10 m from 2017 (Ministry of Finance, 2014). Due to the reform and other government decisions, the institutes' institutional research funding dropped by 37% between 2013 and 2016 to €197 m (Haila et al., 2018). However, the evaluation of the reform indicates that, while there were improvements in institutes' ability to work across disciplinary boundaries, the reform did not achieve its goal of securing and strengthening the strategic direction of research institutes at the Government level and the budget reductions served to weaken the conditions for performing research (Haila et al., 2018). The institute sector itself complains that its ability to do lower-TRL research has been reduced, and – especially in public health – that the cuts were so severe as to undermine the ability of the institute to perform its mission properly.

The resources taken for a large part[4] from the institute sector were used in 2015 to establish the Strategic Research Council (SRC), which is hosted by the Academy of Finland. The SRC was intended to make a start on addressing the societal challenges. Its effectiveness and impact are currently being evaluated, and the report will be available in the summer of 2022.

4 Altogether €52.5m was cut from the institute sector, €10m from Tekes and €7.5m from the Academy. About 80% (€55.6m) of the resources was used in 2015 to establish the Strategic Research Council hosted by the Academy of Finland. The rest (about 20%) was allocated to the Government´s analysis, assessment, and research activities.

Other reforms in 2014 of significance to this evaluation were

- Setting up the FIRI research infrastructure funding programme within the Academy, and producing an update of the roadmap for infrastructure investment
- Reforming the Academy Act, removing the President from the Board, allowing Research Council chairs to attend Board meetings as observers with speaking rights, and setting up a steering group for research funding
- Establishing the PROFI profiling programme in 2015 (Finlex, 2015) – taking € 50m p.a. from the universities' institutional funding and having the Academy redistribute it to the universities via competitive bids for 'profiling' funds, which were intended to help them implement new strategies, and potentially encouraging mergers and redivision of labour among the universities to achieve a less fragmented university system with more critical mass in areas of strength

After the austerity programme under Prime Minister Juha Sipilä's government (2015-2019) and the merger of Tekes and Finpro into Business Finland (BF), the programmes of Prime Minister Antti Rinne's (2019) and later Prime Minister Sanna Marin's government (2019–2023) stated that R&I investments would be put on a growth track, though this has yet to be achieved. One of the seven strategic themes in the current government programme, is the promotion of competence, education, culture, and innovation. This includes the following measures:

- Strengthen predictable, long-term core funding for higher education
- Examine the challenges and opportunities concerning the foreseeability, long-term nature, and usability of research funding. On the basis of the study, create an action plan for implementing research funding that fits the purpose
- Create a long-term plan to bring about improvements in the research, development, and innovation environment and through them reach an expenditure-to-GDP ratio for public and private investment and funding of 4 per cent
- Create conditions across Finland for successful clusters of excellence with higher education institutions, research institutes and businesses

- Improve the overarching coordination and management of innovation and research policy across the central government
- Promote Finland's attractiveness as an investment opportunity for the research and development activities of both foreign and domestic businesses
- Reinforce the international competitiveness and attractiveness of the Finnish research and science community by investing in research environments and infrastructure

A specific R&D roadmap for the government prepared by the Ministry of Education and Culture (MEC) and the Ministry of Economic Affairs and Employment (MEAE) was published in April 2020 and updated in December 2021, with a view to raise RDI investments to 4% of GDP by 2030 and to enhance the (PPP-based) environment for innovation and experiments; however, the precise way how to get there is still under discussion.

During 2021 there has been intense public and political debate about the lack of determined investment and long-term public R&D funding in Finland. The measures to reach the government 4% objective were clearly insufficient and targets fell further away. The public debate was particularly strong during spring and summer, when budget cuts were anticipated to the Academy of Finland. The budget of the Academy had been increased over the years. particularly in 2020 with short-term funding, of which some was due to end in 2022. Planned budget cuts to the Academy of Finland were withdrawn in the September 2021 annual budget negotiations, while anticipated budget cuts for years 2023–2025 remain. In response to the debate, Prime Minister Sanna Marin set up a parliamentary working group on long-term funding for R&D, the report of which was published on 13.12.2021.

Table 1 summarises the key policy changes and reforms of the past decade.

Table 1. Timeline of key policy changes and reforms

Year	Event / policy change
2010	1. University system reform -> independent role of universities, mergers, etc
2012	2. Evaluation of the Academy of Finland
2013	3. Reform of public research organisations and financing (TULA) – followed by budget reforms 2013–2018
2014	4. Establishment of Strategic Research Council in the Academy 5. Establishment of the FIRI Committee in the Academy 6. First Finnish Research Infrastructure Strategy 2014–2020 and update of Roadmap dating back to 2009 7. Reform of the Universities of Applied Sciences 2014–2015 8. Reform of the Act of the Academy, e.g. • President no longer on the Board of the Academy • Council Chairs allowed to present at Board meetings 9. Steering Group for Research Funding was established 10. Government Decision on transfer of €50m annual university funding by the state to the competitive funding of the Academy of Finland (2015 establishment of PROFI funding form)
2015	11. Run-down of SHOK programmes 12. Budget cuts to Tekes (Sipilä, 2015) -> focus shift away from (university) research
2016	13. Reform of Research and Innovation Council 14. Team Finland reform (Rehn)
2017	15. Vision 2030 of the Research and Innovation Council 16. Vision for Higher Education and Research in 2030 and its roadmap 17. OECD Country Review of Finland
2018	18. Changes regarding the Research Councils in the Act and Decree 19. Tekes & Finpro merged into Business Finland 20. Finnish Research Infrastructure Strategy and Roadmap 2014–2020, mid-term review 21. Evaluation of Research Institute Reform (TULA)
2019	22. New Team Finland strategy & reform (coordination from PMO to MEE) 23. Overall Evaluation of Sitra & 100 million EUR reallocation of Sitra's endowment to universities

Year	Event / policy change
2020	24. National Action Plan/ RDI Roadmap for the 4% and its annexes 8, including the new partnership model (Academy) -> infrafunding
	25. Strategy for National Research Infrastructures in Finland 2020–2030 (FIRI Committee)
	26. Additional R&D funding given to Business Finland & Academy to help recover from COVID-19 pandemic
2021	27. Academy of Finland, Business Finland & Team Finland evaluated
	28. PM Marin to set up a parliamentary committee to propose on government long-term commitment to R&D
	29. €35m budget cuts proposed to Academy of Finland (withdrawn for 2022)

In view of the tense budgetary conditions and the comprehensive institutional reforms, a challenge at the systemic level is that the different – actors research centres, universities, BF – have to deal with their own repositioning, and holistic governance is weakened at the national level, which is reflected, among other things, in the reduced importance of the RIC. The Academy of Finland is responsible for funding basic research, and has also been required to take on additional tasks in the past eight years. These include the promotion of strategic research via the SRC, the profiling of universities, funding research infrastructure, and 'flagships' with societal and economic objectives, considerably broadening its role. We will argue later that this broadening requires more transparency and formal cooperation relationships in order to sustainably achieve its goals.

2.4 Evolution of the Higher Education sector

2.4.1 Reforms

The higher education sector in Finland has undergone considerable changes during the last decade. This includes increasing university autonomy and changes in the institutional landscape through mergers. In response to these changes, new instruments of the Academy of Finland address the strategic engagement of universities, in particular the Profiling, Flagships and the Infrastructure funding. Whereas PROFI, infrastructure and SRC tasks have come with new money for the Academy, Flagships have been funded by its normal budget. PROFI is financed using money taken from the universities' institutional funding and are now allocated competitively. Flagships are a new form of competence centres, also with a strong focus on universities and their strategic positioning in broader research and innovation ecosystems.

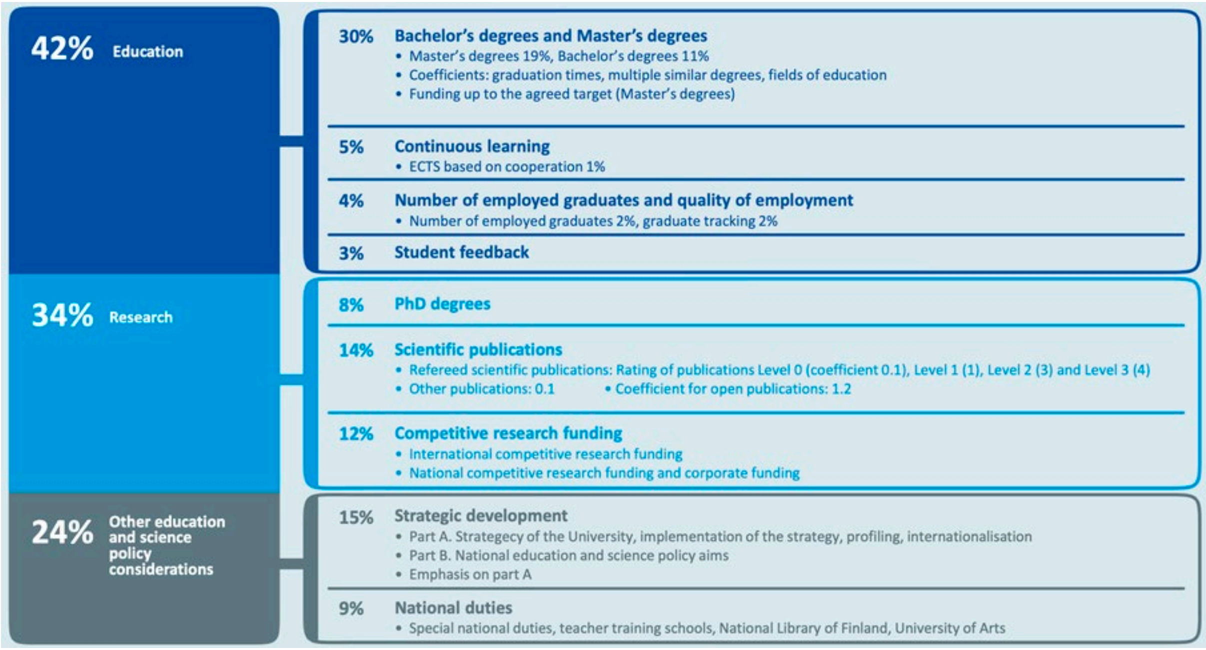
The strategic and systematic interaction and dialogue between the Ministry of Education and Culture and HEIs emphasises the autonomy and social responsibility of higher education institutions (Wennberg et al.,2018). The university reform in 2010 increased the financial and administrative autonomy of the universities and universities of applied sciences, giving them greater flexibility in the acquisition of external funding and utilisation of the capital and financial assets. They are now also responsible for their human resources. Universities' public accountability has been enhanced through the mandatory inclusion of non-university representatives on their governing board (at least 40% of the members).

The main goal of the amendment to the Universities Act (2009/558, implemented in 2010) was to strengthen the university system in its own excellence fields to the international level by improving its quality, international competitiveness, societal impact, and ability to co-operate with foreign universities and research institutes. As a result of the reform, universities were expected to diversify their funding base and focus their research resources on their areas of strength, as well as improve the quality of their research and teaching activities.

The Ministry's control over HEIs can be divided into agreement management, performance management and other forms of control such as information management and educational responsibility decisions. Of these forms of control, performance management is the most important. The performance agreements between the Ministry of Education and Culture and each HEI set operational and qualitative goals for the institution and determine the resources required to reach these targets (see Figure 6). The influence of performance agreements has been diminished due to the indicator-driven performance-based funding system for both universities and UAS.

The performance-based model allocates 12% of the funding based on the average performance in competitive research funding over the preceding three years. The funding model is set for the duration of the contract (currently four years). The current contract period is 2021–2024. This has encouraged the universities to seek more competitive funding (Seuri, & Vartiainen, 2018), but has not contributed to expanding their funding base (Wennberg et al., (2018).

Figure 6. Universities' funding model from 2021



Source: Ministry of Education and Culture

The appropriations for the education and research sections are distributed in different ways. While efforts have been made to develop a more transparent and clearer funding formula to increase its steering effect, the elaborate indicator-based system has over the years become increasingly complex because of the tendency of each government to bring new elements to the formula (Melin et al.,2015). According to Seuri and Vartiainen (2018), however, in Finnish universities, results have improved with performance-based funding. University productivity has improved on all measures (including research publication quality and productivity) despite various challenges, side effects and funding cuts in education and research.

Currently, the universities receive almost half their research income in the form of institutional funds (Figure 7), a quarter from the Academy, and the balance from a wide range of other sources. The amount of funding they have received from Tekes has halved during the decade, reflecting the development of the 'technology gap' in R&D funding.

In the University of Applied Science (UAS) sector, a two-stage reform began in 2011, about 20 years after the establishment of UAS sector, and culminated in 2015 in a new Polytechnics Act. The universities of applied sciences have become independent not-for-profit limited companies, and the responsibility for their institutional funding has been transferred from local authorities to the national level. Since 2014, a performance-based funding formula has also been implemented for the UAS, based on indicators such as the share of completed degrees and credits, as well as R&D, and for local and regional needs. The original performance-based funding model for UAS was updated by the Ministry in 2017 and 2021 (MEC, 2021).

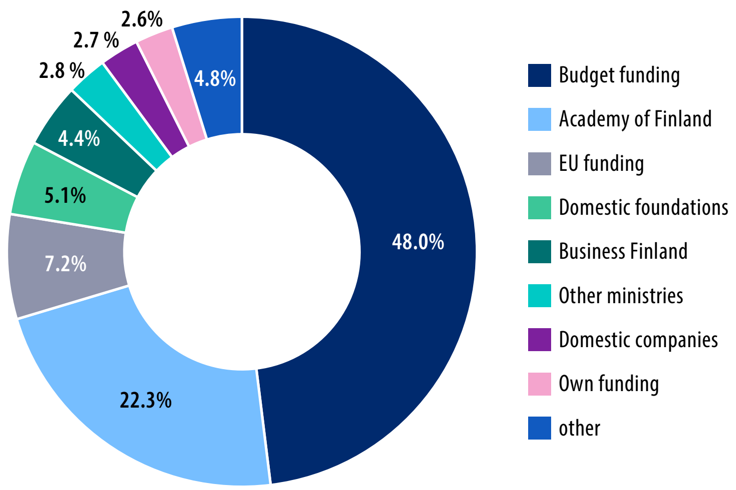
Between 2009 and 2018, the number of higher education institutions (HEI) declined from 48 to 37 through mergers. The number of universities went down from 20 to 13 (with four new universities), while the number of UAS declined from 28 to 24 (Wennberg et al., 2018), XAMK (Kymenlaakso and Mikkeli UAS) being the most recent merger in the UAS sector and University of Tampere (University of Tampere and Tampere University of Technology) in the university sector. The pressure for further consolidation is likely to continue in the UAS sector to guarantee better quality and cost effectiveness and to offer students greater opportunities for diverse studies. So far, the structural reform has been based on the institutions' own plans.

With the Profiling programme, the Academy of Finland became directly involved in the implementation of the reform process, as a small proportion of institutional funding for universities is now provided via a competitive funding procedure of the Academy.

2.4.2 Funding

In 2020, the overall R&D expenditure of Finnish universities was €1,391.9m. The following figure provides the breakdown of its funding sources (excl. Universities of Applied Sciences, for which the respective volume was €291.3m), according to Statistics Finland.

Figure 7. R&D expenditure of Finnish universities by source of funding in 2019

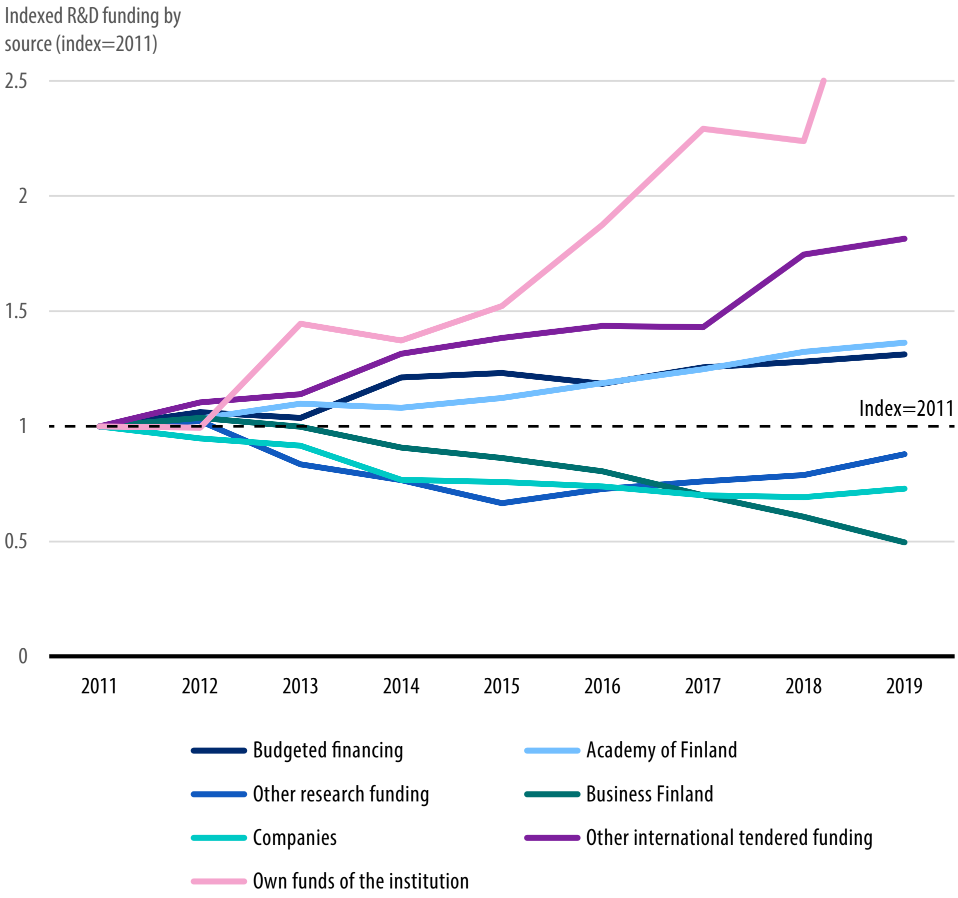


Source: Statistics Finland

In 2019, the top funding sources of Finnish university R&D expenditure were: 1) Ministry of Education budget funding to universities (i.e. estimated share of R&D expenditure in the overall budget funding of universities) €673.3m; 2) Academy of Finland €331.5m; 3) European Union €94.6m; 4) Domestic foundations €68.9m; and 5) Business Finland €64m. Funding from the Academy of Finland represented 24% of their overall R&D expenditures.

Between 2011 and 2019, the R&D funding for universities grew from € 1.19 billion in 2011 to € 1.41 billion in 2019, representing an annual growth rate of 1.9% in current money. Academy of Finland funding has consistently been the second largest source of funding and has increased at a comparable pace as budget funding. Figure 8 shows the evolution of different funding sources since 2011.

Figure 8. Development share of R&D funding by source (in current money)



Source: Vipunen (2021)

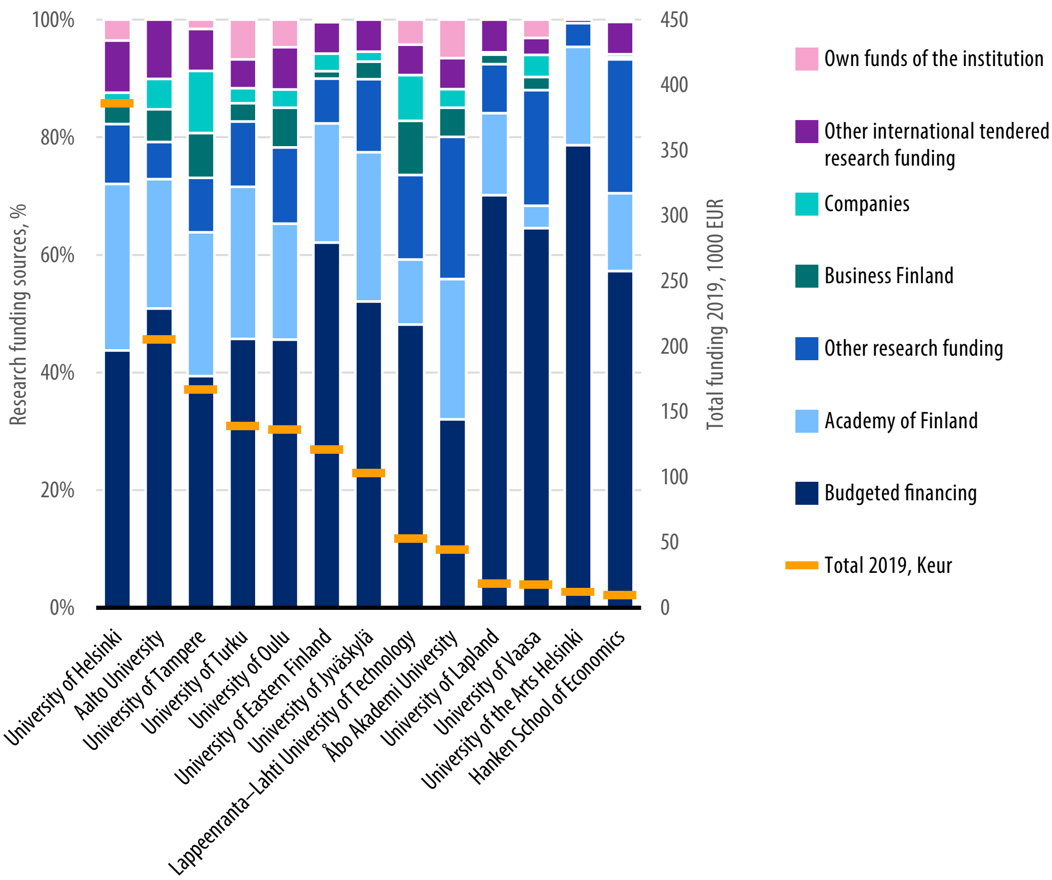
Although still accounting for a relatively small share of 3% in the overall R&D funding of universities, *'own funds of the institutions' and 'other international tendered funding'* have seen a considerable growth over the timeframe 2011–2019, due to the legislative change in 2010 that allowed universities to hold capital and make investments.

Over the period 2011-2019, the R&D funding coming from Business Finland has halved and the funding coming from companies and 'other research funding' for R&D at universities decreased as well, so there has been little progress towards the goal of diversifying university income sources.

The UAS have acquired considerably more funding from ERDF, ESF and other European structural financing (15%, not including the framework programmes) than the 1.1% that is obtained from this funding source by the research universities. Although the UAS indicated that Business Finland was more important to them than the Academy of Finland, the Business Finland funding accounted in 2019 only for 1.3% of R&D funding of the UAS, considerably less than the 5% of R&D funding received by the research universities.

R&D funding allocated to universities is strongly concentrated at a few institutions. In 2019, the top three recipients of total R&D funding were the University of Helsinki (which received 27% of the total R&D funding), Aalto University (15%), and Tampere University (12%). The remaining 10 universities received 10% or less of total R&D funding in Finland. Academy funding is more distributed across institutions. Figure 9 shows from which sources the 13 universities acquire their R&D funding.

Figure 9. University R&D funding by source and university, 2019



Source: Vipunen (2021). Note: universities are ordered by total R&D funding received in 2019

External funding accounted for around 35-61% of the research funding in the higher education sector, being the highest in life sciences and engineering, and the lowest in arts and humanities. Enterprise funding represented 8-9%, being the highest in the same sectors.

Universities with very low research intensity mainly depend on budgeted financing. For the five most research-intensive universities, the share of institutional funding remains below or about 50%. The share of Academy funding varies between 20% (University of Oulu) and 28% (University of Helsinki) in this group.

In 2019, among the Finnish universities, the largest research expenditure volumes funded by the Academy of Finland are in: 1) the University of Helsinki €109.3m; 2) Aalto University €45.1m; 3) University of Tampere €40.7m; 4) University of Turku €35.9m; and 5) University of Oulu €26.8m. This ranking is the same as in overall R&D expenditure. The respective collective volume of the Universities of Applied Sciences was €0.9m.[5]

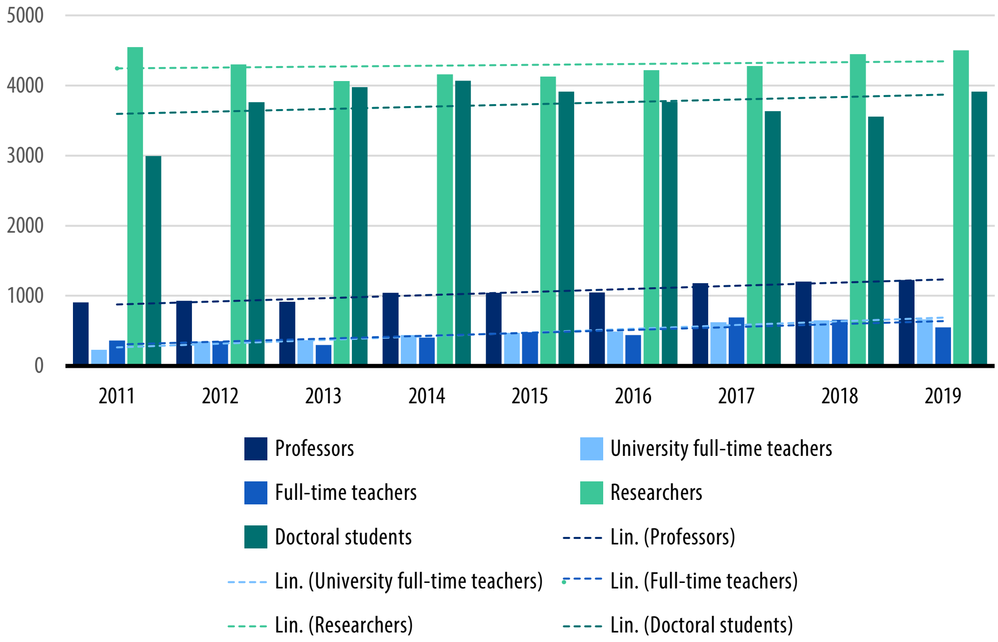
Since the university reform in 2010, the funding received by universities from the Academy of Finland has increased steadily (Figure 5), although the Academy funding has grown more slowly than the number of R&D personnel.

Between 2010 and 2019 the increase in R&D personnel has been biggest at the University of Helsinki, from 5,333 in 2010 to 6,217 in 2019. In other universities the amount of R&D personnel has either stayed at the same level or slightly decreased. Despite the quite noticeable increase in the funding from the Academy received by Aalto, its number of R&D personnel declined by over 100 researchers between 2010 and 2019.

5 Compared to universities, the universities of applied sciences (UAS) benefit little from Academy funding, which is explained by their overall scientific performance, as for instance the publication output of all 22 universities of applied sciences produced in 2014–2017 was about 600 publications (fractional counting), while the corresponding number for universities is over 30,000.

Figure 10 presents the evolution of personnel per category, it shows that the number of research positions has remained constant whereas teaching positions have grown.

Figure 10. Development of staff by position



Source: Vipunen (2021)

Interviews confirm the university sector's teaching capacity has been rising while its research capacity has grown to a smaller degree. This tension also reflects competing policy priorities for the HE-sector, with some emphasising regionalisation policies and others profiling and internationalisation. Increased differences between universities have a potential to concentrate competences and resources, but also challenge the broader perception of basic research as driver of prosperity.

2.5 Government research institutes

A total of **12 government research institutes** operate under the auspices of the several ministries, following mergers among the previous 20 institutes, and the transfer of some activities to universities. In addition to producing research data and expertise, the government research institutes perform various expert, control, training, guidance, and other official tasks as well as service activities, some of which are subject to a fee. The government research institutes are

- Geological Survey of Finland
- Finnish Meteorological Institute
- Natural Resources Institute Finland
- National Land Survey of Finland
- Finnish Food Authority
- Finnish Environment Institute
- Radiation and Nuclear Safety Authority
- Technical Research Centre of Finland VTT
- National Institute for Health and Welfare
- Finnish Institute of Occupational Health
- Finnish Institute of International Affairs
- VATT Institute for Economic Research

Due to the government decisions and partly due to the reform, the institutional funding of government research institutes decreased from €295.2m in 2013 to €185.8m in 2018 (Haila et al., 2018) (see also Figure 4). Their total funding decreased from almost €600m to approximately €400m. In 2020, the funding of research institutes was €193.8m, and the total R&D funding of research institutes was €463.7m. On average, the share of external funding was 58.2%. The share of external funding varied from 6.3% (Radiation and Nuclear Safety Authority) to 67.1% (Technical Research Centre of Finland VTT)(Statistics Finland, 2020). The Academy of Finland's funding to research institutes has slightly increased.

Most of the institutes are government labs. The VTT Research Centre of Finland Ltd is a research and technology organisation (RTO) that supports industrial innovation and is the largest of the institutes. In 2020, the total R&D funding of VTT was €243m, of which €80m was institutional funding (ibid.). Alongside these reforms, VTT strengthened its role in research and innovation that aims to respond to social, economic, and other grand challenges (Hjelt et al., 2018).

2.6 Research and innovation funding organisations in Finland

This section presents other research and innovation funding organisations, next to the Academy of Finland. Since Tekes was set up in 1983, Finland has relied primarily on two R&I funding agencies to provide competitive funding: The Academy of Finland, and Tekes, which was merged into Business Finland in 2018. Historically, while relations have been cordial, these agencies have had few shared activities. They ran some parallel fundamental and applied programmes in areas of industrial relevance particularly in the late 1990s, at the time of a special appropriation for government R&D. More recently, they together operated the now defunct FiDiPro Finnish Distinguished Professor scheme to attract foreign professors to Finland on a part-time basis. Beyond this, there has been little programme-based cooperation between them.

One of the key changes in the R&I system over the past couple of years has been the merger of Finnish Funding Agency for Technology and Innovation Tekes and Finnish Export Promotion Agency Finpro into Business Finland in the beginning of 2018. The aim was to clarify and simplify the enterprise service system, internationalise the innovation system, and strengthen the exports and internationalisation of SMEs. The recent evaluation focused on organisational efficiency and effectiveness and did not deal with the issues raised by the cuts to R&D funding (Halme et al 2021). The merger process has been going on since 2018 and the current operating model was launched only in January 2021. The objective of Business Finland is to enhance the renewal, growth, and internationalisation of Finnish enterprises. A big part of that task is dedicated to promoting and supporting advancement of research, development, and innovation, not only in enterprises.[6] It offers a range of support instruments that is familiar from other innovation agencies. This includes instruments to help research organisations commercialise their research results (i.e. Innovation Scout, TUTLI), and funding for research and innovation based on academic industrial cooperation (i.e. Strategic Research Openings, EVET network R&D, Technology programmes for networks, Co-innovation, or Co-creation)

The Finnish Innovation Fund – Sitra is a national fund directly accountable to the Finnish Parliament. Sitra can fund research to support its strategy, programmes, and initiatives. During 2018–2019, the overall role of Sitra fund was under political debate and some adjustments were made in 2019. Sitra typicaly tests and demonstrates new policies and instruments, rather than operating funding programmes at scale.

6 Business Finland's R&I-related instruments are described in more detail in Appendix G. It also has an extensive range of business and trade support instruments, not discussed here.

In 2020, the State Development Company (VAKE) was transformed into The Finnish Climate Fund (Ilmastorahasto, IR) and moved to the Ministry of Economy Affairs and Employment (Halme & Salminen ,2020).

The Finnish government's analysis, assessment, and research programme (VN TEAS) is commissioned and coordinated by the Prime Minister's Office and supports government decision making. Many of the challenges facing society are highly complex and affect different branches of government. To respond to these challenges, it is necessary to transcend administrative boundaries and generate research, foresight and assessment data that will effectively serve the needs of the entire spectrum of activities.

PMO prepares an annual plan for research, which steers the studies and research selected by the Government towards specific priority areas that are relevant to the work of the Government and the ministries. The research subjects are clearly linked to the information needs and topics in the Government's decision-making processes. Part of the appropriations are reserved for urgent analysis and research needs for policy decisions that may arise at a later stage. The annual funding volume of VN TEAS for 2021 is around € 10 m.

According to the Association of Finnish Foundations, the private foundations provide about €245m in research and science funding per year. The largest foundations give out about €30m per year. The funding is typically in the form of individual tax-free grants. Most of their grants are for Ph.D students for a period of 1–2 years. In recent years the foundations have increased their funding for postdocs and even for infrastructure. The Academy maintains a continuous discussion with the foundations, and there are some excellent examples of joint funding for Academy programmes. Nonetheless, the role of private foundations is in Finland clearly smaller than in Sweden or in Denmark.

Competition for international R&D investment has contributed to the spread of various R&D tax subsidies. At the beginning of 2020, all EU member states, except Finland, Estonia, and Luxembourg, had corporate R&D tax subsidies in place. At the beginning of 2021, a fixed R&D tax incentive was also introduced in Finland for the years 2021–2025, providing credits of 1.5 times the cost to the companies of co-operation with research organisations. The limited size and scope of this exemption was criticised even before its introduction. Hence, in 2021 the parliamentary working group proposed an extension to the duration until 2027, as well as an increase to its ceiling to 150 per cent, resulting in a change in the law from January 2022.

3 The Academy: role, strategy, and operations

This chapter begins by explaining the importance of the Academy's role as the national funder for 'bottom-up', investigator-initiated research and places this in the context of wider developments that are broadening the scope of action for R&I funders collectively. It sketches a short history of developments at the Academy and discusses recent reforms, including changes to the administrative structure intended to standardise processes, where appropriate, and increase efficiency, as well as recent changes in strategy. Finally, it explores the Academy's operating costs and compares them with the funding budget, showing a significant increase in efficiency, with rising funding budgets and falling operating costs.

3.1 Why Finland needs the Academy

Both investigator-initiated and thematic research are needed in any effective national innovation system: thematic research to solve problems that society identifies and prioritises; investigator-initiated research to provide unexpected opportunities and solutions to problems that we cannot specify well from the outset. Investigator-initiated research includes both 'blue skies' or 'curiosity-driven' research and research like that of Pasteur, is fundamental but nonetheless aims eventually to be of practical use (Stokes, 1997).

It follows that a funder like the Academy of Finland is essential in all countries, and its importance increases over time as production and consumption become increasingly knowledge based:

- It enables the production of 'basic' research on topics chosen by the researchers, which cannot necessarily be predicted by potential users of the research results
- By providing an arena where researchers and research proposals compete, it sets a high standard for research quality – not only for the funding it provides, but it also sets a standard against which research-performing organisations judge quality, and therefore tends to quality-assure the national research effort

- It is legitimate in the eyes of the research community because funding decisions are taken via peer review by members of that community, free from any other influence (such as national thematic priorities, or politics) and therefore helps maintain academic freedom

Significant research literature dating back to the 1960s in both science policy and economics provide evidence about the economic impacts of basic as well as more applied research. Useful reviews and summaries include (Martin & Tang, 2007) (Hall, et al., 2010) (Becker, 2015) (David, et al., 2000).

Nelson/Arrow market failure is the economic reason why governments fund fundamental research with high levels of subsidy, and innovation with lower levels (Nelson, 1959) (Arrow, 1962). This market failure is the problem that it is difficult and risky for firms to do, appropriate and exploit the results of fundamental research. Rather, these results easily spill over to society (often over long periods of time). Because capitalists cannot appropriate the results of basic research, they tend – with rare exceptions (Rosenberg, 1990) – not to fund it. Instead, the state pays, and reaps huge social returns, often over long periods, as is easily illustrated by the long time between discoveries and Nobel Prizes. The more specific and applicable knowledge is, the easier it becomes to appropriate it and, usually, the shorter the time-to-market. Hence, governments subsidise innovation less than research.

While in the abstract word of economics the results of basic research are public goods, it is not possible to free ride on the fundamental research done in the rest of the world. Understanding, choosing, and making use of the results of fundamental research requires people who themselves can do basic research, as well as specialised equipment and other resources (Callon, 1994). It also requires engagement by national researchers in international scientific communities – what Price (1963) called 'invisible colleges' – otherwise they can only see others' results when they are published, and they know nothing either about leading researchers' work in progress, or about how the research agenda is changing. Typically, therefore, developing countries increase their basic research effort when they move from technology catch-up to looking for ways to get ahead of competitors in the advanced countries. Correspondingly, advanced countries need to do enough basic research to stay at the forefront in research.

3.2 Third-generation R&I policy: new needs, international examples

Internationally, since the early 2000s, the thrust of R&I policy has been extended to tackle the so-called societal challenges – especially climate change – and the UN Sustainable Development Goals. Traditional R&I policies continue to be needed, but tackling the societal challenges also demands increased understanding of societal needs, bringing additional kinds of stakeholders into policy design and implementation, and ensuring not only that R&I are relevant but also that their results are implemented in society.

In the scientific literature on research policy (which, curiously, pays little attention to the long-established role of government-funded science in pursuing the missions of 'sector' ministries), this change in focus is discussed as a shift to 'third-generation policy. Since the Second World War, R&I policy is seen in terms of three governance generations:

- The first generation largely involved focusing on basic research, delegating the governance of science to the scientists and relying on the idea of 'science push' eventually generating innovations and other benefits in wider society

- The second generation was partly triggered by the OECD's invention of 'science policy' in the 1960s. Society assumed greater control of science, demanding a social return from science through innovation and economic growth, with the idea that 'demand pull' played a major role in the diffusion of the benefits of research

- The third generation aims to address major societal challenges, such as climate change, disease, and loss of biodiversity (Schot & Steinmuller, 2018) (Arnold, et al., 2018). This involves not only the R&I system but also wider society, which is involved in deciding what societal challenges to address as well as implementing the solutions, resulting in systemic changes (such as de-carbonising the electricity supply system)

These generations are best seen as sedimentary layers. Table 2 summarises key changes involved in transitioning into each of the generations.

The first generation started as a reaction to the role of science in the Second World War. Its manifesto is a report commissioned by President Eisenhower, *Science: The Endless Frontier* (Bush, 1945) but it is only one manifestation of the way the scientific community saw itself at the time, some of which Merton codified as "communism, universalism, disinterestedness, and organised scepticism," in which peer review as a mechanism both for quality control and exerting authority in the community was central (Merton, 1942). Polanyi later (1962) built on these ideas to describe the research community as a republic of science – a self-governing and self-regulating community, and a "model of a free society". Bush's proposal was that science should be governed by scientists and that this would nonetheless result in societal benefits – an idea that was systematically rejected across the US government, which wanted to keep 'mission' research firmly under its own control, but which ultimately triggered the creation of the National Science Foundation in 1951. NSF is, like other science foundations and research councils including the Academy of Finland, largely governed by members of the republic of science. The traditional view of such organisations is that the people who sit on their decision-making bodies are representatives of the research community, and that the community exerts its authority as well as quality control using peer review. This view co-exists with the governance perspective that would regard research councils simply as government agencies, and it helps account for the fact that the Academy regards peer review as its central, defining process. Peer review remains central, even where the Academy has been asked to absorb tasks that have something of a social character, such as the SRC or the Flagships.

Table 2. Characteristics of three R&I governance paradigm changes

Characteristics	First Generation	Second Generation	Third Generation
External driver of change	Growth and destructive power of science in WWII	Refocusing of state research on technology, innovation, and industrial growth	Societal challenges
Change in underlying theory	Development of linear model	Producer-user interactions; innovation systems	Interaction between technological change and socio-technical regimes
Change in scope	Focus on 'basic' research	Extends into applied research and innovation	Socio-technical transitions, missions
Change in power and governance	Blind delegation; researcher governance	'Science policy' in the OECD sense, with society (industry) increasingly influencing research	New actors and stakeholders beyond the R&I system
Change in organisations, institutions considered	Modern national science foundations, providing external funding (taking over from vertically integrated research councils and academies)	Innovation and 'sector' agencies, companies	Extension to more of the state, investment, organisations (including companies) involved in implementation
Change in directionality	Towards investigator-initiated basic research	Towards industrial innovation	Towards solving societal challenges
Type of 'failure' addressed by policy	Market failure	Systems failure	Transition failure

Source: Modified from (Arnold & Barker, forthcoming 2022)

During the first generation, funders like the Academy were largely 'aggregation machines' (Rip, 2000) that choose the best bottom-up proposals to fund, so that the pattern of funded projects reflects the shape of the existing academic community. Later, such funders took on a role as 'change agents', tending to the health and development of national science and the development of the research community, so the Academy has been funding centres of excellence, running thematic programmes to address weaknesses and new opportunities among disciplines and even helping shape university strategies through the profiling programme, in addition to its traditional role.

The second generation started in the 1960s, with the idea of 'science policy' (the idea that science should at least partly be under societal control to reach social objectives, notably innovation and economic development). It led eventually to the emergence of innovation agencies as new kinds of organisations and, in theory, to the idea of 'innovation systems'. In Finland, from the start of the 1980s, Tekes was overlaid as a technology and innovation agency, representing the second generation, while the Academy carried on with its first-generation work.

In second generation governance, a Finnish-style 'two pillar' system focused on the education and industry ministries and supported by a policy council at a high level in the government has to some degree emerged as a dominant design for R&I policy. There is no equivalent in third-generation governance. The second generation builds a balance between the education and industry spheres and injects other interests through the high-level council.

The third-generation problem is different because

- The scope of the system to be governed is bigger – not only research and innovation but also the societal need addressed, the demand side more broadly, wider societal interests and the rules, laws, and institutions of the socio-technical regime

- The boundary of the system to be governed has variable geometry – sustainable transport, for example, involves a different set of actors to biodiversity, circular economy, or the ageing of the population

- The activities involved stretch far beyond R&I to encompass implementation, and many of them are beyond the skills and power of the R&I communities

Third-generation governance involves not only a more societal focus in the objectives of research but also the involvement of new types of stakeholders, more policy experimentation and reflexivity. In some cases, addressing societal challenges is expected to involve changing between socio-technical systems, and therefore also involving the reconstruction of socio-technical 'regimes' – rules, institutions, infrastructures, skills, markets and more that are associated with the prevailing systems.

This has led to a search in many countries for organisational solutions for tackling them. Recently, triggered by the European Commission and proposals by Mazzucato (2018), there has been a flurry of interest in defining 'missions' – essentially building-blocks intended to contribute to socio-technical transitions – as a more tractable way to devise and implement programmes, especially for DG-RTD, whose remit is confined to research and innovation. Missions are categorised as either *transformers* that address sociotechnical changes or *accelerators*, which are essentially large-scale programmes addressing technical challenges and that could also be accommodated within the second generation. While the idea of missions is a creative response to the need to design and fund programmes small enough that they actually can be implemented, the reduction in scope focuses the effort on the R&I system and therefore creates a new set of coordination problems between the missions and the way wider society tackles socio-technical transitions.[7]

The scope of the system to be governed is bigger and has a variable boundary. This implies that there must be variety among third-generation governance systems. We may end up with a handful of dominant designs; it seems clear there will be more than one.

So far, there appear to be a variety of different models:

- Centre-of-government led models, such as the Japanese use of a large department within the Prime Minister's Office to set overall R&I policy and the associated budgets. This is done at a much more detailed level than has been done by the Finnish policy council, so the key programmes are defined by the Office
- Decentralised, umbrella organisations that set priorities for, and implement mission programmes
  - These can be public-private partnerships (PPPs), as in the Dutch Top Sectors, which now have responsibility for running mission programmes. PPPs have the strength of involving business actively in setting priorities,

7 The OECD has recently published an overview of mission-like policies among its member countries that surveys national attempts to modify existing instruments and create mission-like programmes. It offers principles for the design of mission programmes, but at the same time points out that there is so far no experience with real missions and largely uses (untested) principles from the socio-technical transitions literature to guide mission design (Larrue, 2021).

in ways that they are consistent with the strengths of business. They have the disadvantage that involving business in making decisions causes a principal/agent problem, so that government has to control them carefully, and that decisions tend to favour the short-term interests of industrial incumbents – which is not always desirable in transitional policy
  - The alternative is to build an umbrella within government structure, as the education and research ministry BMBF in Germany has done within the High-Tech Strategy, which now contains a portfolio of twelve missions, which is managed among the ministries but also uses agents to implement programmes and projects

- Single ministry design and management of a mission, such as the German Hydrogen strategy, which is designed and led by the industry and energy ministry BMWi. That ministry is responsible for both innovation and energy policy, and therefore has the reach to take the strategy through to implementation – for example, not only pointing out the need for a refuelling infrastructure if Hydrogen is to become the fuel of choice for long-distance trucking but also having the power to ensure that such a network is built

- Cross-agency programmes, as Norway has done with the Pilot-E programme, which is a collaboration between the research council (RCN), the innovation and business development agency (Innovation Norway) and Enova, which is the agency promoting energy efficiency. It supports the whole process of increasing energy efficiency from research to demonstration and demand stimulation

- Free-standing platforms, which can be large or small
  - The former Dutch Innovation Council, which was a free-standing PPP outside the government structures, reporting to the Prime Minister
  - The seventeen Swedish Strategic Innovation Programmes are PPP-based platforms funded by the innovation agency Vinnova, the Formas research council and the Swedish Energy Agency. They do research and innovation, in principle aiming to address societal challenges

The Academy so far essentially sticks to what it already does, building on peer review to fund research, but adding societal challenges in its mission statements and in the assessment criteria of funding applications. This does not allow the Academy alone to address societal challenges, which additionally require innovation and implementation activities. An option would be to develop broader strategic skills to be able to participate with others in programmes spanning research, innovation, and implementation, while still retaining the focus on peer-reviewed research. But this depends crucially on how Finnish R&I Policymakers choose to address the societal challenges overall.

3.3 History, governance, and organisational reforms

The Academy of Finland is a central body in the Finnish research and innovation system which offers competitive peer-reviewed research funding and contributes its science policy expertise to advance the quality and impact of scientific research, support the renewal of science and develop research environments in Finland. The Academy nominates up to sixteen leading Finnish and foreign scientists to be given the honorific title of Academician by the President of Finland. However, these academicians play no role in the Academy or its governance.

The Academy of Finland in its present form was founded in 1970. The research council system in Finland however is much older. The first Act regarding the so-called 'old' Academy of Finland was passed in January 1939, Research Councils were introduced in 1950. In 1969, a new organisational form was introduced; the new Academy's responsibilities included funding high quality research, coordinating research funding, and making science policy, starting its activities in 1970. In 1995, the number of Research councils was reduced from seven to four, the Research Council for Culture and Society, the Research Council for Natural Sciences and Engineering, the Research Council for Health and the Research Council for Environment and Natural Resources. The Central Board of Research Councils was replaced by the board of the Academy of Finland, which was led by the Academy's President.

According to the Act on the Academy of Finland,[8] the duties of the Academy shall be: 1) to foster scientific research and promote research framework conditions and the utilisation of research through the provision of funding and through international cooperation; (2) to serve as an expert organisation in science policy development and implementation; and (3) to carry out other expert tasks laid down in the Government decree or assigned to it by the Ministry of Education, Science and Culture.

8 Laki Suomen Akatemiasta, 20.11.2009/922, section 2 of the law has been amended in 6.4.2018 (213) and it concerns the task of the Academy.

Given the legal framework, there are three levels of steering of the Academy of Finland:

- The Academy of Finland, like all governmental agencies in Finland, is subject to so-called performance management, which is an agreement-based steering model aiming to find a balance between the available resources and the outcomes that can be achieved through them. Performance management is one of the Government's key steering and management systems, and it has a special link to both the Government programme implementation process and the budget process (Salminen, et al. 2021). The agreement contains performance targets and indicators typically in four categories, which are: societal impact; outputs and quality management; operational efficiency; management and development of human resources. In the performance agreements from 2017–2020 the structure of the agreement changes, and instead of the tasks, a somewhat broader mission of the Academy is presented. During 2017–2019 it remains the same and underlines raising the quality and effectiveness of research, as well supporting the renewal of science

- The annual budget is based on the performance agreements but additionally involves the Ministry of Finance

- As stated both in interviews and the self-evaluation report of the Academy, "In the steering relationship the role of informal discussions is important. The staff of the Academy participate in many working groups appointed by the Ministry of Education and Culture, and these provide useful platforms for discussion. The other direction is also used: the Ministry of Education and Culture is represented in some committees/working or expert groups nominated by the Academy (e.g. Research Infrastructure Committee, steering group for the State of Scientific Research)" (Academy of Finland, 2021a).

The Academy of Finland has been evaluated in 1992, 2004 and most recently in 2013 (Arnold et al., 2013). Since then, several reforms have been implemented and formalised in modifications to the Act on the Academy in 2014:

- The Strategic Research Council (SRC) and the Finnish Research Infrastructure Committee (FIRI Committee) were founded

- The Academy president and the chairs of the research councils are no longer members of the Board. The chairs of the councils, the SRC and the FIRI committee have the right to be present and to speak at the Board meetings

- The new Board members are still chosen by the government, but the Board has now five to seven outside members, the chairperson is selected among those and the President of the Academy is no longer a member. The President is responsible for the preparation and implementation of the matters handled by the Board. The chairs of the research councils, the SRC and the infrastructure committee have the right to be present and speak in the meetings of the board, but the Board does not make any funding decisions; funding decisions that are not taken by the Research Councils, e.g., academy professors, profiling, centres of excellence, are made by a subcommittee appointed by the Board. As a result of this, the Board meetings concentrate on strategic issues, not on individual funding decisions

Moreover, new instruments and related decision-making structures have been introduced:

- The four new instruments shall strengthen university profiling, provide infrastructure funding, and address societal challenges (Strategic Research Council projects) as well as to support high-quality research and increase the economic and societal impact emerging from the research (Flagships)

- The introduction of these new instruments has been accompanied by the establishment of two new decision-making bodies in 2014, namely the Strategic Research Council and the Infrastructure Committee, which are responsible for the Strategic Research funding and for infrastructure funding, respectively

- The FiDiPro scheme has been closed, but beyond this no other substantial instruments have been dropped by the Academy in the past decade

Based on these decisions and taking account of the more recent reduction of the number of Research Councils in 2018, the current chart of the decision-making bodies is presented in Figure 11.

Figure 11. Decision-making bodies of the Academy of Finland

Source: Academy of Finland

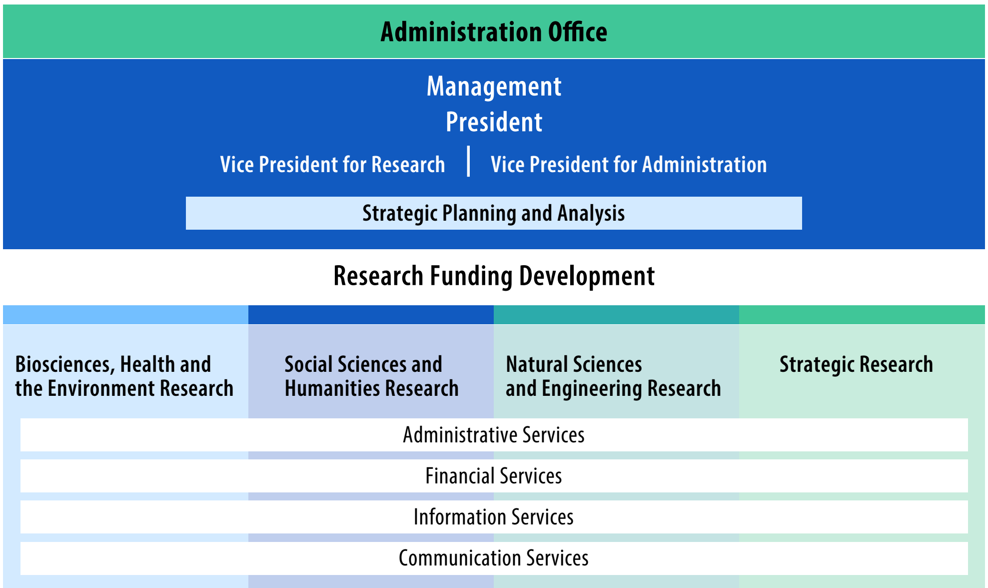
In 2018, the Academy established a Division of Research Funding Development to coordinate research funding processes. It has three tasks that combine staff functions and operational management: coordinating the research funding process and its internal development (funding calls, review process and decision-making); coordination of the Academy's international activities (funding collaboration and policy development); operating funding calls that fall within the domains of more than one research council.

The Division was intended to help standardise processes across Research Councils, for instance in preparing calls for proposals and developing proposal assessment processes. The Division's tasks include also coordination of international activities in the Academy, and the funding process for the Academy professorships, Academy programmes and PROFI. The Division runs centres of excellence programmes and the Flagship programme. In addition, it is responsible for operation of the research infrastructure committee and coordinates research infrastructure activities in the Academy. The reorganisation introduced a light matrix organisation by establishing a division of Research Funding Development which coordinates many processes that fall within the domains of more than one decision making body and more than one division of the administration office. At the same time, the number of Research Councils was reduced from four to three:

- Fusion of the Research Council of Biosciences and the Environment and Health to form the Research Council of Biosciences, Health, and the Environment

- Closing the units Planning and Management support and Academy Programme
- Creation of the divisions of Strategic planning and Analysis, and Research funding Development

Figure 12. The Administration chart of the Academy of Finland, as from 1.8.2018



Source: Academy of Finland

The establishment of transversal services and the creation of a strategic planning and analysis group strengthens the Academy and increases efficiency, given the current scope of activity and budget. In the longer run, if the Academy gets more deeply involved in third generation issues, the organisation will need to become less hierarchical and more flexible, with bigger departments in charge of new roles and activities, in particular in international affairs, science communication, and strategic analysis, monitoring and evaluation.

3.4 Strategy

In 2015, the Academy adopted a strategy, listing three fundamental criteria for research funding: quality (excellence), impact (including impact within science and impact in the rest of the society), and renewal (new topics, methods, and approaches to research). The strategy was updated in 2020, highlighting for the first time a thematic priority, namely climate change, as an example of a major challenge and emphasising the role of solving societal challenges in the funding provided by the Academy.

The change in strategy implied changes both at the level of the Academy programmes and in proposal assessment criteria. Earlier, Academy programmes were launched in response to suggestions from the research community and members of the research councils, based on agreement by the Academy Board. Under the new strategy, programmes are to relate to cross-council issues such as multidisciplinarity or to societal challenges such as climate change.

Proposal assessment criteria depend on the target of the instrument or programme and thus vary between calls for proposals. The proposal assessment criteria and policies of the funding instruments common to the three councils are the same and are published in each call. The policies for the funding decisions, however, can vary between councils. The key change under the revised strategy is that the importance of impact in society has been increased and can be used as a 'tie-breaker' between different proposals that achieve the same score in the quality assessment process. The Department of Research Funding Development is expected to align the criteria more closely across he whole of the Academy. The continuing use of a single aggregate score for each proposal in the assessment process means that the relative weighting of the assessment criteria is not explicit. International experience is that, without an explicit weighting or process for handling new relevance criteria in research council assessment processes, their effects are unstable and can vary among people, panels, and disciplines.

The list of special measures in the planning period includes "*Continuous focus funding on research related to climate change and other similar issues of major importance.*" This objective is not exclusively translated into new thematic programmes. Analysis by the Academy identifying climate relevant research conducted with bottom-up funding suggests that, based on keywords and publication analysis, about 20% of overall Academy funding relates to climate, and of these 20%, only 5% are funded in thematic programmes.

Further dimensions of strategy definition are the Academy of Finland's international policy for 2017–2021 in 2017 (see section 4.1 and the discussion of impacts in section 5.3), and infrastructure (see section 5.4.4), both defined in line with a broader national strategy and roadmap.

3.5 Budget

The budget managed by the Academy of Finland has increased by 47% (in current terms) during the last decade, from €282m in 2012 to €417m in 2021.

Table 3. Development of the Academy of Finland's budget authority in 2012–2021

Academy budget authority, €m	2012	2013	2014	2015	2016	2017	2018	2019	2020A	2020B	2021
Budget authority	282	303	280	319	338	348	343	368	347	438	361
Budget authority for strategic research				56	56	56	56	56	56	56	56
Total budget authority	282	303	280	374	394	404	399	424	403	494	417

Source: Academy of Finland

* 2020A: excluding the supplementary budget; 2020B: including the budget authority from the supplementary budget.

Chapter 4 explains how the budget has been used. This section concentrates on the operating expenses, which, in contrast, have declined over the same period, despite the reforms presented above and an increase in the number of applications from 3,700 in 2012 to 4,451 in 2019 and 5,127 in 2020. Table 4 gives an overview of operating expenses, also showing the budget for the SRC, that is hosted by the Academy, but is not part of it. Over the period, the proportion of total administrative cost to total budget authority (including the SRC) has fallen from 4.5% in 2012 to 2.9% in 2021, indicating a very significant increase in administrative efficiency.

Table 4. Comparable time series of Academy of Finland's appropriations for operating expenditure 2012–2021

Appropriations for operating expenses €k	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Item 29.40.01	12,806	12,455	12,305	13,423[A]	12,871	12,081	11,605	11,542	10,802[B]	11,972[B]
SRC proportion (2015 →)[C]				1,512	1,512	1,512	1,512	1,512	1,512	1,512
Excl. SRC proportion (2015 →)	12,806	12,455	12,305	11,911	11,359	10,569	10,093	10,030	9,290	10,460
Programme coordinationD										800
Operating expense appropriations excl. SRC, programme coordination and one-off cuts	12,806	12,455	12,305	11,911	11,359	10,569	10,093	10,030	9,290	9,660

Source: Academy of Finland

added to the 2015 appropriations. The level of appropriations was €10.423m.

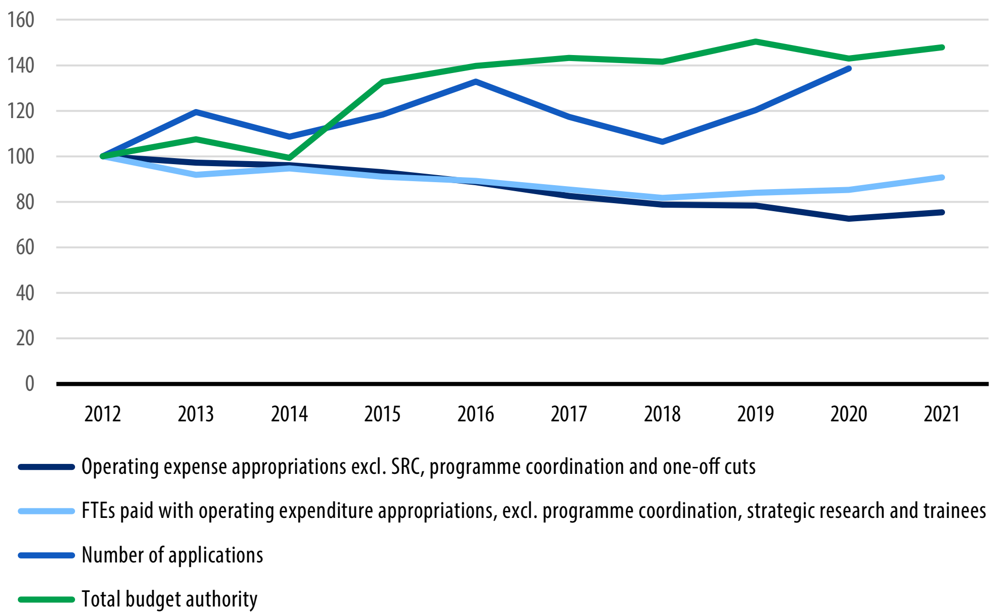
B The figures include a cut of €700,000 and a cut of €729,000 due to the level of carryovers.

C As the administration of the Strategic Research Council was only assigned to the Academy in 2015, its proportion €1,512,000 is deducted as of 2015. This allows for an examination of the development of the other proportion of the Academy's operating expenses. The administration expenses related to the funding of strategic research have accounted for 2.5% (2019) of the funding granted, that is, approximately €1,390,000, excluding overheads. With overheads included, the sum is greater than the reduction of €1,512,000.

D Until 2020, the costs of programme coordination were paid up from the research appropriations. In order to ensure comparability, their proportion, €800,000, have been deducted from the operating expenditure appropriations for 2021.

Figure 13 again refers to data provided by the Academy and compares selected indicators over the last decade (2012=100). While operating expenses and the number of full-time equivalent (FTE) members of staff declined, the number of applications and the overall budget increased considerably. According to the Academy, the staff numbers for 2020 and 2021 show the impact of both the scarce appropriations of previous years and the supplementary budgets for 2020. FTEs paid with operating expenditure appropriations, excl. programme coordination, strategic research and trainees reduced from 129,4 in 2012 to 110 in 2020, and saw an increase in 2021 to 117, as "In 2020, additional staff had to be recruited in order to implement the funding calls of the supplementary budget within the given timeframe. In addition, tasks had to be postponed from 2020 to 2021".

Figure 13. Evolution of budget authority, operating expenses, Academy staff (FTE) and number of applications, 2012 (=100) to 2021



Source: Data: Academy of Finland. Calculation and presentation: Technopolis

The Academy of Finland's operating expenses were already exceptionally low compared to the amount of grant funding it provided at the beginning of the period. Table 5 shows the Academy operating expenses as a percentage of the total funding volume for the Academy and some comparable research councils. The Academy's figure is 2.8% in 2021. In comparable small open and research-based economies this share varies between 3,4% (DRNF, Denmark) and 6% (NO, Netherlands).

Table 5. Percentage of expenses in research funding agencies' total research funding volume

	2018	2019
Academy of Finland	2.3/2.8%	2.3/2.8%
Danish National Research Foundation (DNRF, Denmark)	3.2%	3.4%
Austrian Science Fund (FWF, Austria)	3.8%	4%
Research Foundation – Flanders (FWO, Belgium)	3.8%	4.2%
National Fund for Scientific Research (FNRS, Belgium)	5.3%	5.6%
Swedish Research Council (VR, Sweden)	5.1%	5.6%
Dutch Research Council (NWO, Netherlands)	6%	6%

Source: Academy of Finland, based on annual reports and information from the organisations listed

This clearly reflects increased process efficiencies and the changed organisation internally to the Academy. However, the low level of operating costs in the Academy also means that there is little or no scope to add further activities without also adding cost. The present budget therefore effectively forbids needed improvements such as broader communication with the public and societal stakeholders, experimentation with new assessment approaches and means for the Academy to contribute to tackling societal challenges or increasing Finnish participation in international research communities.

4 Operation: instruments and processes

This Chapter describes the Academy's instrument portfolio used and shows trends over time. It discusses the use of different instrument types, and shows which organisations benefit from them. It discusses proposal success rates, which in general are troublingly low, and the gender balance among beneficiaries, which largely reflects the gender balance in the research community more widely. It describes the Academy's funding processes, finding that they are consistent with the generality of international practice and explains the Academy's internationalisation activities, which are becoming more efficient but could become more effective.

4.1 The Academy's funding instruments

The funding instruments at the Academy broadly divide into three main categories: bottom-up funding, thematic funding, and funding for centres and research environments.

'Bottom-up' funding includes most of the Academy's instruments that focus on traditional 'basic research', i.e. investigator-initiated or 'bottom-up'. This category includes several types of project funding and fellowships. These are the most long-standing of the Academy's instruments and altogether account for slightly more than half of the funding it awards. The funding instruments in this category are as follows:

- Academy Research Projects are designed to promote the quality and diversity of research, scientific impact, and impact beyond academia as well as the renewal of science. The aim is to attain internationally as high a scientific standard of work as possible and to support scientific breakthroughs and top-tier international research collaboration. This instrument is by far the largest in the portfolio and accounts for over 28% of the funding the Academy awarded over the last 10 years

- Postdoctoral Researcher funding supports the most talented researchers who have recently completed their doctoral degree in developing the skills needed to take on demanding researcher or expert positions

- Academy Research Fellows work on research plans that have been assessed to be of a high scientific quality. They have built extensive research networks, and the funding allows Fellows to develop academic leadership skills and establish themselves as independent researchers in the international scientific community

- Academy Professors are internationally leading-edge researchers and recognised experts in their field who are expected to have great scientific impact in the scientific community and in society at large. They are also expected significantly to advance research and to develop creative research environments. Since the 2010 university reform, Academy professors (as well as Academy Research Fellows) are no longer employed directly by the Academy but by their university or their research institute. The time between calls has been increased to two years, and it is questioned whether this instrument creates an impact on research excellence or renewal, given that the beneficiaries would in any case be employed as professors at their universities

- Clinical Researcher: the Academy funds part-time research by physicians and other researchers engaged in clinical practice. The aim is to promote clinical research careers in cooperation with, for example, university hospitals, and to encourage medical doctors and other researchers working in clinical practice to engage in research

- In addition, there are also various elements of project funding associated with fellowship funding

In contrast to bottom-up funding, thematic funding instruments do not include any fellowship schemes and instead are all project-type awards. This category of funding instruments accounts for just over 22% of funding awarded in the last 10 years. All instruments include some form of pre-determined thematic focus. Critically, this category includes funding awarded by the Strategic Research Council (SRC). Instruments in this category are as follows:

- Strategic Research Council programmes (including programme Director Calls): the funding granted by the Strategic Research Council (SRC) is intended for extensive, multidisciplinary research consortia that carry out research with an emphasis on interaction and engagement with users and beneficiaries of research. The funding instrument for strategic research provides funding for long-term multidisciplinary research addressing challenges facing Finnish society. It also supports the regeneration and competitiveness of business and industry, the development of working life and the Finnish public sector and can also be used to support the provision of evidence for policy and to disseminate research results. The SRC also provides some matching funds for EU projects. This relatively small amount of investment is classed as 'other' rather than thematic funding in the Academy's data, but we note it here as it forms part of the SRC's remit and is distinct from the rest of the Academy

- In 2021, a mid-term review was conducted, covering the first four SRC programmes (URBAN, HEALTH, WORK & SECURITY), and three complementary reports: a self-evaluation, an evaluation of societal impact published in 2/2021, and the evaluation of scientific activities, published 6/2021. According to the second (Hjelt et al. 2021), the definition of the SRC themes based on an open consultation has been successful, and, so far, the outputs and outcomes of the SRC projects provide a wide range of possibilities for wider societal impact. For instance, research has been used in support of national strategies, programmes, legislative reforms, and policy development. Also, the interaction between researchers and knowledge users has been increased. The scientific evaluation underlined that the first four programmes were only three years long, which is very short and not so strategic. The duration has since been increased to 6 years. Three of the four programmes were considered particularly novel and successful, even though evaluators questioned whether all the reported scientific results were really attributable to these very short programmes

- Academy Programmes (including international collaboration and some special funding calls) are thematic, target-oriented and coordinated research programmes that cover a range of activities to support innovative, high quality and high-impact research and promote international and national research cooperation. The topics of Academy Programmes are often science driven. Based on open surveys, the Research Councils make joint or separate proposals to the board. During 2011–2014 the Board of the Academy prioritised the topics of grand challenges e.g. sustainable energy, Northern environment and climate, and ageing. Current examples include climate change and health, digital humanities, and critical materials in the circular economy. More recently, the focus has shifted to the renewal of research in addition to the focus on grand challenges. The Academy Board currently decides on the start-up and financial resources of new Academy Programmes, on the basis of open consultation and discussion with the research councils. Important new topics can also be identified by the Board. One part of the funding for new programmes RESILIENCE and Climate change and Carbon neutrality was allocated to the Academy of Finland by the Parliament. The funding for Academy programmes is granted for a minimum of four years. There are 15 Academy Programmes running in 2021. In 2021, a new type of the Academy program was adopted to enhance the impact of funding and the collaboration between stakeholders and researchers funded by different Academy instruments.

- Targeted Academy Research Projects, international joint programmes and calls:[9] Targeted Research projects are mainly used in bilateral or (increasingly) multilateral programmes and calls. Targeted research calls by Research Councils are in principle possible but are rarely implemented. Funding for this is earmarked, and specific rules are defined for each initiative based on the international agreements

- ICT Programme: The research, development and innovation programme ICT 2023 is jointly coordinated and funded by the Academy and Business Finland, with a view to further improving Finland's scientific expertise in computer science and promoting the extensive application of ICT. In the first 10 years, €100m has been spent, and at least €10m of the Academy's budget authority for 2020 will be used to further implement the ICT 2023 programme, partly provided in the framework of a bilateral programme with NIH and NSF (see section 4.8.2 below). Business Finland will not open a parallel call for business-related projects, but funding is available under this topic through BF's normal application process. A mid-term evaluation (Academy of Finland, 2020 a) indicated that Academy funding very well contributed to the programme goals. The evaluation panel identified internationalisation and the promotion of scientific quality, novelty, and the renewal of science as the key strengths in Academy's contribution. However, their contribution technology transfer to industry and promoting multistakeholder collaboration was weak

- Development Research (since 2018 the Academy Programme for Development Research): this instrument provides funding to multidisciplinary, problem-based research that targets global development issues, helps boost development in developing countries and makes good use of Finnish knowledge and expertise in the field. The aim is to help solve problems related to, for example, health, natural resources, the economy and education. The programme provides funding to four-year research projects.

9 See also section 4.1 on international collaboration and bilateral agreements.

The first seven research projects selected for the programme started in March 2018. Five more projects were selected in October 2018 thanks to additional funding from the Ministry for Foreign Affairs of Finland

In addition to project and fellowship awards, the Academy also provides **funding for centres and research environments**. This third main category of funding accounts for just under 23% of funding awarded over the last 10 years. Being aimed at strengthening entire institutions (or parts of institutions), individual award sizes in this category tend to be substantially larger than the fellowships or projects in the 'bottom-up' or 'thematic' categories of funding. Instruments in this category are as follows:

- **Strengthening university research profiles (PROFI):** In 2014, the Finnish Government decided to move €50m per year from the core funding of the universities to the Academy of Finland to strengthen the research profiles of the universities. To date, altogether €350m has been allocated to universities via PROFI funding, to speed up the strategic profiling of Finnish universities to improve the quality of research. The funding is intended for measures that strengthen the universities' strategic research fields and new initiatives. The instrument is used by universities, not individual researchers, and is open to all scientific, scholarly, and artistic disciplines. Its impact is discussed in chapter 5.4.3

- Centres of Excellence: the objective of the Academy of Finland's Centre of Excellence programmes is to create framework conditions for groups of research teams and to promote opportunities for scientific breakthrough. A Centre of Excellence is a research and training network that has a clearly defined set of research objectives and is run under a joint management. Centre of excellence proposals are investigator-initiated, and are important for longer term development of research groups. This instrument is highly competitive: the last call (2021) attracted a total of 184 letters of intent, of these, 34 applications were invited to the second call stage, and 11 selected for funding. While focusing on excellence, as other instruments, CoE now also include further criteria: as stated in the press release to the latest call: "*The decision-makers in particular examined that the research team applying for CoE status conducts excellent science and breakthrough research and contributes to scientific renewal. Emphasis was also placed on the possibilities of the team to rise to or stay at the international forefront in the field. Among the key selection criteria were also the impact of research beyond the scientific community and that the researchers and subjects of the CoE candidate can reinvigorate Finnish science.*" The last independent evaluation of this instrument dates back to 2008, when an impact evaluation of the CoE programmes for 2000-2005 and 2002-2007 was carried out (Hielt et al. 2009). Further to that a bibliometric impact analysis of the Academy of Finland's Centre of Excellence Programmes was published in Dec 2015, and all CoEs participating in the 2014–2019 CoE Programme conducted a self-assessment of their impact in their final report, which are summarised on the Academy's website.[10] These have little to say about specific impacts but tend to illustrate the roles of CoEs as enablers of potential impact

- Research Infrastructures: This instrument provides funding for the acquisition, establishment, upgrading or expansion of nationally significant research infrastructures. Research infrastructures refer to a reserve of instruments, equipment, information networks, databases, materials, and services enabling research at various stages. Research infrastructure funding is presented in more detail in chapter 5.4.4 on the new role of the Academy.

- The Flagship Programme supports high-quality research and aims to increase the economic and societal impact emerging from the research. The Finnish Flagships represent a mix of close cooperation with business and society, adaptability and a strong commitment from host organisations. The Flagships create future know-how and sustainable solutions to societal challenges and promote economic growth by, for example, developing new business opportunities. The Finnish Flagship Programme now comprises ten Flagships, whose host organisations include seven universities, five research institutes, Helsinki University Hospital, and the Finnish Red Cross Blood Service. Chapter 5.4.2 discusses expectations and impact of this instrument

- Special funding for RDI Partnership Networks was a unique call in 2020 to support and promote the networking of higher education institutions and government research institutes with the business sector to boost the societal impact of high-quality research. The actions may strengthen and deepen existing networks, or build and experiment with new collaborations, with a project budget varying between €100k and €600k and a total budget of €10m, and a funding period of 1.7.2020–31.12.2022

- Bilateral Mobility: With this funding opportunity, the Academy of Finland promotes the international interaction of Finnish researchers as well as the internationalisation of Finnish research environments. The mobility funding

10 https://www.aka.fi/en/research-funding/programmes-and-other-funding-schemes/finnish-centres-of-excellence/centre-of-excellence-programme-impact-through-research-funding/

call is implemented with India, Japan, China, Germany and Russia. Funding can be used for mobility from or to Finland. For some countries, funding is granted only in one direction

- EUI International Joint Call: €332k in grants to 12 researchers for research training at the European University Institute (EUI)

- IIASA: The Academy of Finland sponsors the participation of Finnish students and students enrolled in Finnish universities and research centres in the IIASA's Young Scientists Summer Programme (YSSP) and certain other events hosted by the IIASA. The Academy represents Finland's interests in the IIASA

- Finland Distinguished Professor Programme (no longer in operation): The 'Finland Distinguished Professor Programme' (FiDiPro) was a joint initiative of the Academy of Finland and the National Technology Agency [formerly Tekes, now Business Finland]. It responded to a call by the Finnish Council of State for public funding agencies to develop new methods and instruments to attract foreign researchers to Finland to work with a research group or groups. Grantees could so some teaching, but the main purpose was to transfer research capability.

The yearly overall funding budget is roughly distributed between programmes as follows:

- Approximately €200m goes to Academy project & programme funding for research groups, including Strategic research Council programmes and international joint calls

- € 60–70m is spent for fellowship funding, including mobility funding

- Approximately €100+m per year for funding for competence centres and research environments, including Centres of Excellence, Flagships, Profiling of universities and the research infrastructures calls

- The Finnish Research Infrastructure Committee (FIRI) has a total of € 18,5 m per year for the competitive funding calls. In addition, membership fees for 30 international research infrastructures amount to of € 21.5 m

- In 2020, the Academy allocated altogether about € 40m of extra funding for COVID–19 related research.

The table below lists the 20 funding tools described above, sorted by the total share of funding awarded for each tool over the 2011-2020 period.

Table 6. Academy of Finland Funding instruments – overview sorted by share of total funding awarded

Funding instrument	Instrument type	Total awarded grants 2011–2020	% share of total funding awarded 2011–2020*	Average award size
Pure bottom-up			**53.3%**	
Academy research projects	Project funding	2,324	28.1%	€445,093
Postdoctoral researcher	Fellowship	1,187	8.1%	€250,683
Project funding associated with fellowship funding	Fellowship	1,366	7.8%	€211,007
Academy research fellow	Fellowship	652	7.4%	€418,313
Academy professor	Fellowship funding	69	1.4%	€742,878
Clinical researcher	Fellowship funding	92	0.5%	€219,931
Thematic funding			**20.2%**	
Strategic Research Council programmes (including programme director calls)	Project funding (SRC)	387	8.4%	€800,586
Academy programmes (including international collaboration and some special funding calls)	Project funding	749	6.8%	€335,641
Targeted academy research projects, international joint programmes and calls	Project funding	612	4.4%	€263,462
ICT programme	Project funding	283	1.9%	€248,796
Development research (since 2018 the academy programme for development research)	Project funding	68	0.7%	€394,351
Centres and research environments			**22.7%**	
Strengthening university research profiles	Centres and research environments	64	8.1%	€4,685,823
Centres of Excellence	Centres and research environments	127	6.9%	€2,006,202
Research infrastructures	Centres and research environments	406	5.2%	€473,985
Flagships	Centres and research environments	27	2.2%	€2,944,444

Funding instrument	Instrument type	Total awarded grants 2011–2020	% share of total funding awarded 2011–2020*	Average award size
Special funding for RDI partnership networks	Centres and research environments	41	0.3%	€243,902
Other			**1.8%**	
Strategic Research Council matching funds for EU projects	Other funding (SRC)	448	0.6%	€50,444
Finland Distinguished Professor Programme	Previous funding instrument	22	0.5%	€863,636
Bilateral mobility funding, EUI and IIASA grants	Other funding	1,289	0.4%	€10,813
Miscellaneous other funding	Other funding	87	0.3%	€131,272

Source: Academy of Finland, Presentation: Technopolis

* Based on the total funding awarded 2011-2020 of € 3,687,687,689

4.2 Headline figures and trends over time

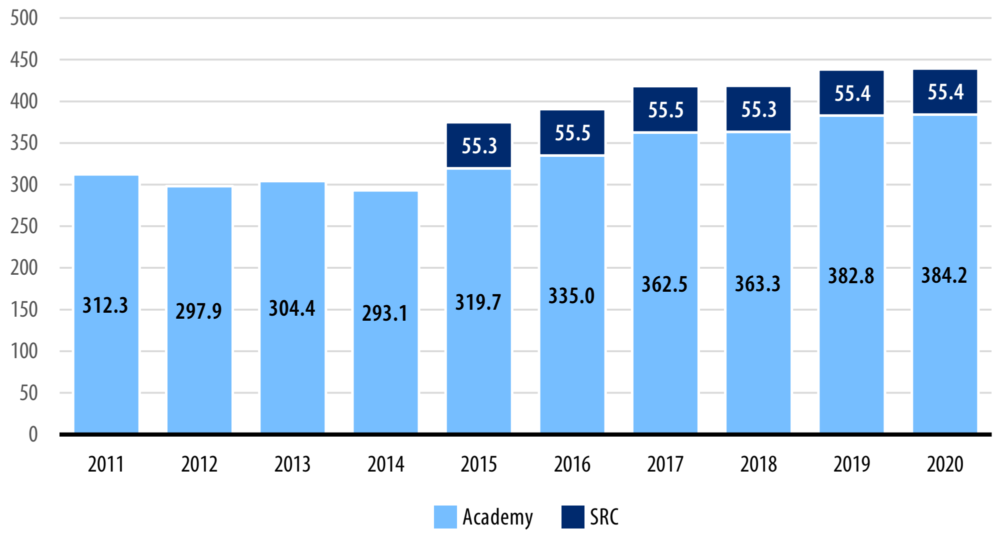
The Academy of Finland has awarded research funds totalling € 3.7 bn over the 2011-2020 period. However, the annual awarded funding has increased substantially over this time, from € 312 m in 2011 to € 440 m (excluding the additional Covid funding) in 2020, with a marked increase taking place since 2015. However, we note three caveats here:

- First, € 50 m of the universities' institutions funding was reallocated to Academy of Finland. This increase in Academy funding therefore does not constitute an increase in funding at a system level

- Second, from 2015, there is the inclusion of SRC funding, which constitutes the presence of additional instruments rather than enlargement of existing ones. We therefore flag SRC instruments as such in various parts of data presentation below, and show below the development of Academy funding overtime once as a total, and then with SRC funding separated

With these caveats the overall amount of Academy funding has only marginally increased over the 2011–2020 period.

Figure 14. Total funding awarded by the Academy 2011–2020, Academy funding and SRC, in current €m



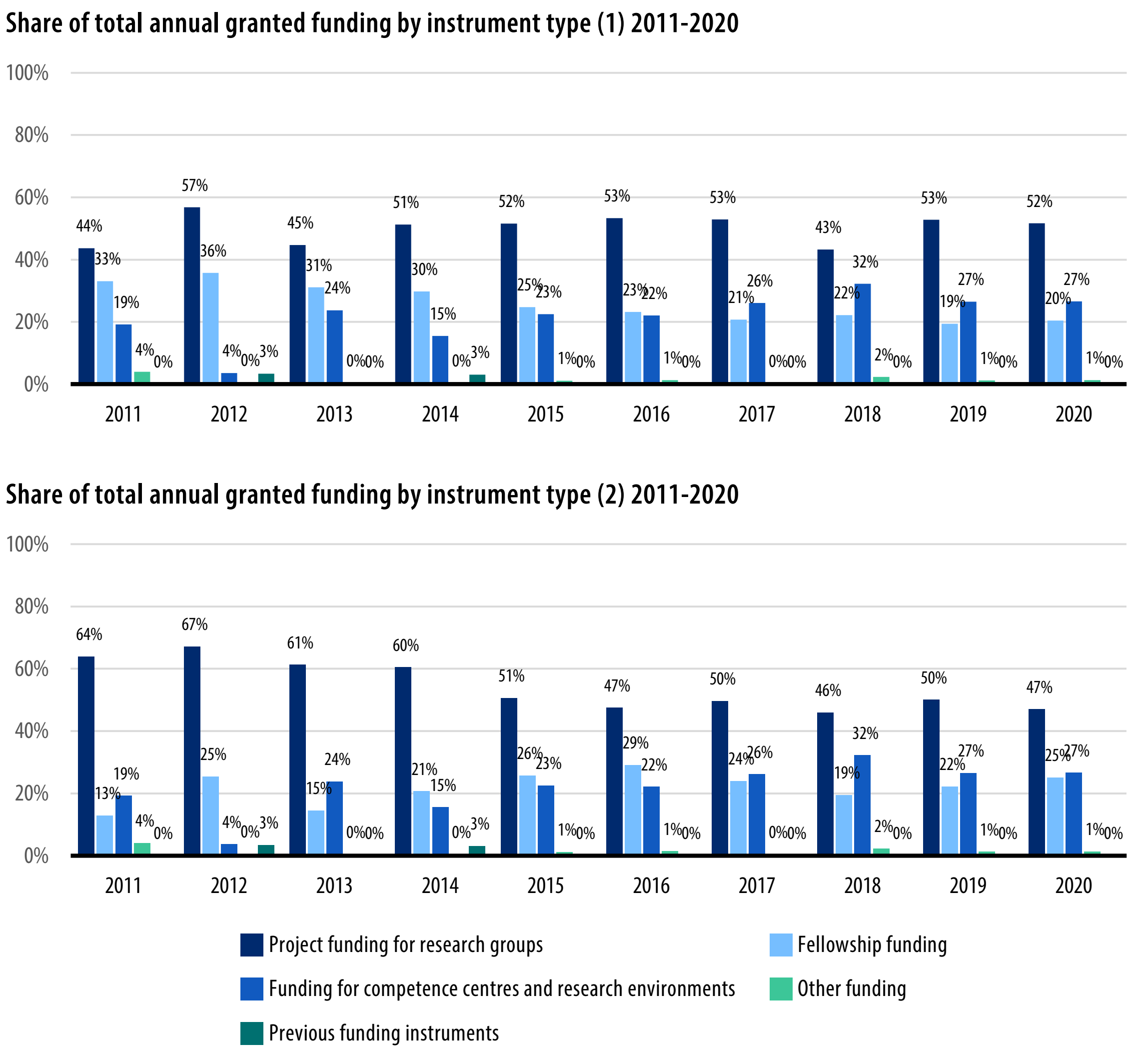
Source: Data: Academy of Finland, Presentation: Technopolis

4.3 Instrument types

This overall increase accounts for the fact that there appear to have been few de-facto budget decreases in any specific kind of funding over the ten-year period. However, if we consider the share of total annual funding committed to different types of instruments, some trends and shifting priorities become apparent:

- The share of pure bottom-up funding decreased substantially between 2014 and 2015, from around 60% of total annual funding awarded to just under 50%, and since then remained on a lower level
- The two growing priority areas in terms of budget share have been thematic funding and funding for centres and research environments
- Project funding for research groups has consistently accounted for around half of the Academy's awarded funding
- Fellowship funding has gradually decreased as a proportion of the Academy's investment, accounting for around 30% of awarded funding in 2011, decreasing to around 20% in 2020

Figure 15. Total funding by instrument type – trends over time



NB: 'competence centres and research environments' appears in both instrument classifications
Source: Data: Academy of Finland. Calculation and presentation. Technopolis

We note that newer instruments targeted to areas other than 'pure bottom-up' instruments have been organised in a way that leaves the traditional research councils and instruments largely intact – hence we stress that we describe here a shift in overall budget proportions going to different funding areas, rather than budget reductions as such.

4.4 Beneficiary organisations

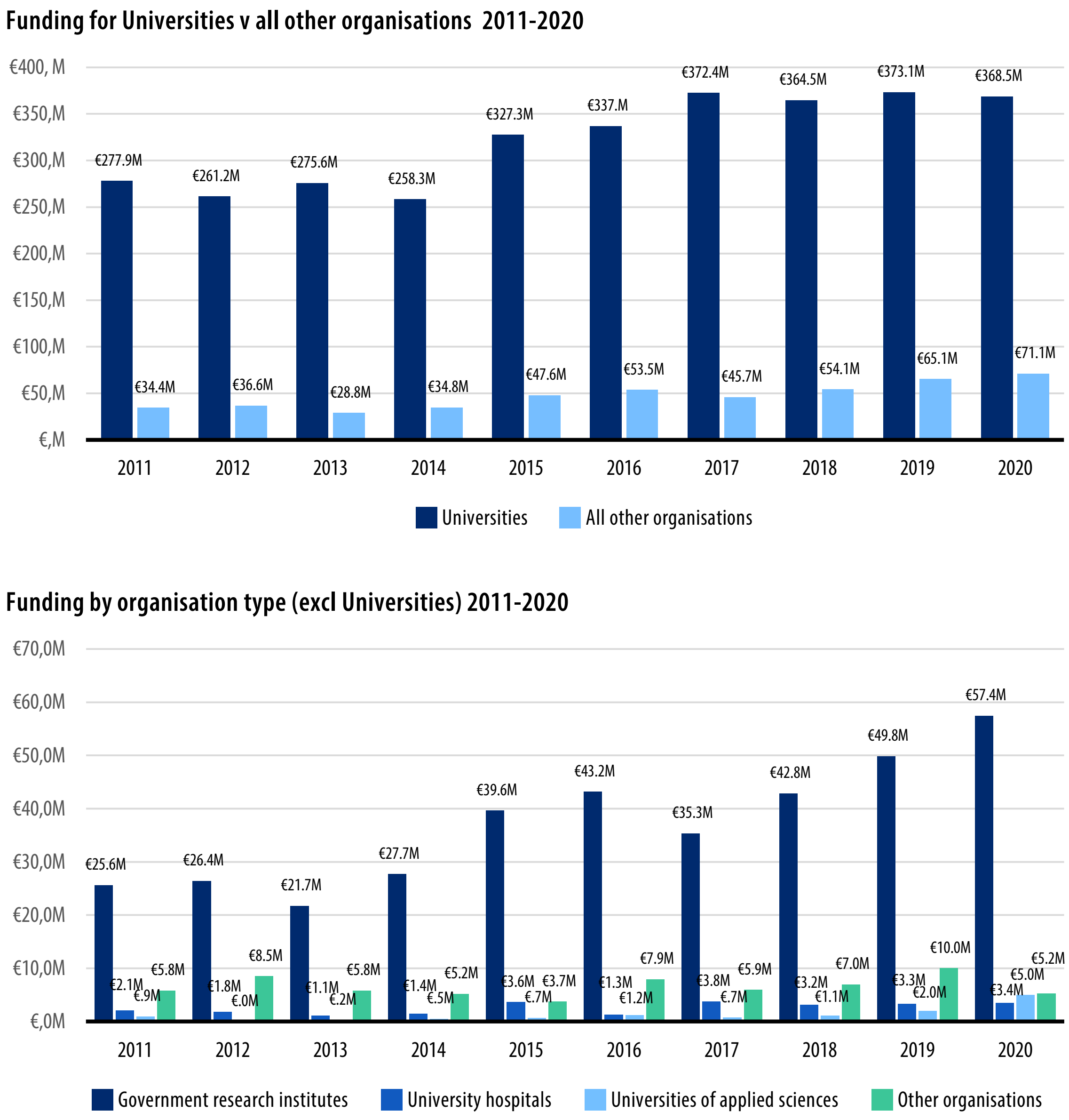
Alongside the shifts in terms of different types of funding instruments, there have also been some shifts in the beneficiary institution types. Universities account for the great majority of Academy funding awarded in the 2011-2020 period. However, the share of funding awarded to institutions other than universities – essentially, the research institute sector – has grown since the TULA funding reform and the creation of the SRC.

Institutions other than universities received 11% of total Academy funding in 2011, gradually rising to 16.2% in 2020. In monetary terms, this (over 50%) increase in share, combined with the overall increase in annually awarded funding by the Academy, means that the amount of money granted annually to these institutions has roughly doubled over the ten-year period. However, this increase far from compensates for their loss of institutional funding as a result of the TULA reform.

The great majority of the funding not going to universities has gone to government research institutes (with especially clear increases from 2015 onwards). VTT, in particular, has devoted significant effort to replacing some of the institutional research funding it lost with money from the Academy. Funding awarded to university hospitals and universities of applied sciences has also increased. In relation to the Academy's overall awarded funding, these latter two institution types account for only a negligible fraction of funding. However, the rate of increase here is especially strong: universities of applied sciences consistently received less than €1m in each year up to 2015, but almost €5m in 2020.[11]

11 This is partly explained by the founding of SRC and by the state budget temporary amendments directed towards networking of different types of research performing organisations. Peer review is used, but its emphasis is not solely on quality.

Figure 16. Funding by recipient institution type – trends over time



Source: Data: Academy of Finland, presentation: Technopolis

One conclusion of this is that universities have not been able to broaden their research funding base after the 2010 university reforms, rather the opposite, as the role of the State (University Institutional Funding + the Academy) has increased since 2010. As we pointed out in Chapter 2, the share of industry in the universities' research income has declined over the same period, presumably driven by the decline of BERD, the closure of the SHOKs and the large reductions in Tekes funding for applied and collaborative research, which would normally be expected to crowd in additional industry funding for the universities.

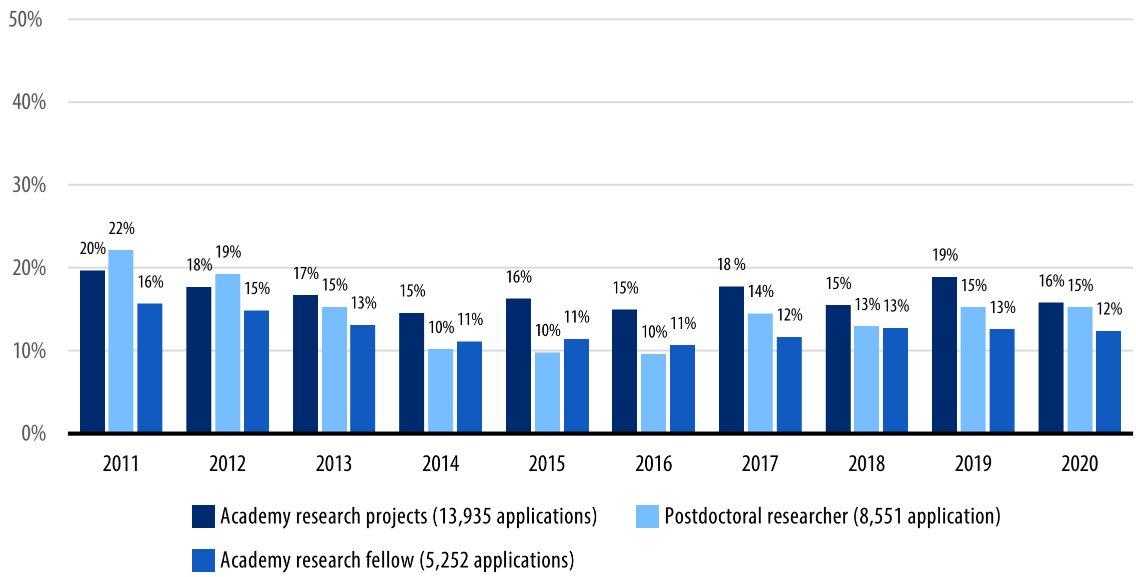
4.5 Success rates

The aggregate success rate for all the Academy's funding instruments combined (total awards vs. total full applications submitted) was 27%. Aside from a slight dip in 2014–17, this aggregate figure has been stable over the past decade. However, the aggregate hides a substantial amount of variation, especially by instrument type and field of research, as well as a serious issue with low success rates in the bottom-up funding instruments. They also include some instruments where applications are made by invitation only (which is typically linked to high success rates). Further, some instruments include an 'expression of interest' or similar pre-proposal phase. Rejected applications from such early stages are not included in the Academy's success rate data.

For further context, we provide below the application success rate figures over time for the three largest instruments by total number of applications received. Together, these account for 69% of all applications received, and together form almost the entirety of the pure 'bottom-up funding' category of the Academy's activities. None includes a two-stage application process, so the caveats noted above do not apply here.

We note that for all three instrument types, success rates dropped substantially to low points in 2014–16 and have risen since, though not to the levels of 2011.

Figure 17. Application success rates of the largest one-stage funding instruments, 2011–2020



Source: Data: Academy of Finland. Presentation: Technopolis

Table 7 shows the aggregate application success rate for the 2011–2020 period for each funding instrument, noting also where the success rate does not tell the 'whole story'.

For Academy Research Projects and the main fellowship instruments, the success rate is consistently (far) below 20% (as illustrated above), which is low in international comparison and broadly perceived as a problem. Academy research fellowships and postdoctoral fellowships (the two 'highest intake' fellowships) have the lowest success rate of any instruments at 12% and 14% respectively. According to panel feedback notes and interviews, this percentage is too low given the quality of research. By contrast, thematic funding programmes tend to have substantially higher success rates, since they address more-focused research communities. However, these almost always have pre-proposal stages which are not included in these figures. We also note that there is very little relationship between success rates and award sizes, i.e. small awards are often just as competitive, or even more so, than larger ones.

Table 7. Application numbers and success rates by instrument

Funding instrument (Sorted by % share of total funding granted for all instruments combined 2011-2020)	Total No. of applications 2011–2020	Total awarded grants 2011–2020	Total success rate 2011–2020	Average award size
Pure bottom-up funding				
Academy research projects	13935	2324	17%	€445,093
Postdoctoral researcher	8551	1187	14%	€250,683
Project funding associated with fellowship funding	1374	1366	99%**	€211,007
Academy research fellow	5252	652	12%	€418,313
Academy professor	250	69	28%*	€742,878
Clinical researcher	334	92	28%	€219,931
Thematic funding				
Strategic Research Council programmes (including programme director calls)	976	387	40%*	€800,586
Academy programmes (including international collaboration and some special funding calls)	2353	749	32%*	€335,641
Targeted academy research projects, international joint programmes and calls	1921	612	32%*, **	€263,462
ICT programme	1004	283	28%*	€248,796

Funding instrument (Sorted by % share of total funding granted for all instruments combined 2011-2020)	Total No. of applications 2011–2020	Total awarded grants 2011–2020	Total success rate 2011–2020	Average award size
Development research (since 2018 the academy programme for development research)	366	68	19%	€394,351
Centres and research environments				
Strengthening university research profiles	76	64	84%	€4,685,823
Centres of Excellence	264	127	48%*	€2,006,202
Research infrastructures	929	406	44%	€473,985
Flagships	115	27	23%	€2,944,444
Special funding for RDI partnership networks	217	41	19%	€243,902
Other				
Strategic Research Council matching funds for EU projects	453	448	99%	€50,444
Finland Distinguished Professor Programme	57	22	39%*	€863,636
Bilateral mobility funding, EUI and IIASA grants	1593	1289	81% **	€10,813
Miscellaneous other funding	88	87	99%	€131,272

* Instrument includes an EoI or similar 'first phase' application, which are not included in the success rate.

** Funding for some instruments is given by two separate decisions, where the second is by invitation only. Thus, the decisions in funding calls for second _part of the funding_ (e.g. Centres of Excellence, Strategic Research Council programmes) are based on the existing peer review and midterm review, and funding calls for research infrastructures may target infrastructures that already have been included in infrastructure roadmaps.

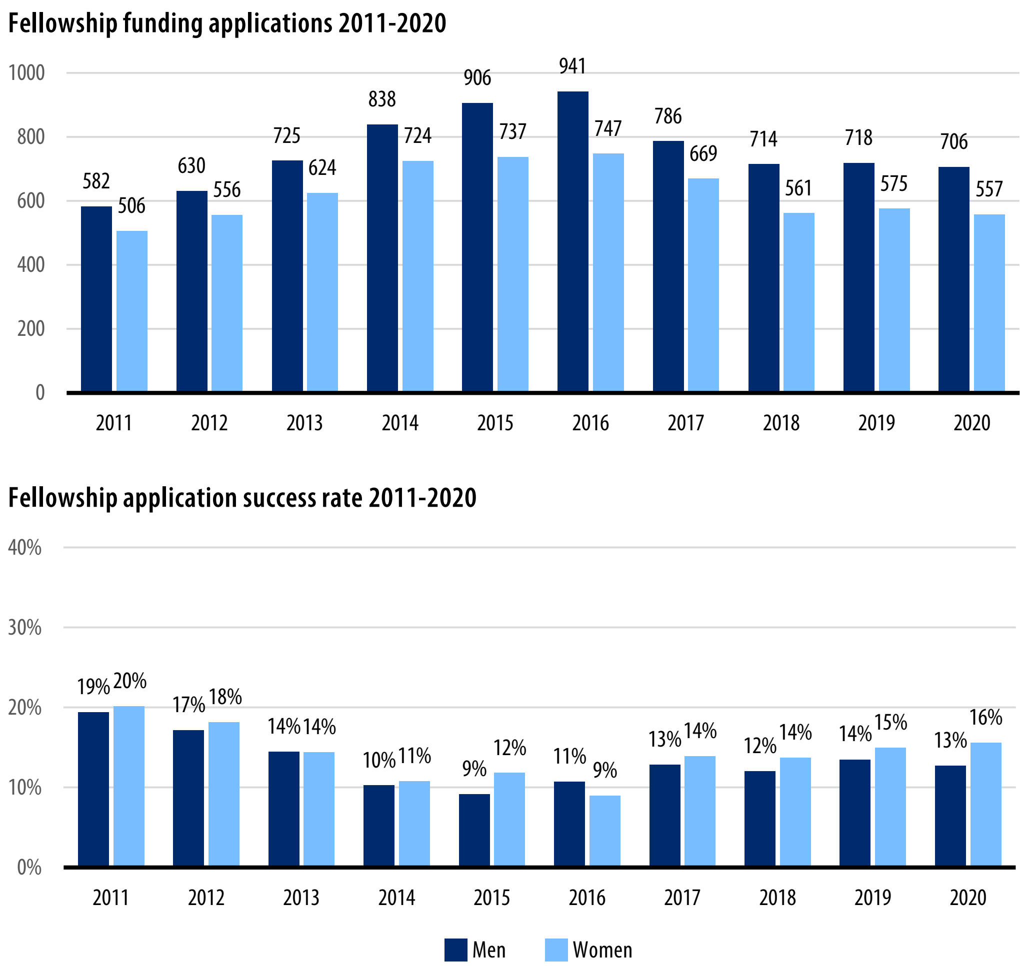
The low success rates in the traditional instruments are perceived by the evaluation panel as one of the major challenges for the Academy, as this creates high costs both for researchers multiplying their trials, and in the selection process, dealing with a high number of good proposals to rank. As this especially concerns individual fellowship programmes, this has a negative effect on researchers' career development, which needs to be tackled together with success indicators within universities.

4.6 Gender balance

Based on the Academy's applications and awards data, we find no evidence of inequitable gender outcomes. In our analysis of the Academy's fellowship awards (where the single-applicant nature allows for an unproblematic analysis of gender), men and women have very similar application success rates, with women's success rates being slightly higher in recent years.

There is however an imbalance in the application rate, with more men than women applying in each year over the analysed period. Based on the 2021 SheFigures (up to the year 2018), this imbalance broadly reflects a gender imbalance in the Finnish researcher population more broadly. In other words, gender inequalities are reproduced rather than created at the Academy. Policies operating directly on the gender balance in the research-performing organisations are therefore needed, as well as incentives by the Academy as a funding organisation to encourage gender equality and diversity. MEC could nonetheless consider whether it would be useful also to intervene at the Academy, which would have an indirect – but nonetheless potentially important – effect on the academic gender balance.

Figure 18. Application and success rates by gender



NB: data include only person-based instruments, i.e. fellowships
Source: Data: Academy of Finland. Presentation: Technopolis

Table 8. Gender balance of Finland-based researchers

	2013	2014	2015	2016	2017	2018
Proportion of women among doctoral graduates in Finland	50.6%	52.7%	52.6%	51.6%	-	
Proportion of women among Grade A academic staff in Finland	26.6%	-	-	29.4%	-	30.32
Proportion of women among Grade B academic staff in Finland	-	-	-	49.1%	-	49.74
Proportion of women among Grade C academic staff in Finland	-	-	-	50,7%	-	50.21
Proportion of women among Grade D academic staff in Finland	-	-	-	49.0%	-	49.29
Proportion of women among academic staff in Finland	-	-	-	46.5%	-	43.11
Proportion of women among heads of institutions in the Higher Education sector in Finland	-	24.0%	-	-	12.0%	
Proportion of women in researchers in Finland	31.5%	32.1%	32.3%	-	-	
Proportion of women researchers in Higher Education sector in Finland	46.8%	47.6%	47.7%			

Source: data from SheFigures 2021

The promotion of gender equality is part of the Academy of Finland's strategy and responsible research policy. The Academy of Finland Equality and Non-Discrimination Plan (Academy of Finland, 2019) for the years 2019-2021 is formulated in line with the recommendations for the responsible evaluation of researchers published by the Federation of Finnish Learned Societies in 2020 (Working group for responsible evaluation of a researcher, 2020). The recommendations emphasise the need to ensure non-discrimination in evaluation processes and the proper instruction of evaluators. The non-discrimination plan includes a broad set of measures for promoting equality and non-discrimination in the Academy of Finland's research funding operations and Administration Office operations, in operations and services, and among Administration Office personnel. At the Academy of Finland, women and men are equally represented in all scientific councils and bodies. In 2010–2018, women's share averaged 49 per cent and men's 51 per cent. This proportion is however lower in panels, in particular the panels of the Research Council for Natural Sciences and Engineering (17% in 2018) and Biosciences and Environment (42% in 2018). In panel of the FIRI committee (autumn 2021), only one woman was present. These inequalities are recognised and addressed in the non-discrimination plan. The gender balance of panels of the other research councils is close to equal.

Close monitoring and transparency are also part of the strategy. The Equality and non-discrimination plan presents a detailed analysis of applications and success rates according to gender. It comes to the conclusion (p. 8) that "A comparison of women's and men's success rates … suggests that the gender differences have narrowed in most funding schemes and research councils' decisions. In the case of Academy Projects, women's success rate reached the same level as men's after 2015. Gender equality in funding for Academy Research Fellowships was achieved a few years earlier. For Postdoctoral Researcher posts, there have been relatively minor gender differences throughout the period under review. The proportion of successful women applicants remains low in the natural sciences and engineering fields, reflecting the corresponding gender breakdown among applicants. However, the proportion of women has increased significantly in researcher training in these fields, so there is obviously greater potential for the future."

4.7 Funding processes at the Academy of Finland

About half of all Academy of Finland funding is allocated via a standard assessment process like those found in most national research councils. Applicants submit their applications via the Academy's web portal, administrators then run various checks and allocate applications to reviewers. Following receipt of at least two reviews per application, a panel meeting of reviewers then discusses all applications, providing a rating for each (on a scale of 1–6) and ranking from highest to lowest quality (the lowest rated proposals tend not to be included in the ranking). The final decision on which applications to fund is then taken by the relevant research council.[12]

There are a few details on which the Academy's standard process is distinct from at least some international counterparts:

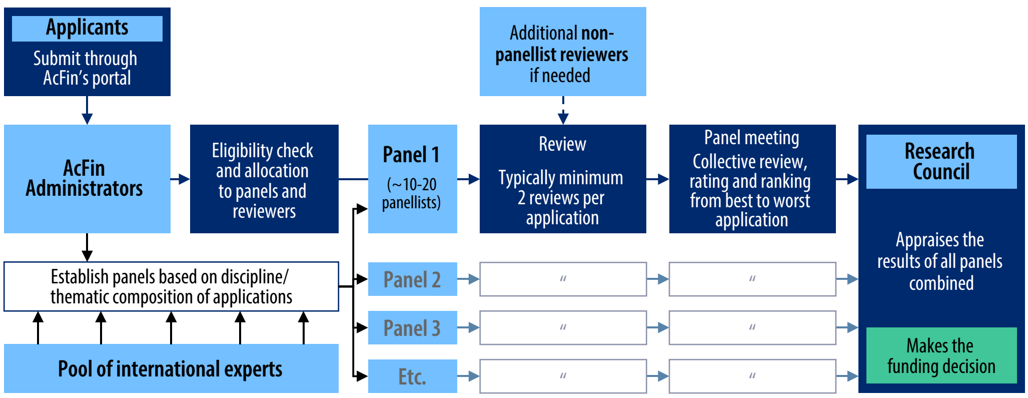
- Remote reviewers and panellists have the same requirements, i.e. they come from the same pool of people. In rare cases, where there is insufficient expertise on a panel for a particular application, the Academy may enlist additional external, non-panelist reviewers, to provide reviews for consideration by the panel

- Panels are formed after submission of applications: the Academy's administrators appraise the spread of disciplines, topics, and fields of the submitted applications, and then finalise panels and panel composition to suit the range of submitted applications

12 See also section 5.1, p. 58f, summarising the feedback of Research councils to the scientific quality of the applications.

- There is a clear distinction between review and decision-making. In other research funding agencies this may also broadly be the case, but the decision-making body's final decision may often just be a formal 'sign-off' of panel recommendations. At the Academy, the relevant research council considers the recommendations of all review panels together and selects funded awards from across the individual panel recommendations. There may however be differences among the panels in terms of how the applications are rated, as well as in terms of overall quality of the field of applications in each panel. This means that there are always substantive decision-making tasks to be performed by the research councils.

Figure 19. The Academy's main 'one-stage' application assessment process

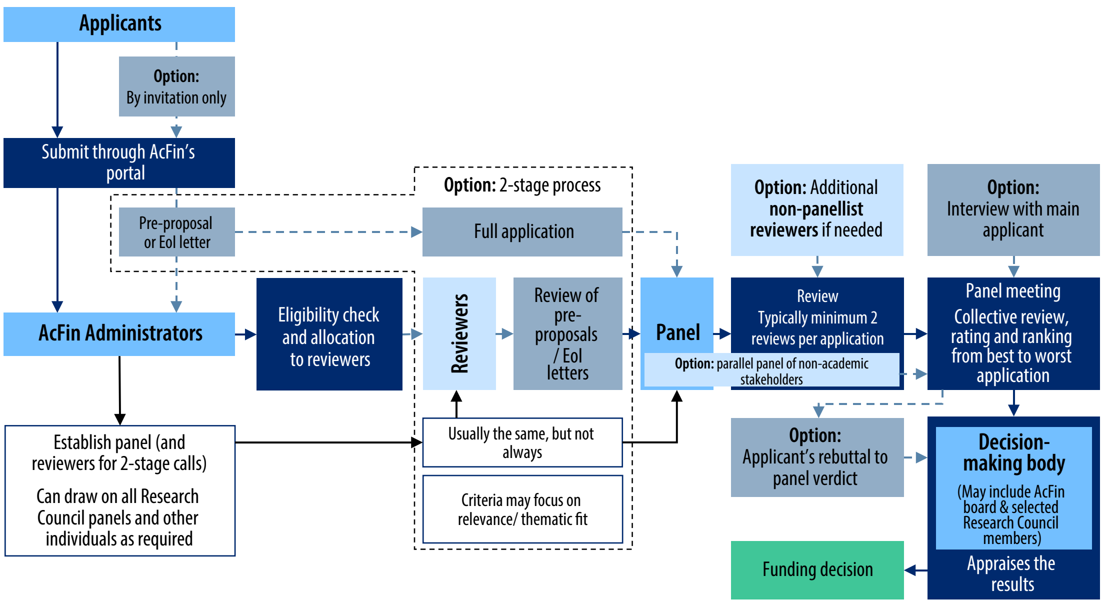


The above process is used fairly uniformly across all funding tools where one of the three research councils is the final decision-making body. These are the core basic research funding tools, namely Academy research projects, as well as most fellowships (including the high-intake postdoctoral and Academy research fellowships). As noted, these make up just under half of Academy's total awarded funding over the past decade.

Roughly the other half of funding is distributed through processes that are similar to the above, but make use of various kinds of modifications, sometimes minor, sometimes major. Modifications of the 'basic' funding process are generally associated with funding tools where the final decision-making body is not one of the three main research councils. Instead, the decision-making body may either be the Strategic Research Council, or some form of programme board (typically consisting in large part of Academy board members and members or chairs of more than one research council).[13]

We present below an overview of the process modification options that exist among the Academy's funding tools (lighter shades), and how these fit around the components of the 'basic' funding process described above (darker shades). Various funding tools may have just one or several of these options added to the assessment process.

Figure 20. Modification options used in the Academy's application assessment process



- Application by invitation only: the Academy may use this in some cases for targeted projects or especially large (e.g. institution-level) awards. We note that 'by invitation' calls are never used without a prior peer review. E.g. the project funding decisions for recipients of Academy Fellowships are based on the Fellow's research plan that has been reviewed when they applied for the fellowship in the first place
- Two-stage process: applicants begin by only submitting a short Expression of Interest (EoI) or similar format of short pre-proposal. Only after a successful

13 We note that the distinction between 'standard' funding processes in research council led funding and modified processes for non-research council led funding is neither mandated nor absolute: it is simply a strong tendency we have observed.

review of this is a full application reviewed. The final decision-making body tends to consider reviews of the pre-proposals and determines which ones proceed to full proposal stage. The SRC programme calls always employ a panel review also in the first stage of the call. The pre-proposal stage may focus solely on thematic fit/relevance to the programme but may also involve a focus on scientific quality. Pre-proposal reviewers may often be the same individuals who then feature as panellists in the full application review stage, but they may also be different people

- Parallel panel of users/non-academics: the application goes through two panels simultaneously, one to check scientific quality/excellence, the other to assess relevance and impact. This is in use specifically for Flagships and Strategic Research Council programmes

- Interview: the main applicant(s) is/are interviewed. This is in use for Flagships (applicants and host institution representatives), and PROFI

- Applicant's chance for rebuttal: after the panel verdict has been reached, applicants can see the panel decision and report, and can then submit a rebuttal to clarify any misunderstandings that may have occurred. This does not change the panel verdict, but the final decision-making body has sight of the rebuttals and can consider them in their decision-making. This has been used for Flagships, and the latest PROFI, Academy professorship and FIRI calls

Table 9. Process modifications used in the Academy's funding tools

Funding instrument	Instrument type	% share of total funding awarded 2011–2020*	Invitation only**	Two-stage	User-panel	Interview	Applicant rebuttal
Pure bottom-up funding							
Academy research projects	Project funding	28.1%					
Postdoctoral researcher	Fellowship	8.1%					
Project funding associated with fellowship funding	Fellowship	7.8%	X				
Academy research fellow	Fellowship	7.4%					
Academy professor	Fellowship funding	1.4%		X			X

Funding instrument	Instrument type	% share of total funding awarded 2011–2020*	Invitation only**	Two-stage	User-panel	Interview	Applicant rebuttal
Clinical researcher	Fellowship funding	0.5%					
Thematic funding							
Strategic Research Council programmes (including programme director calls)	Project funding (SRC)	8.4%	X*	X	X	X	
Academy programmes (including international collaboration and some special funding calls)	Project funding	6.8%		X			
Targeted academy research projects, international joint programmes and calls	Project funding	4.4%	X	X			
ICT programme	Project funding	1.9%		X			
Centres and research environments							
Strengthening university research profiles	Centres and research environments	8.1%				X	X
Centres of Excellence	Centres and research environments	6.9%	X*	X			
Flagships	Centres and research environments	2.2%	X*		X	X	X
Other							
Finland Distinguished Professor Programme	Previous funding instrument	0.5%		X			
Bilateral mobility funding, EUI and IIASA grants	Other funding	0.4%	X				

Source: Technopolis based on documentation of the Academy of Finland

Excludes some small miscellaneous instruments, match-funding and research infrastructures. NB: this table may not capture all variations that have existed over the past ten years, but we are confident that the great majority are noted here.

* Funding decisions on the other 'half' of a CoE and Flagship term upon a mid-term review by invitation only.

** By invitation calls are not used without a prior peer review of some kind, i.e. the project funding decisions for recipients of the Academy fellowships are based on the Fellow's research plan that has been reviewed when they applied for the fellowship in the first place.

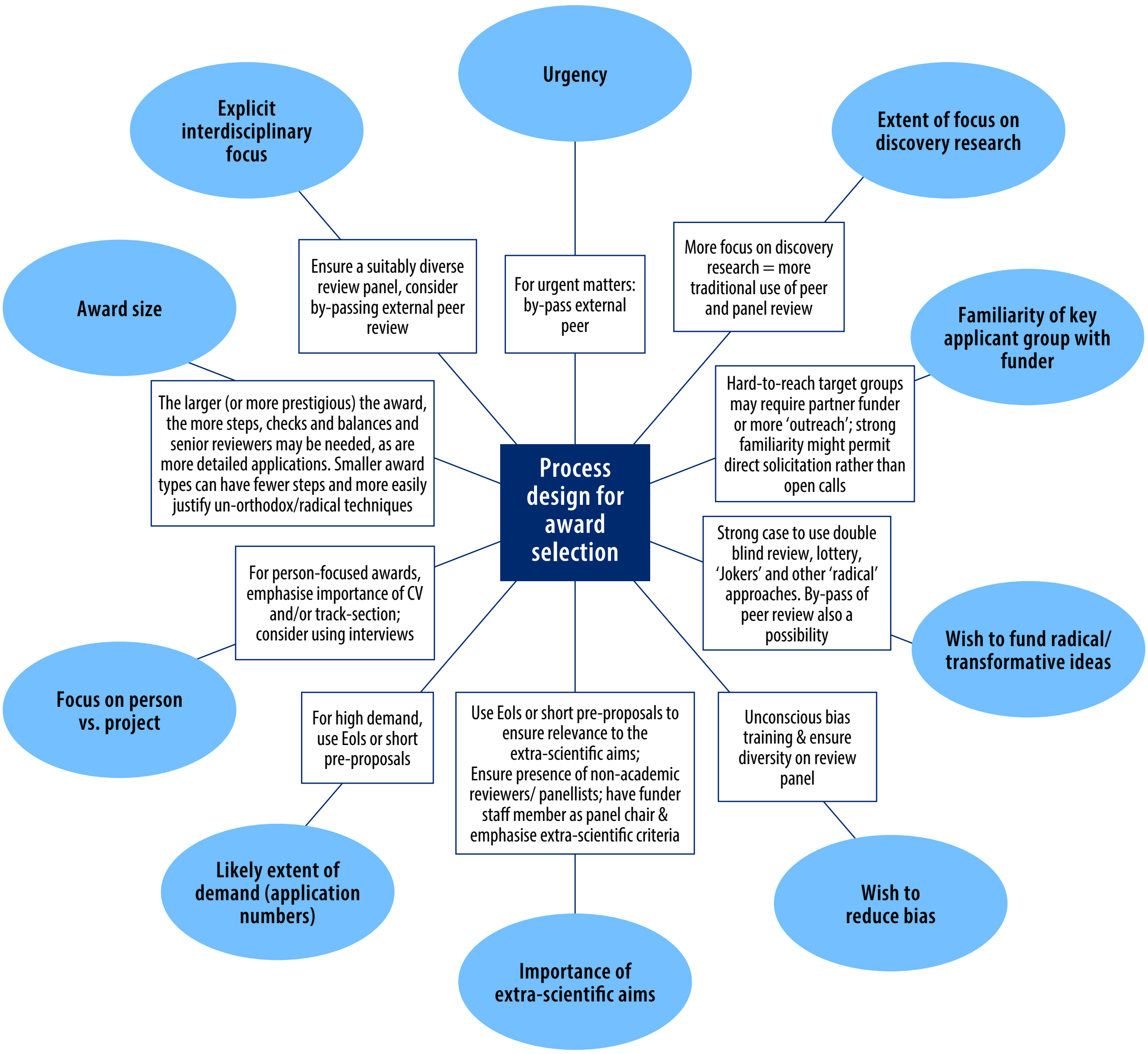
New call types or programmes are usually overseen by a working group, where (among other things) the process design is considered, although the Academy's VP for research takes the final decision on what the process will look like.

Aside from the relative lack of process modifications in funding tools led by the three main research councils, and much stronger prevalence of modifications across other funding tools, there are some general tendencies that suggest intentional linkage between award characteristics on one hand and funding processes on the other:

- Large award types with long and complex applications tend to have two-stage calls, in part to ease the burden on applicants and reviewers – this holds for centre of excellence and Academy Programmes, but not for the Flagships and infrastructure calls
- Thematic funding also tends to have two-stage calls, as these provide specific spaces where relevance and impact can be checked. The same is the case for the use of parallel impact panels
- Rebuttals and interviews appear to be used for funding tools with high levels of prestige

At many research funding organisations, the design of funding process can often be historically determined. As discussed in section 3.3, in recent years genuine efforts have been made for funding processes to be optimised to serve call and award types. The figure below provides some further parameters for such optimisation.

Figure 21. Considerations for award process design



At least some of these are already in place at the Academy, at least to some extent. This holds for the wish to reduce bias, the importance of extra scientific aims, in some programmes the use of expressions of interest and short pre-proposals, and an explicit interdisciplinary focus.

Panelists' feedback on the processes is generally very positive, though some recommend using a more standardised structure of applications to facilitate comparative assessments.

Recent reforms mainly increased efficiency and introduced new types of expertise on societal or industrial impact. There is however little to no room for further improvements of efficiency without losses in quality, due to very tight resources. It would be important to invest in new processes to tackle the very low selection rate in bottom-up funding. This probably needs some experimentation and negotiation with universities, to reduce the number of applications. For bigger and more complex funding, it would be helpful to broaden the possibilities to do interviews in the selection phase. Finally, the evaluation shows a clear need to enhance the collection, monitoring and analysis of funding data. This could help establishing a portfolio perspective on funding, enhance the quality of strategic evaluations, and provide important information on various research ecosystems.

4.8 The Academy of Finland's involvement in international collaboration

In February 2017, the Board adopted the Academy of Finland's international policy for 2017–2021. Six areas, in which the Academy will take measures to promote the internationality of both Academy-funded researchers and the Finnish research and innovation system at large in 2017–2021 are presented in the strategy paper "Quality, impact and renewal in international cooperation – Academy of Finland international policy for 2017–2021" (Academy of Finland, 2017). The Academy aims to integrate internationalisation across all funding schemes as well as through multilateral and bilateral collaboration and mobility support. The international policy therefore says that *"In the review of funding applications, the Academy will take into account the international merits of the applicants, underlining the fact that international collaboration reinforces the quality and impact of research as well as science renewal."* The following table is taken from a background memorandum on the Academy's current international activities. It includes both explicitly international activities and estimates of the share of international activities funded in the classical research funding activities of the Academy.

Table 10. Funding schemes that promote international engagement and cooperation

	2016, €m	Average 2018–2020, €m	2018–2020
Academy Projects and research career funding (estimated at 25% of total funding)	51.5	51.5	35%
International research infrastructure fees*	19.5	21.6	15%
SRC programme projects (estimated at 25%) and SRC matching funds for Horizon 2020	17.3	17.8	12%
FIRI Committee funding for the promotion of international engagement and cooperation (estimated 90%)	16.7	22.4	15%
Competitive funding to strengthen university research profiles (estimated 25%)	12.5	12.5	8%
Centres of Excellence and Academy Programmes (estimated 25%)	10.2	7.6	5%
Funding cooperation under ERA-NET, JPI and Article 185	5.8	5.8	4%
Mobility funding (2018-2020)** Research and mobility funding for bilateral agreements (2016)	4.2	1.7	1%
Antarctic research, Academy Programme for Development research***, (2016: also EUI and IIASA funding)	2.6	3.9	3%
Nordic NordForsk and NOS cooperation	1.5	2.9	2%
Total	**141.8**	**147.6**	100%

*) Includes annual membership fees, in 2016: only membership fees

**) Includes bilateral mobility grants, also EUI and IIASA, based on agreements between organisations. EUI and IIASA membership fees are included in "International research infrastructure fees"

***) Antarctic call is implemented every fourth year; Academy Programme for Development Research every third or fourth year according to how agreed with the Ministry for Foreign Affairs

Source: Academy of Finland, Quality, impact, and renewal in international cooperation – Academy of Finland international policy for 2017–2021 Background Memorandum (2016 data), update in 2021.

The biggest financial share for collaboration, around 60%, is provided as part of the programmes and instruments of the Academy: According to the Academy's estimates, about 25% go to international collaboration, i.e. as travel costs, long-term visits abroad, seminars and conferences. The second big share goes to infrastructure, on the one hand international infrastructure fees, on the other hand further funding activities of the FIRI Committee, summing up to further 30%. Only the remaining 10% go to multilateral and bilateral funding agreements.

There is an important tension related to the Academy's desire to expose its grantees to research milieux abroad. Interviews with established researchers and the review of panel feedback on applications mention that mobility is often expected at the point in life where researchers are setting up homes and having small children. This can discourage young researchers, especially women, from pursuing an academic career. It also leads in some cases to applicants making exaggerated claims in proposals about their mobility intentions.

4.8.1 The Finnish context of bilateral and multilateral agreements

The Finnish Ministry of Education and Culture has published a strategy titled "'Better together for a better world – Policies to promote internationalisation in Finnish higher education and research 2017–2025"[14] in 2016, with the goal to achieve a globally acknowledged frontrunner position by 2025. One of the main actions taken was the establishment of the Team Finland Knowledge Network in 2018. The network comprises eight university and science specialists working in Abu Dhabi, Buenos Aires, Moscow, New Delhi, Beijing, Pretoria, Singapore, and Washington. The tasks of the senior specialists stationed in Abu Dhabi, Buenos Aires, Pretoria and Singapore are regional.[15] The Team Finland Knowledge Network shall help to achieve a more internationally oriented position in higher education and research and attract talented people The Academy of Finland is one of 24 Team Finland organisations, addressing economic, diplomatic, scientific and higher education objectives. The Academy has the mission to support international collaboration of Finnish research, and interacts on the level of Nordic countries, the EU and global partnerships. However, it has few resources to engage in the relevant networks. So far, the most important effective relationship was built in the USA with a new €10m cooperation agreement.

4.8.2 Bilateral agreements

The Academy of Finland has 23 bilateral agreements with funding organisations in 14 countries. Most framework agreements and Memoranda of Understanding are over 20 years old. Based on these, the Academy has longstanding researcher mobility cooperation with eight organisations in six countries: China, Germany, India, Japan, Russia, Taiwan. The Academy funds this mobility with approximately €1,6m annually.

In recent years, the Academy of Finland has reviewed its bilateral agreements and networks with European and other countries. The aim is to increase efficiency and

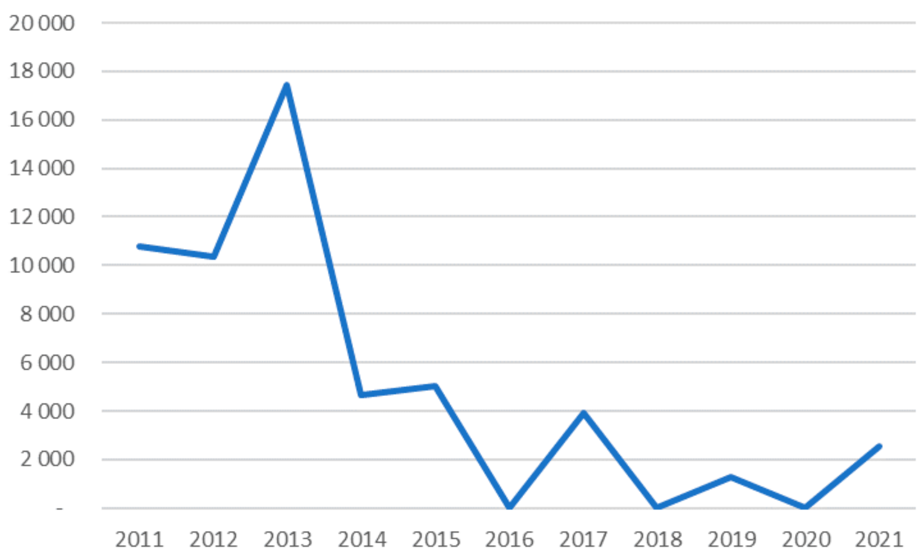
14 See https://okm.fi/en/international-strategy-for-higher-education-and-research

15 https://okm.fi/en/team-finland-knowledge-network

coherence across agreements, to align the processes and to avoid funding poor-quality activities. This needs to be done by negotiating with each country individually. The review of bilateral calls for research projects with non-European partners concluded that the quality of applications was below the level of the regular calls of the Academy. After 2010, this led to a reduction of bilateral calls, and the emphasis in the Academy's international policy defined in 2017, that cooperation with non-European countries should be primarily conducted in multilateral frameworks (i.e. ERA-Partnerships such as ERA-RUS and ERA-Africa, and more recently, by the NordForsk pilot calls with Japan). Since 2010, the Academy has not terminated any bilateral agreements. Instead, it signed a few fixed-term agreements (South Africa, South Korea). These have not been renewed, as the emphasis was shifted to multilateral cooperation.

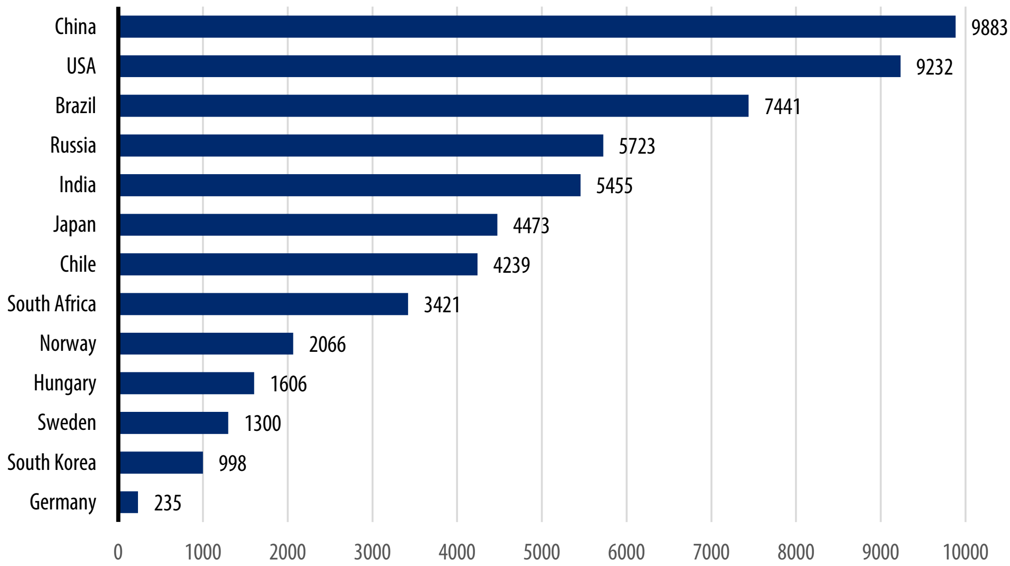
This policy has led to a considerable reduction in the funding for bilateral research projects over the last decade:

Figure 22. Academy funding for bilateral research projects in total (€k)) in total in 2011–10/2021



Source: Academy of Finland

Figure 23. Academy of Finland funding for bilateral research projects (€k) by co-operation country in 2011–10/2021.



Source: Academy of Finland

This reduction and reorganisation of bilateral agreements is consistent with refocusing on multi-lateral cooperation. However, as Table 10 shows, the decrease in bilateral funding has not been fully compensated by increased multilateral activity. As discussed earlier in the context of Finland's comparatively low performance in European programmes, there is room for improvement, however, only if accompanied by an increase in dedicated budget.

Mobility funding

Table 11 gives an overview of mobility funding based on bilateral agreements, which have launched in different contexts and partly been in place since a long time. These mobility agreements are now under revision, renegotiation, and reorganisation. So far, two reforms have been implemented:[16]

1. In 2020, the Academy of Finland and its partners in China (NSFC, CAS, CASS) decided together to renounce the quota for researchers and the traditional funding model in which the sending side pays for the travel costs and the receiving side for the living costs. In the new model, both sides pay all travel

16 This information is based on interviews and on a note provided by the Academy of Finland on Academy funding for mobility and research projects based on bilateral agreements (2011–2021) on November 9, 2021.

and living costs of its own researchers. Moreover, the focus has been shifted from individuals (personal grants) to research groups and joint projects. In 2021, the new model was implemented with India (DBT).

2. In the Academy of Finland, all mobility applications are now evaluated by the members of the Research Councils. Previously, this was the case only with DAAD applications, while other applications were evaluated by Academy officials.[17]

Table 11. Mobility funding modalities (bilateral agreements) and success rates by country

Country	Finnish researchers travel to counterpart country (personal grant)	Finnish researchers invite researchers from counterpart country to Finland	Joint seminars	Joint mobility projects*	Success rate in 2020	Number of applications in 2021	Academy funding, € (tbc 10.11.2021)
China			x	x	22%	77	445,000
Germany				x	83%	14	20,000
India				x	100%	6	100,000
Japan	x (incl. JSPS Fellowship**)		x		78%	11	260,000
Russia	x	x			94%	44	589,000
Taiwan	x	x			100%	5	60,000

Source: Academy of Finland

New types of bilateral agreements

Despite the reduction in bilateral engagement, the cooperation with the US National Science Foundation (NSF) continued throughout the decade in the form of several calls for bilateral research projects in wireless communication (WiFiUS). Academy funding for these calls came from the ICT 2023 programme, which the Academy of Finland Research Council for Natural Sciences and Engineering implement together with Business Finland.

17 Sending mobility applications to external reviewers, like in other regular funding instruments of the Academy of Finland, was rejected considering the benefits and the costs of the administrative process relative to the size of the grants.

In November 2020, new initiatives between the National Institutes of Health (NIH) and the Academy of Finland, and between NSF and the Academy of Finland have been launched, with first common calls in 2021. The themes of the cooperation are within the thematic areas of the Flagships and part of the funding comes from the ICT 2023 programme. From the perspective of the Academy of Finland, all proposals submitted must have significant research involvement from researchers from both countries funding will be provided for collaborative research activities falling within the missions of participating NIH's Institutes and Centres (for the NIH-cooperation) and the thematic areas of the Academy's Finnish Research Flagships. The Academy is prepared to fund the Finnish components of the collaborative US-FI projects with a maximum of €3 m in 2021, maximum funding for five-year project is € 500,000 (Academy of Finland, 2020 b).

Another new type of thematic funding collaboration has been signed with the Research Council of Norway (RCN) in engineering, (following the so-called money follows cooperation principle). The evaluation of the application is conducted by the funder who received the application, as part of its normal evaluation process, and this organisation also funds the consortium if the proposal is accepted.

The collaboration with Nordic countries is a pillar in Finnish research collaboration, in the years 2014–2019, about €20m has been put into Nordic projects, most in societal development issues, health and education. This regional collaboration has recently been opened to Japan, with two health-related pilot calls with a new funder in Japan (AMED) (Academy of Finland, 2021b).

Finally, with Sweden, Finland engaged in the Tandem Forest Values initiative,[18] which has allocated around €9.36m to bilateral forest research between 2017 and 2020. The programme brings together several funders from both Finland and Sweden, including foundations and ministries.

18 This programme was evaluated in 2021 (Tunberg & Torfgård, 2021).

5 Quality and impact

Scientific quality, interdisciplinarity, internationalisation, and societal relevance are the key criteria of success of the Academy's funding activities. The following sections look at each of these with different methodological approaches. This evaluation focuses on dynamics of the context, the organisation, and the impact. The quality of research is therefore assessed not simply by a summative exploration of excellence of scientific outputs. Section 5.1 opens the impact chapter with a summary of feedback of international peers, members of the panels of three Scientific Councils. Section 5.2 looks at interdisciplinarity of proposals and thematic clusters that appear from bibliometric analysis. This allows the identification of strengths of the scientific community in Finland, and the thematic links between scientific fields. Funding data show that projects funded by the Academy of Finland became increasingly interdisciplinary. Section 5.3 discusses internationalisation, in terms the share of foreigners funded by the Academy and in terms of the success of the Finnish research community in European funding and international co-publications, both compared with selected countries. The final section 5.4 addresses the Academy as a change agent, starting with the perception of the new orientation towards societal impact by universities. We then have a closer look at the two new instruments (Flagships and Profiling) and the new role of the Academy in infrastructure funding.

5.1 Scientific quality of the proposals

The Academy of Finland has published aggregated feedback from the applications to the three Scientific Councils, based on feedback collected across the various panels: 80 documents in total. These panels were responsible for assessing funding applications for Academy projects, Academy Research Fellows and Postdoctoral Researchers.

Key messages from these panel feedbacks are as follows:

- Most if not all panels agreed that the level of applications is comparable to the international level. The top-ranked applications would have been competitive in their respective countries' funding councils, as well as in other international funding schemes

- Applications to Academy projects are perceived as excellent in international comparison. Some were also 'particularly impressed with the quality of the postdoctoral fellowships – this scheme is producing very high ranked applications'

- One observation was that 'those applicants who are located in institutions with a strong research infrastructure submitted excellent, highly polished projects'

- On the other hand, some of the proposals appear to have been written quite quickly and were surprisingly weak given the experience and expertise of the applicants

One driver for this last point is that at least some universities create an incentive in their human resource policies for researchers to apply to the Academy – independent of success. This is confirmed by a researcher who said in interview '*The low success rates is the most problematic thing. We're still encouraged to apply, as this is part of the evaluation process of the university. Most people take the application seriously, yet it is anticipated that it's likely you lose.*'

Several comments indicate an issue with the integration and success of younger researchers:

- One review mentioned that 'the applications for Postdoctoral Researcher funding were not particularly strong, but the great majority were at least solid by international comparison, and six out of fourteen were graded 4 ("very good") or above, with some excellent applications.'

- Another review suggested that 'the applicants are encouraged to discuss the application with colleagues before submission. Receiving some mentoring in preparation of application is particularly important for younger applicants with limited experience in applying for research funding'.

- The third review 'wondered whether universities offer training to early career scholars to develop applications. The least strong field, on average, was in the individual Academic Research Fellow applications. The panel wondered whether this might be an inevitable feature of the instrument (many applicants may be mid-career scholars who have not yet developed the experience to devise a novel outstanding application and are beyond their early-career enthusiasm, having completed the doctoral and postdoctoral projects), and whether some more targeted support should be given by universities to mid-career scholars.'

Feedback regarding international integration was partly very positive, partly more critical.

- The first sees a well-integrated research community: 'There is clear evidence of a very lively research context in Finland, with extremely productive collaborations among Finnish universities and with international ones. The international orientation of the research is highly commendable.'

- Another observed that applicants tend to name international collaborations that do not seem to be founded on sufficient commitment.

These messages are in line with the perception of our interview partners: there is a consensus that the Academy selects high level proposals and thus in effect acts to assure the quality of research more broadly. It is also clear that the universities could at once improve success rates and the training of junior researchers by imposing some outgoing quality control and improving mentorship.

Researchers and the Academy both see participation in international research communities as an important factor in career development and research performance. However, there is a trade-off between mobility and family commitments for early-stage researchers, which both researchers and the Academy should consider, in relation to enforcing strict mobility requirements for junior research grants and fellowships.

Finally, there is a virtuous circle is in relation to research infrastructure, as applicants working in places with good infrastructure can propose particularly high-level projects.

5.2 Interdisciplinarity and thematic clusters

Interdisciplinarity is a challenge for research councils, as the selection of applications for funding is based on peer review, organised a priori along scientific disciplines. However, traditional classifications do not necessarily hold in a changing world; scientific progress is itself often interdisciplinary, and there is an increasing need for scientific research to be orientated towards societal problems that inherently require interdisciplinary solutions. Typically, the combination of different knowledge areas has a better chance to solve a problem. Interdisciplinarity can increase relevance of research for societal challenges.[19]

19 In 2021, Henrique Pinheiro et al. from Science-Metrix studied this relationship. They show that it is more likely that research results published in peer-reviewed papers are taken up in policy papers if researchers from different areas are working together (Pinheiro et al., 2021).

Research councils, therefore, need to adapt their selection processes to these new requirements. The Academy decided in 2011 to introduce multidisciplinary programmes to tackle grand challenges. This was followed by both the introduction of the SRC and the recognition of the potential for Academy programmes in cross research council interdisciplinarity. The Research Funding Development unit has encouraged the creation of cross-council selection panels where needed. The Academy monitors the interdisciplinarity of its applications and presented its approach and results to Science Europe in 2018 (Jokela, 2018).

Most recent reforms were implemented in mid-2018, so they are too recent for it to be possible to assess their impact. This section therefore focuses on the last decade, to identify domains in which interdisciplinarity is important and/or rising and to identify instruments and programmes which are drivers of interdisciplinarity within the portfolio of the Academy.

To understand the dynamics behind interdisciplinarity we combine three approaches, starting with an analysis of application data, to get a differentiated picture on interdisciplinarity across funding instruments and programmes, across time. We also look at differences in success rates of multi- or monodisciplinary applications. Second, publications are analysed based on a network analysis. This network has been constructed from a publication dataset of Academy-funded research, in which fields of study are linked together via their common association with a publication. Although this approach does not provide a direct measure of interdisciplinarity across the different fields of study, it allows us to identify which research areas work closely with others (i.e. to identify clusters of research fields), by virtue of analysing the relative distances among research areas within the network.

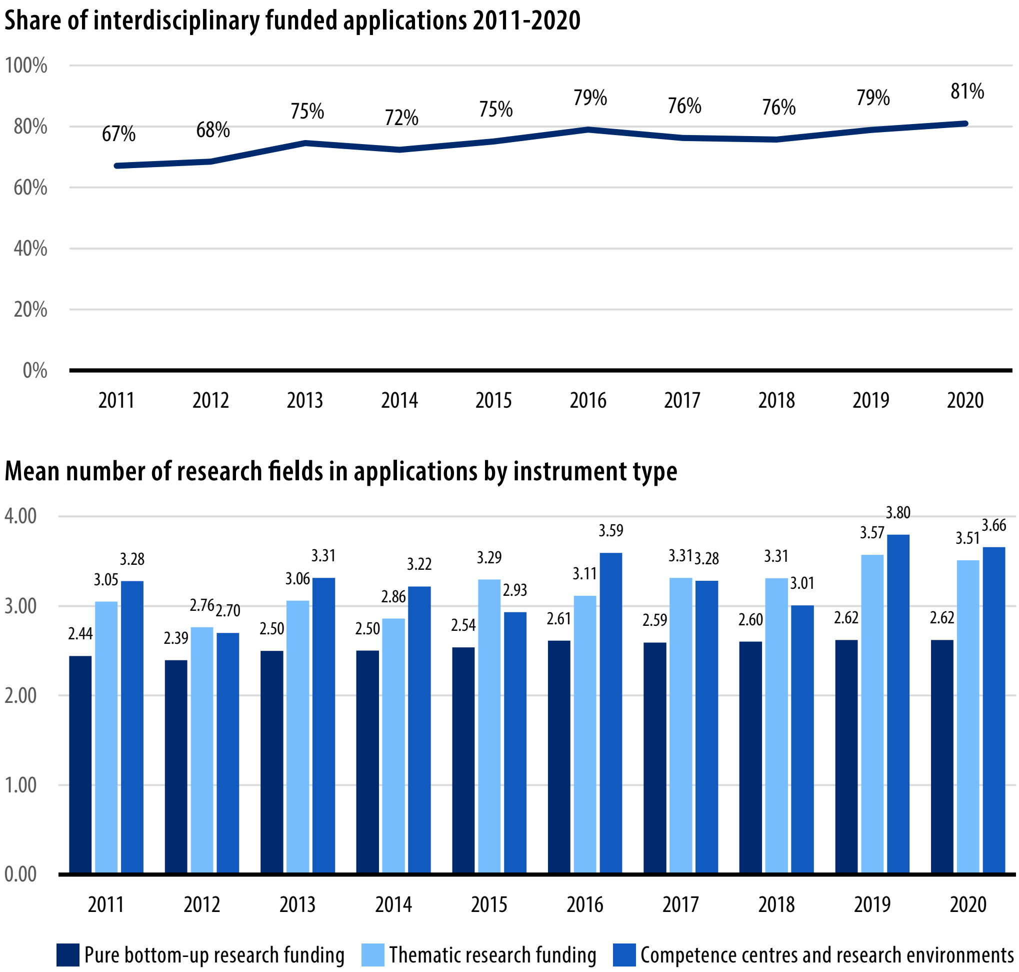
5.2.1 Interdisciplinarity of applications to the Academy of Finland

Apart from the SRC programme calls, which are explicitly intended for interdisciplinary research and list interdisciplinarity among the eligibility criteria, the Academy does not have any funding instruments that are explicitly intended for interdisciplinary research.

However, our consultations at the Academy suggest that interdisciplinary research is broadly encouraged, particularly in thematic funding instruments, but also more generally. Indeed, most applicants tag their applications as belonging to more than one main research field. Either their research is becoming more interdisciplinary, or new research areas do not fit within the traditional taxonomy of scientific disciplines. Strategic behaviour cannot be excluded, but it is not likely, and neither interviews nor feedback from the panelists go in this direction.

The share of interdisciplinary funded applications has increased from 67% of total funded awards in 2011 to 81% in 2020. Awards in thematic funding tools or in the rubric of competence centres and research environments generally specify a greater number of research fields than is the case in pure bottom up-funding. However, even in bottom-up funding, specifying more than one main research field is the norm rather than the exception. Figure 24 shows that, in terms of the numbers of fields specified by applicants in their proposals, competence centres and research environments mention the most fields, followed by thematic programmes, while bottom-up funding applications mention the fewest. This order is unsurprising – more unexpected is the large number of fields mentioned in the bottom-up programmes, which we traditionally think of as monodisciplinary.

Figure 24. Interdisciplinary applications – headline figures



Source: Data: Academy of Finland. Calculation and presentation: Technopolis

NB: Following the Academy approach, we class as 'interdisciplinary' any application that specifies more than one of the 64 main fields used in the Academy's classification, without further differentiation of the differences between the disciplines.

The indication of one or more research fields guides the Academy in selecting the right panel. Increased numbers of projects with more than one field therefore must be assessed differently, possibly introducing a bias. Funding data analysis shows that there is no significant difference in success rates for interdisciplinary and monodisciplinary applications. For pure bottom-up research funding, 451 out of 2,404 (~20%) that listed more than one research fields in their applications were funded in 2020. This is approximately the same success rate as for mono-disciplinary applications (144 out of 751) and the total success rate in the same year (595 out of 3,155). Similar patterns can be discerned for other funding instruments (details about the underlying funding instruments of the Academy can be found in Chapter 4).

Table 12. Comparison of success rates for interdisciplinary (ID) and non-interdisciplinary applications as well as total funding granted per funding instrument (data for 2020)

ID = Interdisciplinary applications	ID funded/ID *Success rate*	Non-ID funded/ Non-ID *Success rate*	Applications funded/Total *Success rate*	ID/Applications Total *share*	Total Funding Granted (2011–2020)
Pure bottom-up research funding	451 / 2.404 *19%*	144 / 751 *19%*	595 / 3.155 *19%*	2.404 / 3.155 *76%*	€ 199.654.269
Thematic research funding	237 / 589 *40%*	14 / 78 *18%*	251 / 667 *38%*	589 / 667 *88%*	€ 39.048.698
Funding for competence centres and research environments	117 / 418 *28%*	14 / 35 *40%*	131 / 453 *29%*	418 / 453 *92%*	€ 44.999.813
Other funding	112/131 *85%*	43/53 *81%*	155/184 *84%*	131/184 *71%*	€9,243,918
In total	917/3.542 *26%*	215/917 *23%*	1.132/4.459 *25%*	3.542/4.459 *79%*	€292,946,698

Source: Data: Academy of Finland. Calculation and presentation: Technopolis

The main drivers of the increase in research fields in applications are thematic research programmes as well as funding for competence centres and research environments. The number of research fields listed in applications is the highest for thematic research funding and funding for competence centres and research environments, as these instruments are either more problem-oriented (thematic research funding) or allow for bigger and longer-term budgets (competence centres and research environments). In the more traditional programmes (individual grants and Academy projects), the share of proposals with more than one discipline indicated is 75%, with no difference in average success rates compared with mono-disciplinary projects.

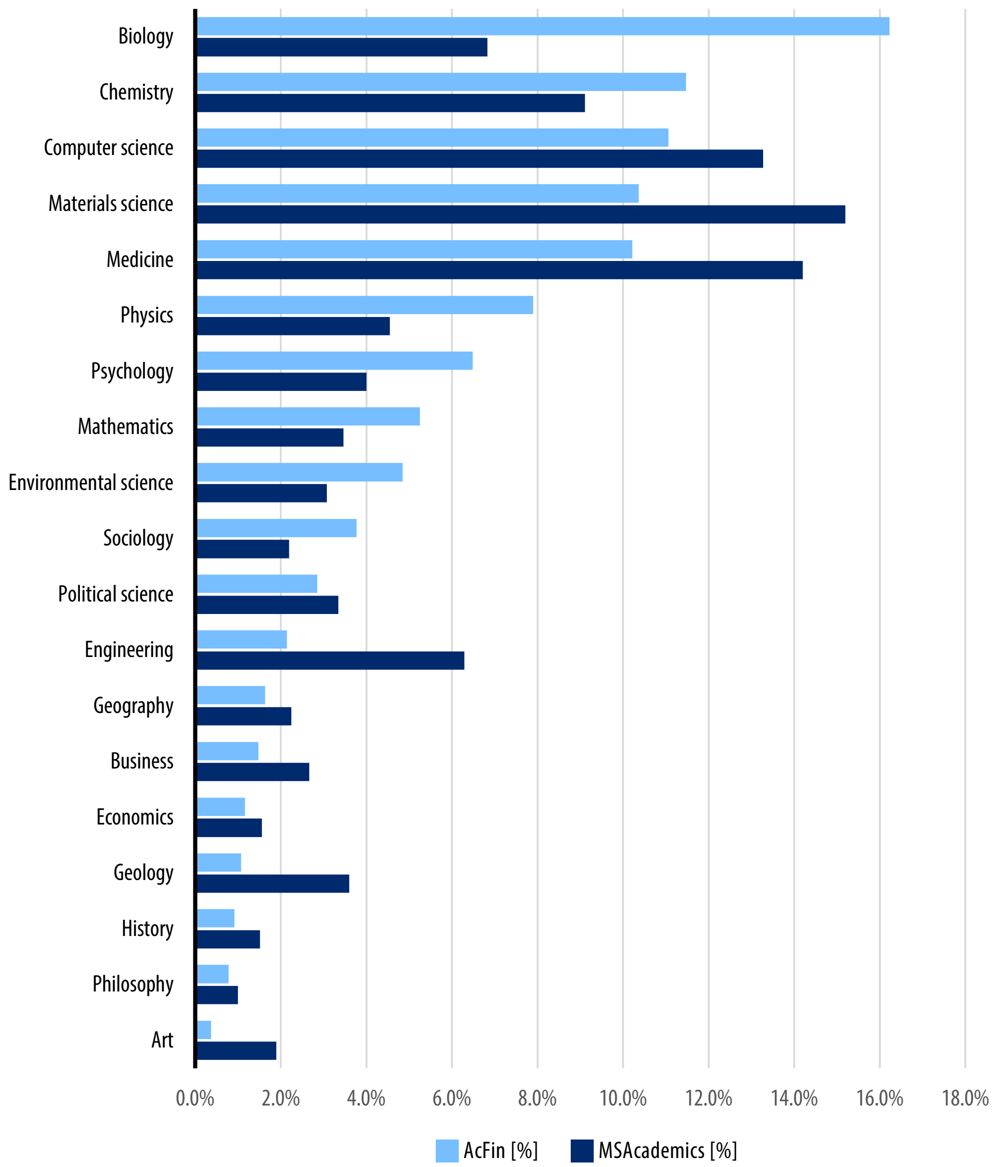
It is important to note that there are no differences in success-rates – however, the notion of 'interdisciplinarity' as proposed by the Academy of Finland and taken up in this section probably overestimates 'real' interdisciplinarity, as there is no further analysis of the 'closeness' of the fields indicated by the applicants. A more detailed monitoring would provide better input to the discussion.

5.2.2 Dominant scientific fields in Finland

This section is based on analysis of publication data to provide information on research fields identified ex post by algorithms. The goal is to understand in which scientific fields researchers publish their work funded by the Academy of Finland, and how these fields are interconnected. The analysis itself is rather technical, so it can be found in the appendix.

Figure 25 compares the overall pattern of Finnish scientific publishing with the global pattern, as represented by the top-level fields in the Microsoft Academic topic tree.

Figure 25. Distribution of top-level fields: relative total share in publications comparing Academy of Finland and MS Academics Database

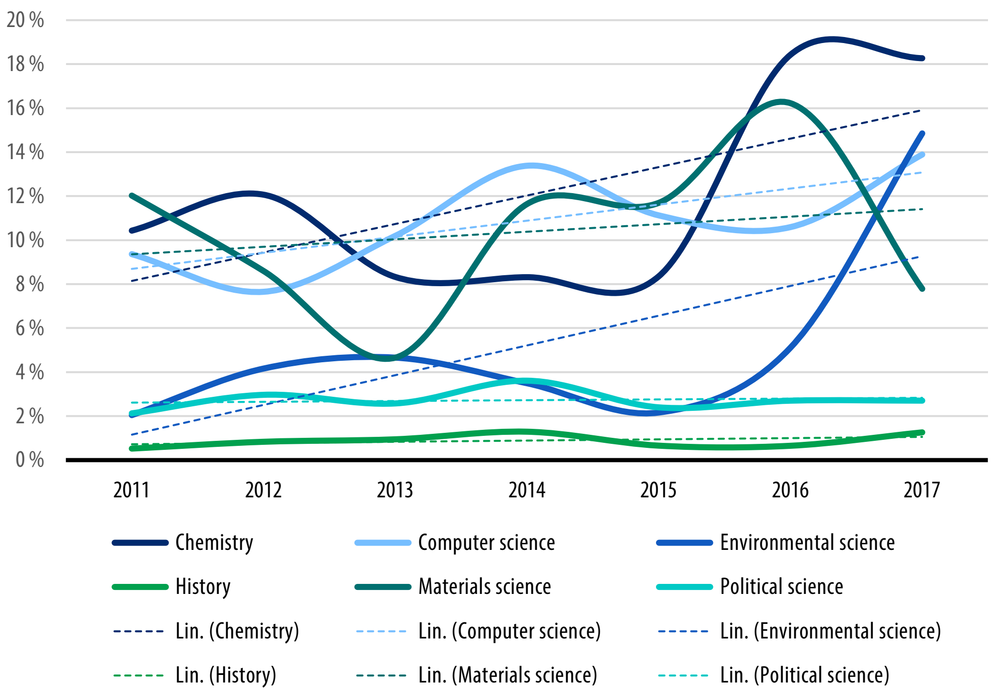


Source: Data: Academy of Finland, MS Academics. Calculation and presentation: Technopolis

Very clearly, natural sciences (biology, chemistry, mathematics, physics, and environmental science) are not only important in Finland, but they also have a weight above the global average in the database of MS Academics. On a lower level, but still with a specific pattern, this also holds for psychology and sociology. In contrast, engineering, geology, material sciences and medicine are less represented in the Academy of Finland publications than in the global average identified by Microsoft Academic.

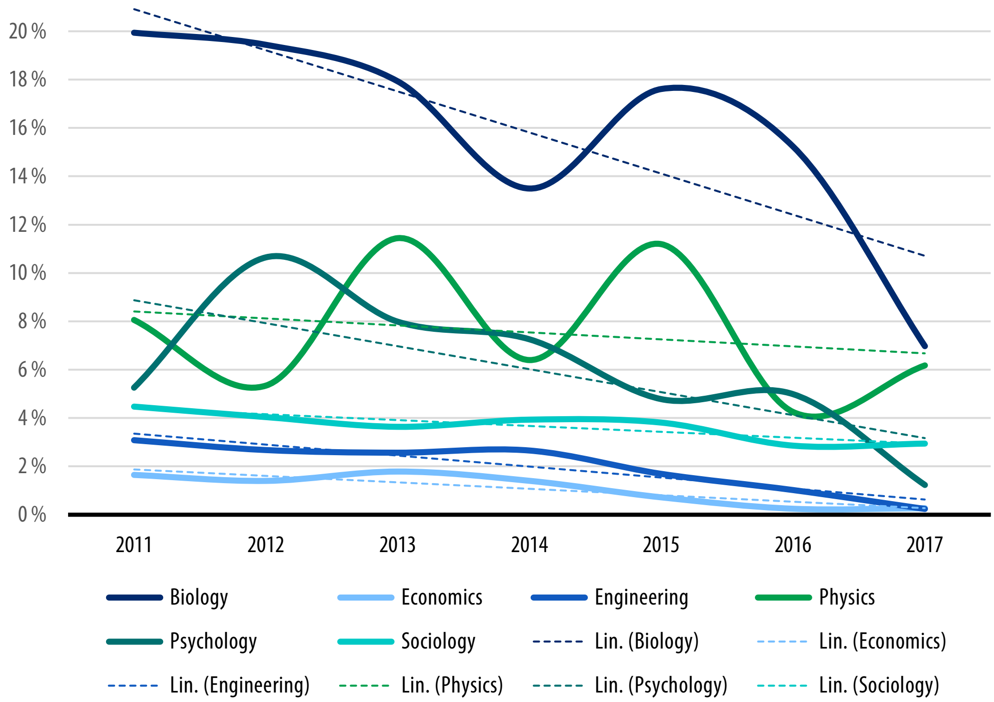
To illustrate the dynamics of publications for different top-level fields, we plot the shares of some top-level fields of study relative to the distribution of all top-level fields in the publications of Academy of Finland-funded research projects. The following figures depict the development of the number of publications for (a) the top 3rd top-level fields whose relative shares are increasing the most, and (b) the lowest 3rd of top-level fields whose relative shares are declining the most.

Figure 26. Top 3rd of research fields with fastest growing shares in publications



Source: Data: Academy of Finland, MS Academics. Calculation and presentation: Technopolis

Figure 27. Lowest 3rd of research fields with fastest declining shares in publications



Source: Data: Academy of Finland, MS Academics. Calculation and presentation: Technopolis

We can summarise the main findings from this analysis as follows:

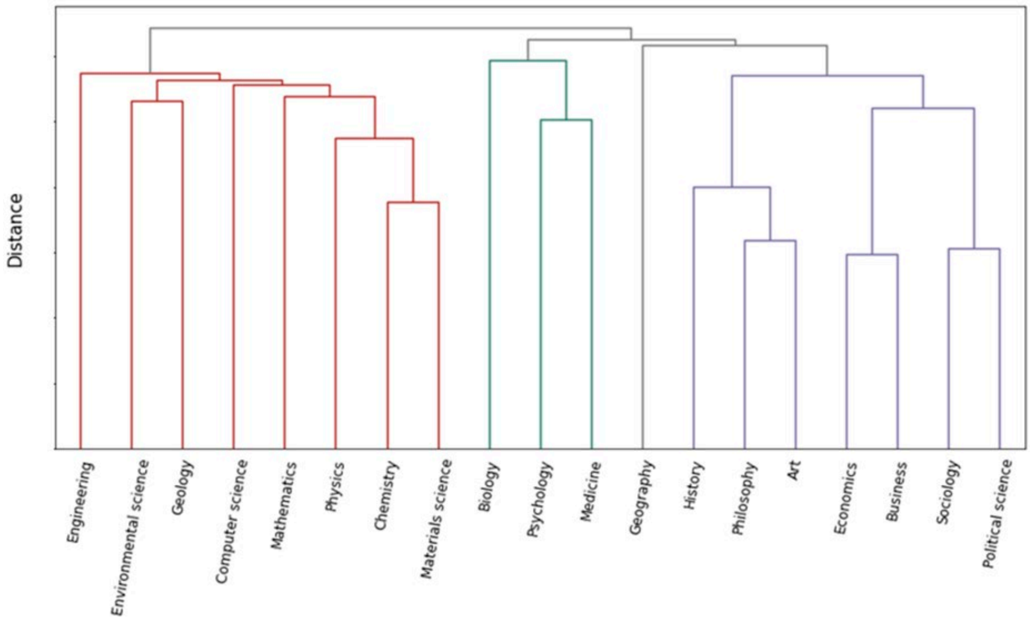
- The fields that are increasing the most are: environmental science, chemistry, computer science, materials science and (to a lesser extend) history, and political science. Especially the latter two are not only increasing at a lesser speed, but also hover around an absolute share of only 1%–3%. What is striking is the very visible recent increase in environmental sciences, which is likely to reflect the increasing demand that is placed upon researchers to address direct societal needs.

- The fields that are declining the most are: biology (with a particularly strong decline), psychology, engineering, sociology, economics, and physics.

The changes are explained both by the evolution of the number of publications and by differences in reporting practices (e.g. a high number of publications being reported in one year for a given research field with a strong thematic focus).

We additionally looked at how related are the top-level fields in the MS Academic topic tree, based on the number of sub-fields that underlie them. This is possible because in the hierarchy an individual lower-level field can appear under more than one higher-level field. In this way, we were able largely to recreate the division of disciplinary labour between the Academy's three councils. Figure 28 visualises the results of this analysis.

Figure 28. Visualisation of the main clusters (dendrogram) from a high-level



Source: Data: Academy of Finland, MS Academics. Calculation and presentation: Technopolis

The largest distance is between chemistry/materials science and sociology/political science. Other fields in the natural sciences also have weaker links to the social sciences and the humanities. Economics stands somewhat isolated.[20] Engineering and computer science, however, have the lowest distances to fields outside the natural sciences. Overall, three major clusters of similar top-level fields can be discerned,[21] which follow relatively traditional groupings, with geography being outside/in-between the major clusters:

- Cluster 1 – 'Natural Sciences'. The first and largest cluster contains the natural sciences (red, on the left). The strongest connection can be found between chemistry and materials science. The closest field to chemistry and materials science is physics, with mathematics being the field that interacts most

20 See also the network in the appendix, Figure 42, p. 114.

21 See also the heatmap in the Appendix, Figure 44, p.123.

strongly with physics. Furthermore, environmental science and geology also form a sub-unit within the cluster of the natural sciences. Engineering is the most isolated field within this cluster

- Cluster 2 – 'Health and Life Sciences, Biology': In this cluster (central), medicine and psychology interact most strongly, while biology also interacts with the adjacent cluster of the natural sciences. Further analysis (see the heatmap in the Appendix) shows that psychology has a relatively low distance to fields in the humanities and social sciences (especially sociology and political sciences)

- Cluster 3 – 'Social Sciences & Humanities': Within this cluster, there are three fragmented groups: (a) philosophy, art and history, (b) economics and business, and (c) sociology and political science

- 'Geography': Geography is the stand-alone case in the network of publications. Although it has the lowest average distances, it does not have any particularly strong ties to any other remaining fields and is therefore not part of any specific sub-cluster. As noted above, this is related to the low average distance between geography and other fields (geography reaches 'deep' into the network) without there being any particularly strong connections to specific fields. In other words, many of geography's subfields are also subfields of other research areas; however, this distribution is relatively equal across the remaining research fields

This configuration in three clusters is particularly interesting, as the Academy has reduced the number of Research Councils from four to three in 2019. Thematic analysis of publications based on Academy funding from the years 2011–2017 supports the fusion of biology and medicine in one research council. However, using our approach, environmental sciences are rather positioned in the cluster of natural sciences.

The cluster analysis does not refer to any impact indicator of the publications: We therefore came back to more classical bibliometrics, using Scopus data on the percentage of scientific publications among the world's 10% top-cited publications. The comparison of Finland's performance with the OECD and EU-27 averages in selected fields that most closely correspond to the dominant top-level fields identified by the cluster analysis (see Figure 43 in the appendix) that Finland performs well, most often above the EU-27 average, and most of the time close to the OECD average.

5.2.3 Bibliometric analysis undertaken by the Academy of Finland

In 2021, the Academy of Finland published its own bibliometric review (Mankienen & Leino, 2021). Their approach considered all English language publications with at least one author with Finnish affiliation, in order to derive popular topics and trends in the Finnish research landscape based on a topic modelling algorithm.[22] It is basically in the same spirit as the approach we have taken above, in as far as thematic areas are defined based on publications. However, Mankinen and Leino's approach is geared towards modelling topics at a more fine-grained level than the analysis of publication data conducted above, and they analyse impact, whereas our focus was on closeness of thematic areas.

Some of the main results by Mankinen and Leino include the following:

- "Most of the topics with the highest top 10 indices are related to various aspects of computer science, electrical and electronic engineering, telecommunications, environmental sciences, materials science, as well as business and management." (p 20)
- "In general, there is more international than national collaboration in the identified high-impact topics, signalling that internationally co-authored publications have higher citation impact. However, co-authoring patterns seem to depend on the topic. In some topics there is an emphasis towards international collaboration, while national collaboration is almost an exception. Such topics include many related to telecommunications and electrical engineering" (p 24)
- Validation structural design of the flagship programmes: each of the flagship themes also emerged in our data-driven topic modelling analysis (p 25–26), in which the authors see a purely data-driven validation of the structural design of the flagship programmes.

If one compares these results – despite different methods – with the above, it can be concluded that international visibility is also high in subjects that – like computer science – are in strong international competition.

22 Prepared by CLARIVATE ANALYTICS, Inc, and based upon publication data indexed in the Web of Science® database. The timespan considered was from 2008–2019 (hence considerably longer than the period covered in the database of Academy-funded publications of the Academy). The authors applied an unsupervised natural language processing algorithm to the abstracts, key words and titles of the selected publications, thus deriving a total of >1k research topics (our approach above included 19 top-level fields and ca. 290 first-level fields). Their analysis of thematic areas within the Finnish research landscape, as well as the collaboration networks, proceeds from the result of this topic modelling step. For details, about the methodology, see Appendix H.5.

5.3 Internationalisation

Internationalisation is a priority of the Academy of Finland, expressed both in the overall strategy and in the Academy of Finland's international policy for 2017–2021 (see section 4.1). The Academy of Finland funds mobility programmes by about €1.7m per year. The share of inward mobility in those programmes is about 60%. Far more important is internationalisation funding as part of all the other funding instruments: according to internal estimates, 20% to 25% of overall funding is spent on international activities like mobility, longer-term stays abroad, conferences etc. However, there is no database available that would allow more detailed analysis.

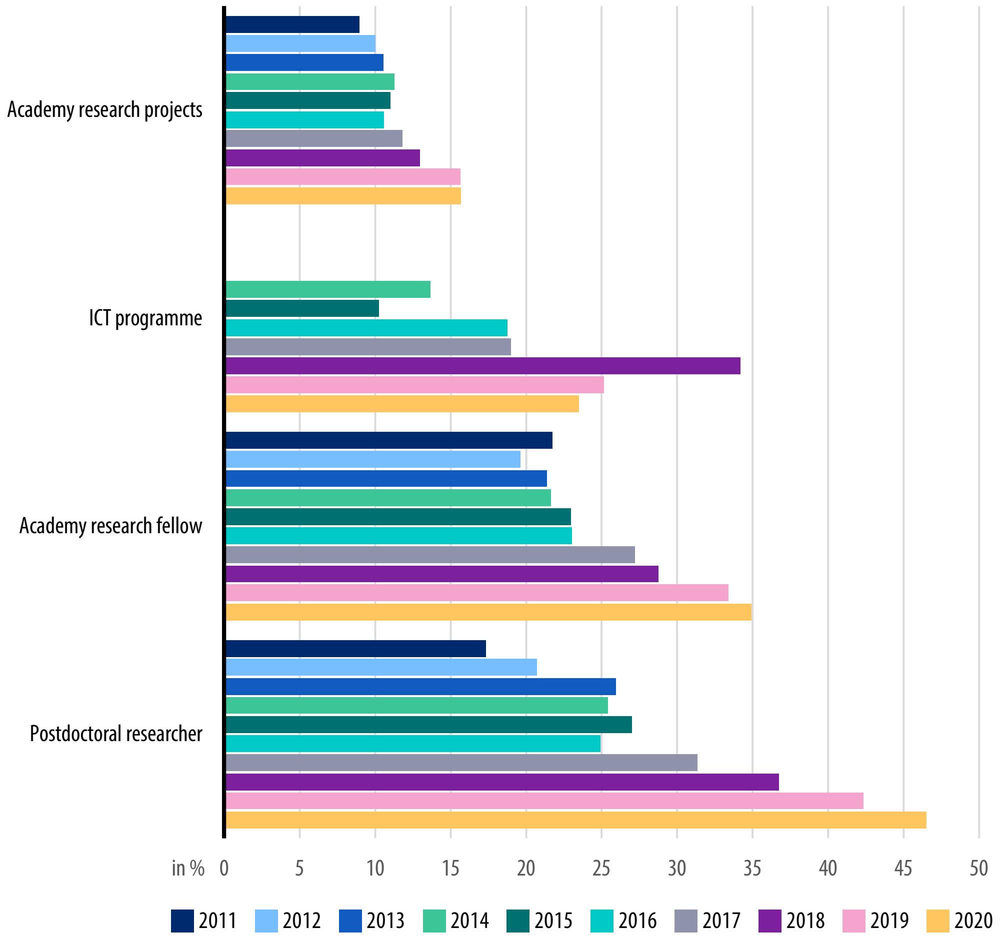
The following section presents data on the internationalisation of beneficiaries of the Academy of Finland, which has increased impressively, accompanied however by a widening in the gap of success-rates between Finnish and foreign applicants. The two other sections cover two dimensions of internationalisation of Finland's research community, not directly linked to Academy funding, but still relevant to understand challenges and success: Section 5.3.2 presents an overview of Finnish participation in EU programmes, a field where Finland's performance is lower than in comparable countries. Section 5.3.3 shows on the other hand that international collaboration in Finnish publications has increased clearly above average researcher mobility.

5.3.1 Funding of researchers from abroad by the Academy of Finland

In recent years, the proportion of international, non-Finnish applicants increased substantially, especially in the group of post-doctoral researchers, followed by Academy fellows. As shown in Figure 29, this holds in particular for postdoctoral researchers, where the share of applications by foreigners more than doubled from 17% in 2011 to 47% in 2020. The share of funded postdoctoral researchers is slightly lower and increased from 13% in 2011 to 42% in 2020. The Academy research fellow programme showed a high increase in internationalisation since 2016, rising from 23% to 35% of applications and 14% to 37% in funded applications.

Compared with individual funding, Academy projects are still predominantly led by Finnish researchers. Until 2016, the share of international PIs was around 10% only, three years later it has increased to 16%.

Figure 29. Percentage of foreign applicants in selected programmes of the Academy of Finland



Source: Data: Academy of Finland. Calculation and presentation: Technopolis Group

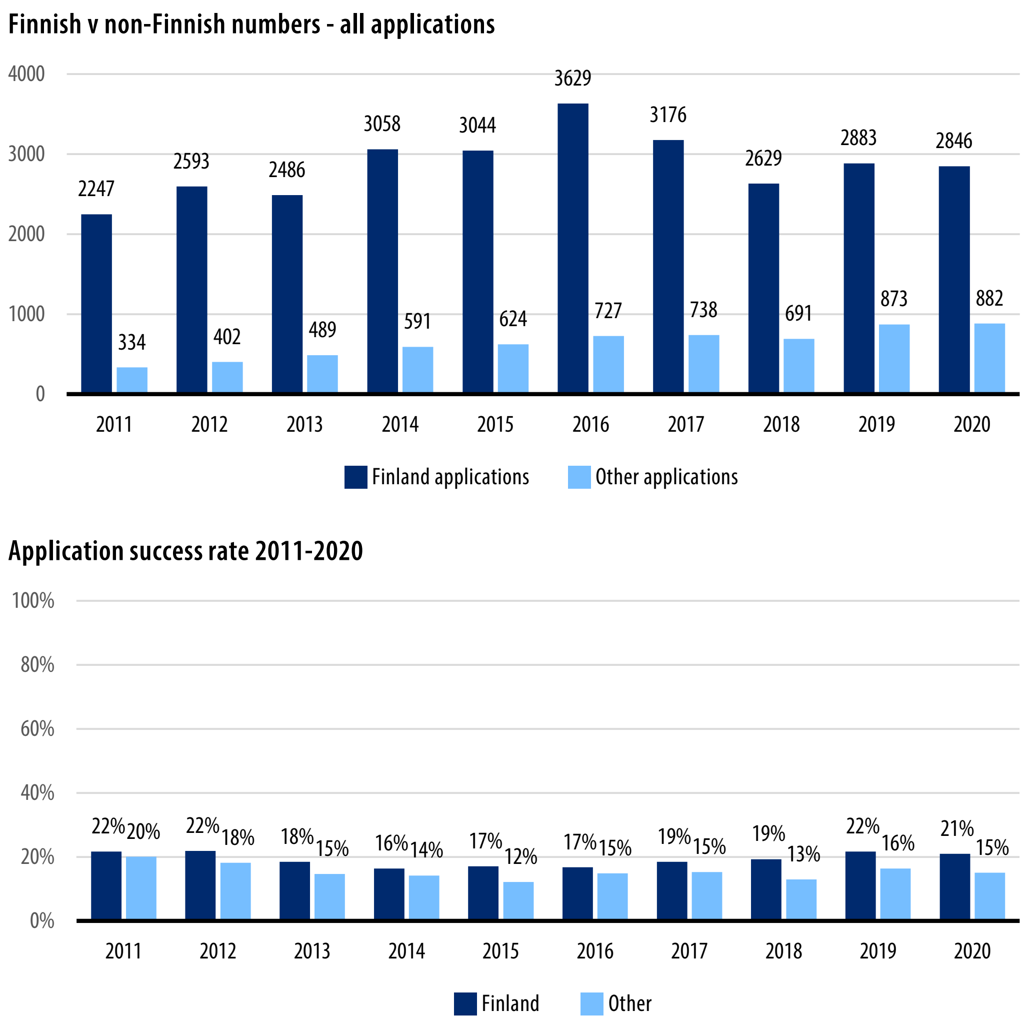
Data on the entire funding portfolio confirm that the share of non-Finnish applicants has increased substantially over the analysed period. At the same time, the success rate of non-Finnish applicants has decreased in relation to Finnish nationals. Non-Finnish applicants' success rates were always slightly lower, but the gap has widened. There are considerable differences between nationalities: in the past, only applicants from outside the EU, UK and USA had substantially lower success rates than Finnish applicants. In 2020 all groups of nationalities have lower success rates than their Finnish counterparts. Chinese nationals are the only exception to this trend.

Table 13. Application and success rates by applicant's nationality

	2011-2020 total				2020 only			
	No. of apps.	% of total apps.	Funded apps	Success rate	No. of apps.	% of total apps.	Funded apps	Success rate
Finland	2,8591	82%	5,464	19%	2,846	76%	598	21%
Nordic countries excluding Finland	277	1%	49	18%	29	1%	5	17%
EU-27 excluding Finland, Denmark and Sweden	2,704	8%	454	17%	339	9%	59	17%
China	630	2%	91	14%	99	3%	21	21%
UK	280	1%	60	21%	37	1%	6	16%
USA	280	1%	60	21%	37	1%	6	16%
Other countries	2,107	6%	235	11%	336	9%	36	11%

Source: Academy of Finland

Figure 30. Application and success rates by applicant nationality



Source: Data: Academy of Finland. Calculation and presentation: Technopolis

These numbers show that the population of researchers in Finland is becoming increasingly international. Data on university staff confirm this trend: 2013–2016 the share of international staff in Finnish universities (career stages III–IV) has increased from 10% to 12%. The growth has been most significant at Aalto University (from 11% to 21%). As Aalto has heavily invested in internationalisation, with substantial funding for recruitment in course of the 2010 renewal, it is likely that most of this development is due to its own actions.

As Figure 29 shows, this internationalisation takes time. Also, researchers from abroad face more difficulties in getting funding for research groups than their Finnish colleagues.

This observation is confirmed by interviews, indicating that the system is not sufficiently transparent to foreigners.

From interviews both with Academy and University representatives we know that the university reform and the introduction of tenure track positions, partly financed in the framework of the profiling programme, has increased the attractivity of Finnish universities for foreign candidates.

ERC grantees in Finland note however a difficulty to access bigger funding opportunities in Finland, for which we do not have statistics on internationalisation, i.e. competence centres or Academy professors. If Finland wants to benefit further from the internationalisation, a key factor of success will be to open leading positions for researchers coming from abroad.

5.3.2 International cooperation at the European level

Fostering international cooperation is one of the tasks of the Academy of Finland. Academy experts act as Finland's representatives on committees of the EU Framework Programme, the Academy is active in Nordic research funding cooperation, and engages in bilateral initiatives (see section 4.8). In cooperation with Business Finland, the Academy provides support of applicants seeking funding.

Most importantly, the Academy sponsors partnerships with the EU and European funding agencies and market them to researchers through thematic ERA-NET and JPI calls. In 2014–2019, the Academy participated in more than 30 EU-based networks and funded their calls with €32.2m. EC funding for these projects was €6.04m. The Research Councils decide on the priorities, based on their proposal, the Board allocates the annual funds. Competition at the European level is very high. According to stakeholder interviews, the Academy does not put a lot of budget into individual ERA-Net calls – about 1–3 projects are funded by call. Other countries like Norway or Sweden are more active.

Finland's performance in Horizon 2020 is not among the strongest, with a low success rate, and a comparably low number of ERC principal investigators and MSCA participations.

Table 14. Comparison of Finland's Horizon 2020 projects with other EU Member States

	Participation* (share of EU total)	Net EU Contribution** (share of EU total)	Applications*** (share of EU total)	Success Rate****	ERC Principal Investigators	MSCA Participation
Finland	3.438 2,24%	€1.52bn 2.53%	21,985 2.5%	13.1%	153 2.22%	425 1.59%
Austria	4.975 3.25%	€1.94bn 3.2%	25,568 2.9%	16.07%	247 3.58%	717 2.68%
Germany	20.310 13.25%	€9.92bn 16.41%	107, 320 12.23%	14.94%	1,348 19.55%	3,356 12.56%
France	16.766 10.94%	€7,3bn 12.09%	77,784 8.83%	15.25%	913 13.24%	2,730 10.22%
Denmark	3.897 2.54%	€1.73bn 2.86%	23,835 2.71%	15.13%	193 2.8%	1,022 3.82%
Norway	3.155 23.59%	€1.67bn 27.7%	17,548 21.12%	15.13%	113 9.74%	441 18.63%
Sweden	5.090 3.32%	€2.28bn 3.77%	29,397 3.34%	14.61%	280 4.06%	879 3.29%
Netherlands	10.759 7.02%	€5.21bn 8.62%	55,801 6.33%	16.03%	739 10.72%	2,107 7.88%

* Number of Organisations involved in Horizon 2020 projects

** Funding received by the project's participants after deduction of their linked third parties' funding (in €)

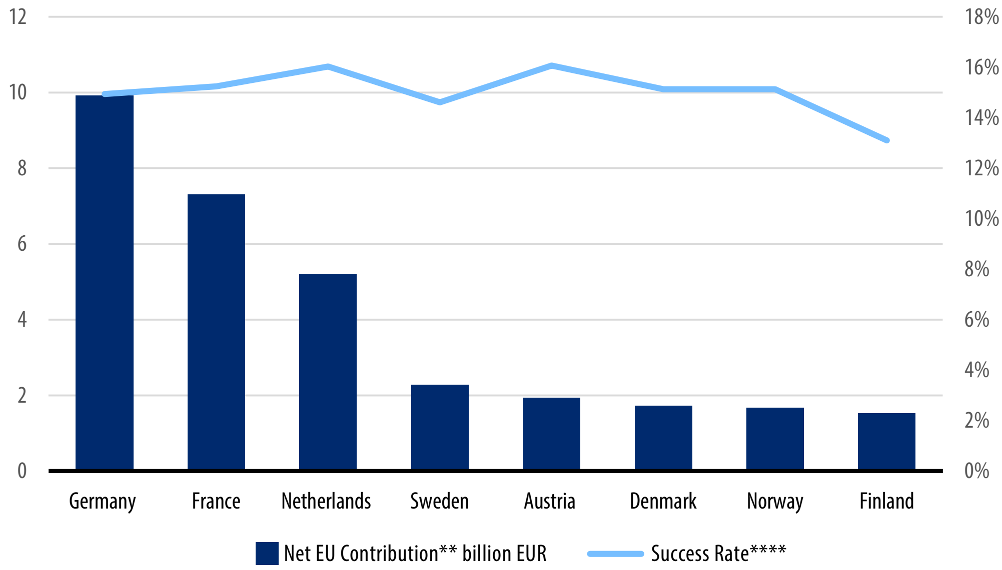
*** Number of Organisations applying for Horizon 2020 grants.

**** Ratio of the retained proposals to the total number of eligible proposals received

Source: H2020 Country Profile for the selected countries, access November 2021, https://webgate.ec.europa.eu/dashboard

Table 14 shows that among the smaller countries, Finland ranks last in terms of participation in Horizon 2020, partly due to the low success rate.

Figure 31. International comparison, participation in H2020, Net EU Contribution per country, total success rate



Source: H2020 Country Profile for the selected countries, access November 2021, https://webgate.ec.europa.eu/dashboard

As shown in Figure 6, EU funding represents 7% of university research expenditure, compared with 24% coming from the Academy of Finland. In case of European funding, VTT is the most active organisation in Finland, followed again by the three Universities receiving the biggest budget from the Academy. Compared with others, for the University of Eastern Finland and the University of Turku EU funding covers a bigger share in total research funding.

Table 15. Organisations in Finland with the highest participation in Horizon 2020

	Top Organisations according to funding received (> €20m)	Net EU Contributions (€m)
1	VTT	256.9
2	University of Helsinki	196.98
3	Aalto University	132.45
4	Tampere University	92.74
5	University of Oulu	57.11
6	University of Eastern Finland	45.56
7	University of Turku	35.09
8	University of Jyväskylä	33.9
9	Luke – Natural Resources Institute Finland	33.24
10	Finnish Metrological Institute	27.6
11	CSC – IT Centre for Science	24.4

Source: H2020 Country Profile Finland, access November 2021, https://webgate.ec.europa.eu/dashboard

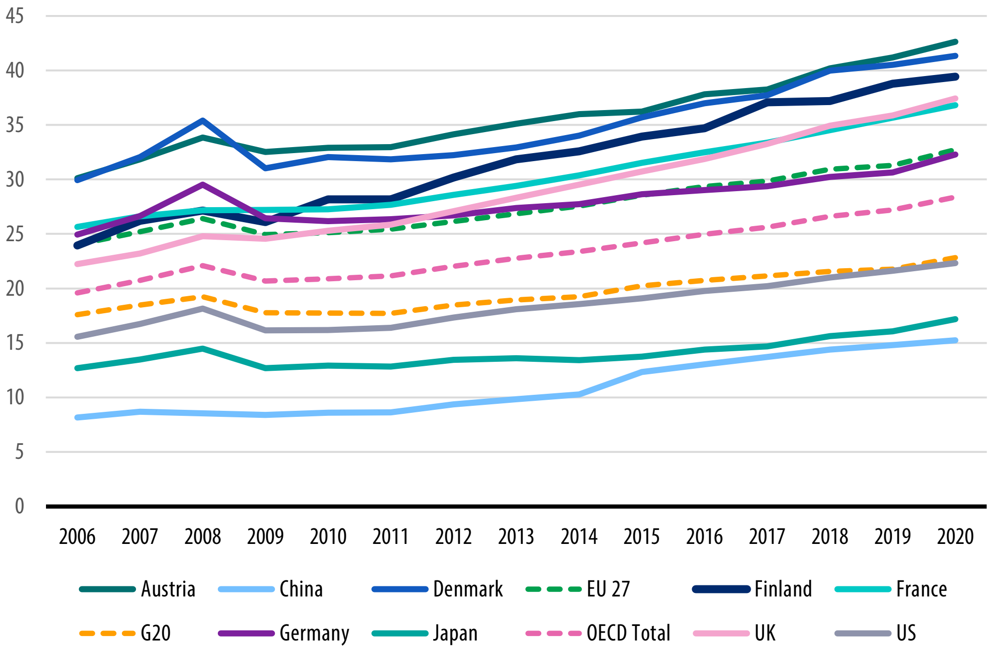
Given the present performance of Finland, there is probably room for improvement, which seems however limited by available resources, as reported by interview partners. According to our interview partners, the Academy has the competence to increase these activities, there would be a high potential to better support international collaboration, but there are budget constraints both in terms of personnel and funding. From the Academy perspective, most funding for international collaboration comes from normal projects.

5.3.3 International co-publications

Between 2000–2020 the share of international co-publications grew from 35% to over 60%. The absolute growth of international co-publications is even greater, as the total number of publications has also more than doubled. Over the last decade Finland seems to be overtaking Norway and closing the gap to Austria and Denmark. This development could be related to changes in the funding model of universities that took place at the beginning of the 2010s, in which there came more attention for international peer-reviewed publications.

This analysis is based on publication data (based on Scopus Custom Data, Elsevier) as presented in the OECD Science and Technology and Innovation (STI) Scoreboard, comparing with the OECD and EU-27 averages and selected countries. The first chart presents the percentage of publications involving international collaboration: here, Finland shows a growth above average, moving from 23.9% in 2006 (the EU average at that time), to 28.2% in 2010 and 2011 and since then continuously rising up to 39.4% in 2020. This is substantially higher than the EU average (32.7% in 2020) and close to the level of Austria and Denmark, countries comparable in size, but starting from a higher level.

Figure 32. Percentage of scientific publications involving international collaboration

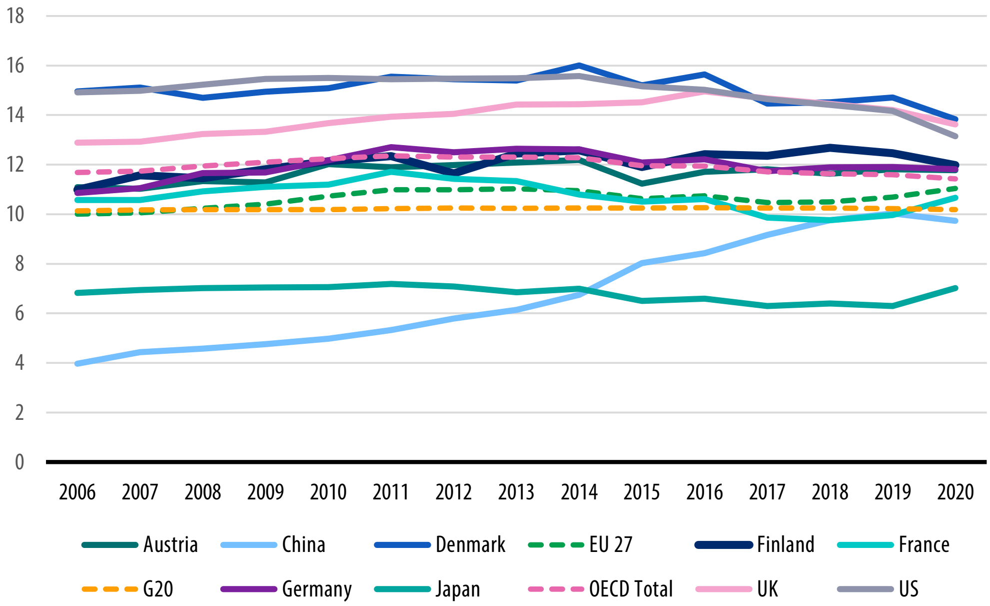


Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 5.2021, September 2021.

Note: International collaboration refers to publications co-authored among institutions in different countries. Estimates are computed for each country by counting documents for which the set of listed affiliations includes at least one address within the country and one outside. Single-authored documents with multiple affiliations in different countries count as institutional international collaboration.

The second chart compares Finland internationally in terms of excellence, taking the percentage of scientific publications among the world's 10% top-cited publications as an indicator:

Figure 33. Percentage of scientific publications among the world's 10% top-cited publications (fractional)



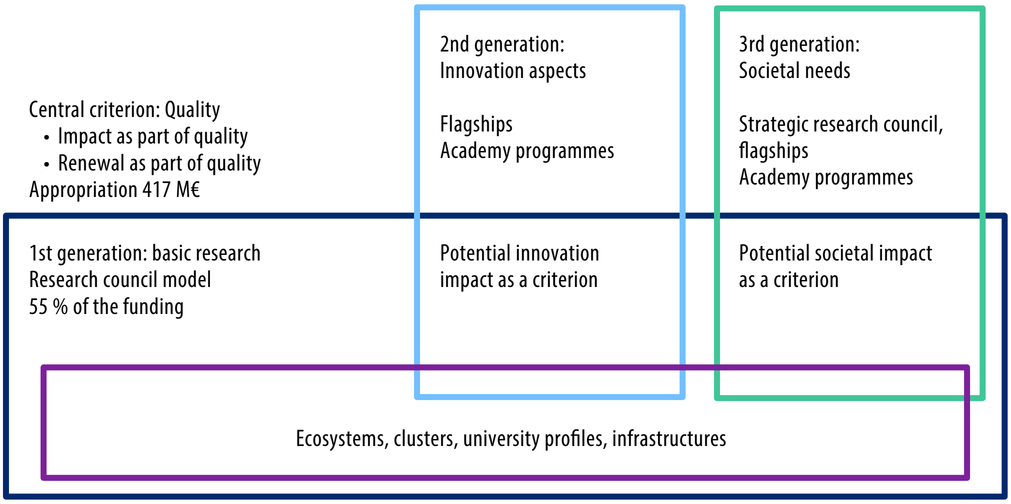
Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 5.2021, September 2021
Note: The top 10% most cited documents is an indicator of 'excellence'. This rate indicates the amount (in percentages) of a unit's scientific output that is included into the group of the 10% of the most cited papers in their respective scientific fields. It is a measure of high quality of research output of a unit, in this case the country. The indicator of scientific excellence is calculated at the document level using fractional counts by authors affiliated to institutions in each economy.

Finland performs close to the EU-27 and the OECD average, as do Germany and Austria, but less well than Denmark, UK, and the USA, with no substantial change in the observed period.

5.4 A change agent in the science system?

The Academy of Finland engages has a core identity as classical funding agency but describes itself as also engaging in second and third generation research governance as depicted in a chart presented at the opening of the panel review in June 2021 (Figure 34).

Figure 34. Academy of Finland in 2021



Source: Academy of Finland, Presentation to the evaluation panel, 22 June 2021

With this new approach introduced broadly in 2014 and since then continuously increased, the Academy addresses not exclusively research excellence but ecosystems, which can be understood as the interaction of different type of actors in self-regulated systems. The Academy has various instruments for this, mainly Flagships and Academy programmes (which existed already before 2014), the Strategic Research Council, Profiling Funding, and Infrastructure Funding. Recommendations of the previous international evaluation of the Academy (2013) have been used for policy planning.

On the process level, this new orientation calls for new competences and procedures in the selection of applications. As with first generation bottom-up funding of individual researchers, projects and centres of excellence/research groups, the Academy mainly relies on selection committees and panels, but introduces new expertise, to cover potential economic and societal impact. For Infrastructure Funding, a representative of Business Finland is involved in the selection process as member of the FIRI committee. Representatives from BF and/or the industry are included in the Flagship Impact Panel.

The following sections discuss the impact of the new orientation in four dimensions: starting with the universities' perception of societal impact as a funding criterion, we then discuss the impact of Flagships, Profiling, and Infrastructure Funding.[23]

5.4.1 The new requirement of societal impact in research funding perceived by universities

Universities interviewed observe a noticeable impact of Academy funding on the societal relevance of their research. Some universities indicated that the requirements for societal relevance in some of the funding instruments have brought about a new way of thinking in research, has raised the levels of inter-disciplinary cooperation within and between universities, and has led to more cooperation amongst different actors. Particularly instruments such as the strategic profiling instruments and strategic research council instruments have played important roles in emphasising and pursuing societal impact within research. Researcher funding instruments also trigger questions and reflections on the societal impact of the research to be conducted; while some interviewees consider this a positive development in the thinking of applicants, other universities interviewed feel that the emphasis on societal impact is too strong. In the first instance because it is difficult to know what the outcomes, let alone societal impact will be of a research project and in the second instance, because they feel that societal impact should not come at the cost of the quality of excellent research. Top researchers see themselves as being obliged to add impact stories to their research proposals, which they see themselves as unqualified to write and which they feel have limited relevance, because they regard research excellence as the precondition for realising societal impact.

While universities appear to appreciate the importance of societal relevance in research, some interviewees do describe a tension between societal relevance of research and research excellence and sound expertise. Fundamental, basic research tends to be a long-term process and is risky. One must think in time spans of 5 to 10 years – and much longer than this in some fields – when considering fundamental research and outcomes, and results are never certain. Several interviewees indicate that by safeguarding research excellence, as they note the Academy strives to do, societal relevance will ultimately follow; good research has a better chance of aiding societal issues in the long run.

23 A separate evaluation of the SRC, hosted but independent of the Academy of Finland, has been conducted in parallel to this evaluation.

There is a nuance here between the UAS and research universities, however, where the UAS indicate that their missions are naturally geared towards societal impact of research, so the Academy's increasing interest in impact does not affect them.

5.4.2 Flagships

The aim of the Academy of Finland's Flagship Programme is to *'pool together expertise from different fields in Finland to form high-level research and impact clusters that will further contribute to increasing the quality and impact of Finnish research. A flagship is an effective mix of cutting-edge research, impact in support of economic growth and/or society, close connections to the business sector and society at large, adaptability, and a strong commitment from host organisations to meeting the set targets. Flagships are high-quality, high-impact competence clusters that work in flexible ways, simultaneously running several research projects and other activities.'* (Flagship programme call text, 2018).

After a third call, the Finnish Flagship Programme now comprises ten Flagships, whose host organisations include seven universities, five research institutes, Helsinki University Hospital and the Finnish Red Cross Blood Service (Academy of Finland, 2021c). Flagships are funded bottom up and selected by a subcommittee of the Board, based on reviews from expert panel(s) and on interviews by both the panel and the subcommittee. Further funding instruments like the partnership programme between the National Institutes of Health (NIH) in the USA and the Academy of Finland, launched in November 2020, explicitly addresses Flagship themes and are managed by the Flagship Programme subcommittee.

Although the Flagship Programme is an Academy funding instrument, most of the funding for Flagships comes from others. According to the call text (Academy of Finland, 2018) *'Host organisations must be prepared to make a significant, steadily increasing investment in establishing and supporting the flagships. Allocating funding not to individual research teams but to organisations that have a strong commitment to the Flagship Programme is a way to support the long-term development of competence clusters and their high-quality research and broad impact.'* There is however no threshold defined for the overall size or the share of host or partner funding. Data from the recent mid-term evaluation of the Flagship programme show that the total funding of the first six Flagships was €530m after first two years of their operation, the Academy Flagship funding is only a small part of that. The major sources of funding funders are:

- Host organisations 38%
- Academy Flagship funding 3%
- Other Academy funding 14%.

- EU funding 16%.
- Business Finland 6%
- Companies 7%.
- Other domestic funders and in-kind funding 14%

Flagships are an important instrument for policy and for the Academy. Expectations are high: '*The Flagships create future know-how and sustainable solutions to societal challenges and promote economic growth by, for example, developing new business opportunities.*'(ibid.). This introduces a new role of the Academy of Finland, directly addressing business opportunities., Centres of Excellence were also well positioned to address societal challenges and provide knowledge to economic actors. However, before the Flagship programme, this was not part of the overall goals of the Academy. This change goes in hand with the national RDI roadmap partnership model '*to strengthen, broaden and increase the impact of the clusters of excellence in order to bring together the networks that support research and its exploitation into larger clusters and ecosystems of excellence.*' (Academy of Finland, 2020c)

So far, it is not clear how this programme will be evaluated at the systemic level. According to the Academy of Finland (presentation to the evaluation panel, June 2021), the Flagships 'have realised the combination of excellence, already demonstrated impact, renewal, support from host organisations.'

Stakeholder feedback from interviews underlines the systemic change in the role of the Academy and is partly more sceptical: the selection process of Flagships involves scientific experts assessing research quality, but also completely different experts, for economic and societal questions. With this approach, the Academy has started facilitating different kinds of interaction with other actors, going beyond its traditional competence. In the longer run, it will be important to see, how well this works, and how the inter-agency cooperation in particular with BF is further enhanced, so that industrial developments are systemically taken into consideration.

Flagships are seen by interview partners as a way to '*educate researchers to think about applications*'. It is not yet clear whether the Flagships work well for the companies – it is an attempt to reach out to the industrial ecosystems. '*Flagships suggest that researchers should be encouraged either to know their impacts or to know who in the system will generate them*.' The key question is whether Flagships will indeed fill the hole left by Tekes 'as a new attempt to show the path from fundamental research to applications, combining the role of the previous Tekes and the Academy'. Some Flagships work very well, however, according to an interviewee, 'there are so many Flagship projects, that Finland is clearly not among the best in all of them.' Impact is very long-term, and it is not sure whether researchers know the pathways to impact.

Taken together, Flagships and profiling have some potential not only to shape science-industry relations but also redistribute resources between universities and between faculties. It will be important to have a critical and independent evaluation of the Flagships, assessing their performance in the broader, systemic context, identifying additionality of both the funding and the labelling effect on visibility. At the present stage there is a lack of evidence to provide an external evaluation of the impact. It will be worth investing in evidence on the outputs and outcomes of the two funding instruments, their effects on both on the profiling of beneficiaries and the new shaping of science industry relationships.

5.4.3 Profiling

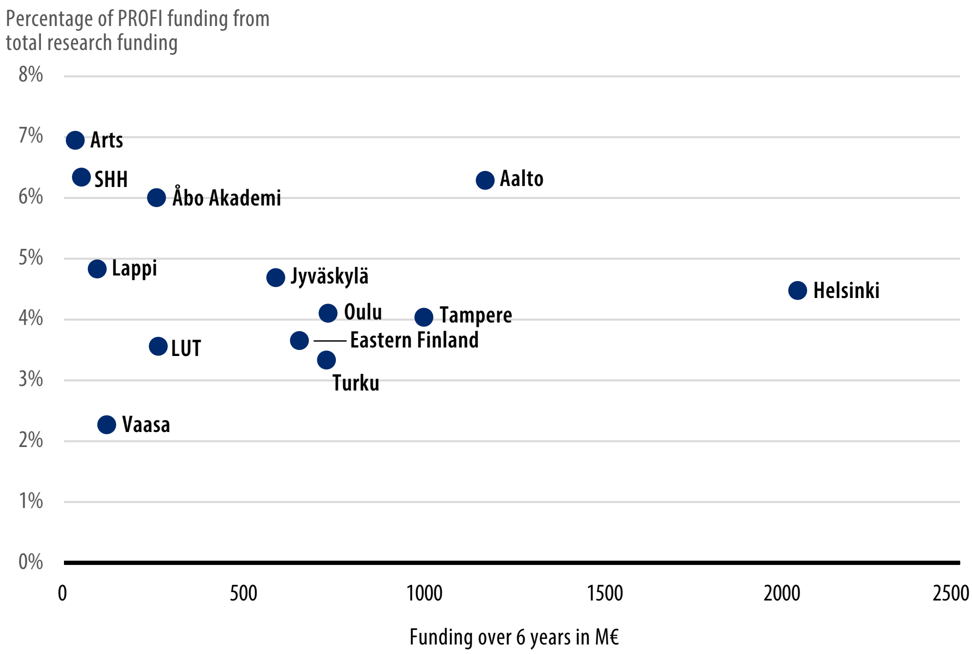
Finland's Ministry of Education, Science and Culture decided in 2015 to move €50m from the budgets of Finnish universities to be channelled through the Academy of Finland. Universities have to submit plans about their research strategies and goals for several years ahead. The duration of profiling grants was extended from four to six years in 2020. These plans are reviewed by an independent panel of rectors from universities outside Finland.

Feedback about profiling from interviews with university representatives and ERC grantees is contradictory. On the positive side, the importance of peer reviewed research in steering universities is increased, and universities say they have indeed strengthened their research profiles. According to one interviewee, '*the biggest impact on the Finnish R&I system comes from the instruments that provide big and long-term funding, which are at the same time bottom up, such as the university profiling funding, which is quite significant. This has changed the way of thinking; it has improved the quality and sharpened the universities' thinking about the long-term perspectives.*' On the other hand, there are more critical views, stating '*We get funding from the ministry of education based on a financial model, for training and research. If you look at the percentage of funding, how much we can get from profiling money, those numbers converge. The steering effect becomes insignificant, but it creates a lot of work at universities. The research groups within the universities compete. The net value has been insignificant. The work at universities very much consists in administration efforts … it is our 5th or 6th round, the quality of proposals increases, this costs one fulltime person. But there is not more money available, universities compete with each other with low impact.*' Internally, this leads to competition between faculties, potentially resulting in a rather general description of priorities. On the other hand, it is recognised that profile funding greatly strengthens the ability of rectors to devise and implement strategies.

The total annual volume of PROFI funding is €50m. PROFI funding has been allocated to 14 universities (since 2019 to 13 universities after merger of the University of Tampere and Tampere University of Technology). The sums granted have varied between €350k and €28m. In the latest round, the Academy granted a total of €100m as the PROFI rounds are at present organised biennially.

Figure 35 shows that PROFI funding, which was taken from the indicator-based basic contractual funding from universities, led to a redistribution of funds between universities. According to the evaluation in 2019, PROFI funding had more effect on the strategic performance of the smaller than the bigger universities. The granted PROFI funding per university has varied between the profiling calls. The unpredictability of the funding has been perceived as a challenge. In each PROFI 1–6 call, some universities have not received any funding at all.

Figure 35. Total research funding (over 6 years) and the percentage of PROFI funding from total research funding



Source: Academy of Finland

The universities have allocated PROFI funding to a total of 99 profiling areas, which is rather a lot – it should be expected that the number of areas declines and that the interaction between profiling areas increases, as for instance Flagships and SRC projects mostly involve more than one university. So far, according to the evaluation, the impact of PROFI on steering the division of research labour among the universities is however weak. The universities have used PROFI funding primarily for tenure-track recruitment. In addition to salaries, the funding is used for materials, supplies and goods, instruments, services, travel, research infrastructures and other costs.

PROFI is perceived as being more valuable than the amount of money involved would suggest. According to the mid-term evaluation, PROFI has enabled more agile profiling at the universities than would have been achievable without the funding. It has succeeded in speeding up the strategy-based research profiling of Finnish universities and had an impact on Finnish universities internally. The PROFI instrument has succeeded in reducing fragmentation within disciplines and enhanced interdisciplinary and multidisciplinary cooperation in research themes selected by the university. The evaluators note that the funding instruments have had a cumulative effect. For example, the Flagships, for which universities apply, are based on their profiling areas.

This view is also supported by the feedback from the evaluation panel of the 5th PROFI call (February 14, 2019): '*The Profiling process was very successful in accelerating the implementation of the strategies of the Finnish universities. Several Panel members observed a clear improvement in the formulation of the applications over the five rounds of Profiling funding. The universities learn from each other and move up together.*' More detailed and also critical assessments and recommendations were formulated in the feedback of the panel of the 3rd PROFI call,[24] putting particular emphasis on increased attention to the continuity in the proposals for profiling actions, and that the profiling actions could be more specific, as compared with their rather generic approach so far: *'(T)he universities should concentrate on the profiling actions in which they already are or will be in a short term, successful. This also implies that the profiling actions could be more specific, as compared to the rather generic characterisation they are now described with. Most universities refer to the "standard" global challenges, such as "demography" and "health", "sustainability (with climate included)", "information technology opportunities", etc. But these are very generic drivers, cited by everybody. But what are the specific research questions? When will there be successes or failures? What will be the international competition? Who are the international peers and benchmarks?'* They also suggest that more attention could be devoted to other profiling action instruments than tenure track positions, like measures for more internationalisation, publication strategies (not only numbers but also impact), technology transfer initiatives, research based educational

24 Chair's recommendation, Prof. Dr. Bart De Moor ESAT-STADIUS KU Leuven Belgium, containing suggestions and additional remarks collected during the convening of the Panel meeting for the 'Competitive Funding to Strengthen Universities' Research Profiles', during a two-day meeting at February 14–16 2017 in Helsinki at the premises of the Academy Finland, which was chaired by the author of these recommendations.

initiatives, science outreach initiatives, etc. – this suggestion is repeated the next year, as well as in 2019, where in addition, it is recommended '*to exchange good practices among the Universities for the process of evaluation of tenure track professors.*'

Interviewees from universities confirm that PROFI funding has helped them to reflect more clearly on their identities and their longer-term strategies. While this had been happening to some degree before, the funding instrument has helped to bring this process further. Universities also indicate that this funding has helped their branding internationally and has led to more cooperation with other universities in Finland and more international cooperation as well. The strategic profiling instruments have helped to renew the universities' strategies and their research activities, indirectly contributing to the quality of the overall research area in Finland.

Further, some universities interviewed indicate that, beyond facilitating strategic profiling and branding, cooperation, and internationalisation, the profiling funds can also be used rather flexibly within a university. This means that they can also be used to balance areas and practices for which research funding was not won.

At the system level, interviewees describe the following impacts: first, the funding was mainly used for tenure track positions, and these turn out to be a pillar for the attractivity of the Finnish research system, which is – next to the profiling of universities – a positive effect on the research system. Second, channelling this funding through the Academy increases the strategic importance of research in the HEI, compared with, e.g. regional or educational goals. As for Flagships, to assess the institutional impact of PROFI, there is certainly a need to evaluate this in a broader strategic context, taking into consideration other funding instruments as well as the longer-term development of universities.

5.4.4 Infrastructure

In 2014, the Finnish Research Infrastructure Committee (FIRI Committee) was established in the Academy of Finland. Since then, the Academy has had a central role in funding research infrastructures, monitoring and developing Finnish and international research infrastructure activity and developing a long-term plan for research infrastructures for the Board of the Academy of Finland. The 10-year strategy for national research infrastructures in Finland (published in 2020) sets the overall targets for the development of the national research infrastructure landscape to support high quality research and its impact. The roadmap for Finnish research infrastructures is developed based on the strategy and defines the significant national research infrastructures within the Finnish research infrastructure ecosystem. It includes a list of selected roadmap infrastructures for 2021–2024 (N=29), an analysis of the research infrastructure landscape, and the Finnish partnerships in ESFRI projects (European Strategy Forum on Research Infrastructures) as well as international infrastructures where Finland is a member state.

Funding provided by the Academy of Finland for the research infrastructures supports them in four ways:

- Finland has been the member of a number of international research infrastructures like CERN, EMBL, EMBC, ESRF, ESO or FAIR, already before the Research Infrastructure Working group and later the Infrastructure Committee existed. The annual budget for the big infrastructures is €18m. As the budget available has not increased in line with increases in the costs, they have partly to be covered by FIRI funding, originally meant for national infrastructures

- €18.5m is used for building new national or international RIs or upgrading the old RIs and the membership fees of international RIs. The RI-Roadmap defines funding principles for four categories of RIs. According to Academy data, FIRI funding was 17% of the total funding of these national RIs included in the previous roadmap (2014–2020). Other important funding come from the own organisation, other domestic actors, and the Ministries. FIRI does not fund usage fees of infrastructure, these are covered by other funding instruments

- In 2021 and 2022, FIRI steers parts of the non-recurrent RRF funding opportunities of €20m and €30m respectively, with the objectives to promote digitalisation of research infrastructures and green transition, and funding periods from 2022 to 2025

- Costs of the use of RIs are eligible costs in the other Academy funding (e.g. academy projects, centres of excellence)

Based on these key figures, as well as interviews both with representatives of the Academy and of universities, we come up with various observations:

On the very positive side, the structured selection process is appreciated, as summarised by one interviewee. *‘The research infrastructure committee was formed, the road map for research infrastructure defined, with clear criteria. If you are on the roadmap, you can apply for money from the Academy. We do not have overlapping infrastructure; the money is used in much better way. Previously it was first come first served, wild west. Now it is a very well administered process.’*

However, there is unanimous agreement that the budgets are too small, and due to this, FIRI may have only a limiting steering effect: '*Agenda setting should not mean that they define the themes, but for example when it comes to defining of suitable level of research infrastructure funding in Finland. Here the Academy should have a say on the fraction in comparison to other instruments.*' '*The research infrastructure funding should be increased quite substantially … there are so many actors in practice, it is co-funding, international players and agreements.*' '*The Academy of Finland has instruments for infrastructure, but funding is low and only covers a narrow part of infrastructure, in comparison to Germany.*' '*The role of research infrastructures has not been realised. A big part of the money goes to CERN. Top science is much more dependent on infrastructure – there is an allocation challenge.*' '*Huge concern in the whole system. Lacking behind in infrastructure leads to lacking behind of research.*'

As for PROFI, the feedback from FIRI panels gives relevant insight on the quality and challenges with regard to the funding applications: First of all, the Chair's memorandum in 2021 offers a very positive judgment of the scientific quality: '*The applications compared favourably by international comparison. The Chair has served on the FIRI Panel for the last three years. From year to year there has been a clear improvement both with regard to the average quality of the applications as well as the number of outstanding or strong excellent applications. Both the number of outstanding applications and average quality of applications had improved most noticeably from 2020 to 2021. A significant number of the applications submitted to FIRI 2021 would likely have been considered competitive in equivalent calls in leading scientific nations.*' They also very much appreciate the organisation by the Academy: '*The panel felt that the organisation was outstanding. It was not only well organised, but expert guidance was also provided by the Academy staff at each stage of the review process. The agendas were very full and the review process demanding. However, due to the friendly, competent support from the Academy team, it was nevertheless an enjoyable and highly valuable engagement*.'

By centralising and structuring information on research infrastructure, the Academy of Finland sits on a goldmine of information, which is so far underexplored. In this sense, the 2021 panel recommends: '*to request a "RI landscape analysis" in the application. Such an analysis would provide information regarding the already existing RIs in the specific field of the application. In other words, the panel felt it was important to know if something already exists and whether the applicant "openly" mentions other complementary or competitively relevant RIs as well as efforts to harmonise or cooperate have been made. Interoperability between RIs in related fields is of major importance.*' We would go beyond this perspective focusing uniquely on RI from the perspective of coherent public funding but establish a data management system that makes it possible to analyse the Finnish research landscape from a portfolio perspective.

5.4.5 Science communication and policy advice

According to the self-evaluation report, 'the Academy administration office has a small communications division, whose task is to organise the communication with applicants and the scientific community, to participate (with universities and research institutes) in communicating science news to the general public, and to take care of the organisation's communication and media relations. Most of the available resources are used for communicating the details of application procedures, and in general science policy tasks.' In addition, the Academy participates in national events like the Year of Research-based Knowledge 2021 and is involved in international working groups. However, there are no resources to reach out to other domains beyond communication of the Academies activities, or to involve new target groups, like citizens via citizens research activities, arts-based research or new more experimental approaches in assessing societal relevance of research. This would however be an important area to develop in order to engage in third generation research governance.

One of the three duties of the Academy is 'to serve as an expert organisation in science policy development and implementation'. The most important output in this respect is the 'State of Scientific Research in Finland' report, produced by the Academy since the late 1990s. The materials produced include statistical and bibliometric analyses of research funding, research personnel and scientific publishing as well as analyses of specific themes. Other activities in science policy development are of course the development of the funding instruments of the Academy itself, but also participation in the RIC. In addition to formally defined activities, the Academy is in regular more informal exchange with universities, other funding organisations, in particular Business Finland, and participates in European committees and Science Europe.

6 Conclusions

Our overall conclusion is that the Academy has managed to do an outstanding job in the last decade, but that broader developments have weakened the overall coherence of Finnish R&I policy. This Chapter discusses the drivers of change acting on the Academy, the performance of the Academy and its contribution to impact.

The past decade in Finland has been a period of stagnation in both public and private R&D budgets and a loss of vision and systemic perspective at the level of recent governments. That loss is especially important today, when – with good reason – R&I policies are increasingly trying to address societal challenges. There is an urgent need at the national level not only to correct the policy failures of the last decade but also to reorientate policy towards these challenges. This is not only because some of the challenges pose existential threats to Finland and to humanity, but also because others' efforts to tackle them will lead to phasing out important economic activities, creating new markets and opportunities, from which Finland cannot afford to be excluded.

During the decade, the Academy has been assigned important new tasks and increased its operational efficiency. However, this has been at the cost of opportunities to innovate, reflect and learn sufficiently from its operational experience, advise on science policy (beyond the very useful ongoing review of the state of science in Finland, which it has published for some decades), and play a bigger role in increasing the internationalisation of the Finnish R&I system. The Academy has nonetheless had an important positive influence on the quality of Finnish research and the development of the research community. There are opportunities to extend this influence and the contribution of the Finnish R&I system to addressing societal challenges in the future.

The following conclusions are presented in line with the structure of the evaluation framework, recognising the role of research funders as potential change agents. Special attention is paid to external and internal drivers of change, the Academy's behaviour and performance, and its impacts.

6.1 Drivers of change

6.1.1 The context

During the last decade, successive governments have given low priority to maintaining a systemic view of R&I policy.

- GERD as a share of GDP has declined by roughly one percentage point from 3.75% to 2.75% during the last decade, and then stabilised for the last few years. Nokia's decline has been a major factor in this, as has a series of government decisions to cut funding for technology programmes in Tekes and more recently Business Finland. While governments have promoted, and still back, a target for Finland to spend 4% of GDP on GERD, this has not been reflected in R&I funding. Leaving aside transfers from the institutional funding of the Universities and research institutes, there has been only in a slight upward shift in funding to the Academy, at the same time as it has been given several new tasks

- At the policy and institutional level, the reduced role of the RIC as the national 'arena' for strategic policy development has weakened the institutional foundations for policy definition and guidance. Science policy, which by its nature has a long-term and international perspective, is challenged by short- and medium-term objectives, including the focus on the educational mission of universities, which are additionally influenced by regionalisation objectives. Despite the existence of a government programme and a roadmap, there has been a policy vacuum and lack of commitment to R&I policy, which can hopefully now be remedied, based on a new cross-party consensus

- Internationally, research is increasingly expected increasingly to address societal challenges. While the Strategic Research Council provided a useful start, unlike other countries, Finland has not evidently reprogrammed significant amounts of R&I effort towards the societal challenges or made organisational responses to these challenges

- Three major institutional reforms have been implemented: (i) the university reform in 2010, granting financial and administrative autonomy to the universities, and followed by several mergers of universities; (ii) the overall reform of the Government's research institution and financing (TULA Reform) following a decision in principle made by the Government in 2013, applying to merge and corporatise research institutes, deepen cooperation between research institutes and universities, develop new forms of financing research supporting new decision-making; and (iii) the creation of Business Finland (BF) in 2018, by merging Tekes and Finpro. The aim of the merger was to create a continuum from innovation, through start-up and business development, to support for companies to internationalise

- The creation of BF exacerbated the pre-existing shift in Tekes away from technology programmes and towards entrepreneurship support, which means not only that there is substantially less funding for applied and technological research than before but also a steep reduction in the capacity within the funding system to deliver it. The Academy is therefore working within an incomplete R&I funding system, and this is an important constraint on its ability to impact the performance of the national innovation system as a whole

- The main goal of the Universities Act (2010) was to strengthen excellent fields within the university system towards the international level. Micro-management by government was deliberately reduced, in line with international practice in increasing the autonomy of universities, and thus steering via money flows rather than via detailed instructions. The Academy was subsequently required to support government's ambition for strategic profiling of the universities via a new programme

6.1.2 Ministry of Education, Science and Culture, steering of the Academy

Each of these changes affected expectations about the Academy's role. Four new programmes were implemented: the research infrastructure programme (FIRI); the Flagship programme, addressing cooperation with industry and society; the Profiling programme addressing universities (funded by moving money from the universities' institutional funding to the Academy for the purpose); and the Strategic Research Council, addressing societal challenges (funded by moving institutional funding from the state research institutes). Correspondingly, the need for strategic intelligence and policy advice from the Academy increased, though it is not clear that there was much demand for it beyond MEC.

- The Academy has been given important new tasks, while not being told to cut back or stop any existing ones. However, the amount of new money provided by the government during the period has been modest[25]

- Formal steering of the Academy happens at three levels:[26] Regulatory adjustments had an important impact, with an amendment of the law in 2014, changing the structure of the board, the roles of the research councils, and establishing the Strategic Research Council and the Research Infrastructure Committee. Annual budgets are defined in a yearly cycle and must finally be adopted by the parliament as part of the overall government budgetary process. Apart from specific funding for the SRC and Profiling, the Academy is autonomous in defining the use of the budget, while taking into account objectives agreed with the ministry. Compared to this, annual performance contracts and KPIs have a minor role in steering. Good overall performance does not guarantee any bigger budget

- Informal steering through information exchange is an integral and useful part of agency steering.[27] The informal element is also present in science policy advice of the Academy and in the Academy's engagement in a broader dialogue.[28] The President has a central role, as the main representative of the Academy, for example in (inter-) ministerial commissions or the parliament. A strengthened RIC and the adoption of a holistic R&I strategy would increase the need for formal communication and transparency

6.1.3 International cooperation

Internationalisation is high on the Finnish research policy agenda. The Ministry of Education and Culture published an internationalisation strategy in 2016 and launched the "Team Finland Knowledge Network" in 2018. The Board of the Academy adopted an internationalisation strategy in 2017 with a focus on increased multilateral collaboration, rather than bilateral agreements.[29] Research is understood as inherently international. The Academy estimates that 25% of its national funding is used on international activities. Moreover, the proportion of international candidates in individual funding more than

25 See section 3.5, p. 30, and in particular Figure 13, p. 32.

26 See section 3.3, p. 26f.

27 See section 3.3

28 See section 5.4.5

29 See section 4.8, p. 50f

doubled in the last decade, from less than 20% to more than 40%[30] with substantial increases in the proportion of grants going to foreigners.

In line with the strategy, the Academy has revised its international collaboration policy, reducing funding for bilateral initiatives in favour of multilateral arrangements that are larger and more efficient to administer. Greater attention is now paid to quality. However, despite the potential and knowhow of the Academy, it has too few people and resources for internationalisation, both in respect to support services for applicants for European funding and financing for research infrastructure.

6.2 Implementation on the organisational level: Academy performance

In the last decade, the Academy has continuously revised its organisational model to be consistent with policy needs and international good practice.[31] The organisation of the Academy has been reformed, reducing the number of disciplinary research councils from four to three, changing the composition of the board by introducing new members not involved in the Academy structures, and revising the division of roles between the board and the councils. Cross-council support has been strengthened and processes have been harmonized. The SRC and the Finnish Research Infrastructure Committee (FiRI) were also installed.

- The merger of the councils responsible for biosciences, environment and health has been successful in that – despite the breadth of the new council – assessment continues at an apparently high level of quality, while costs have been reduced. According to our thematic analysis[32], environmental sciences in Finland would probably fit better with natural sciences, as they are better linked via lower-level subject fields

- The most recent change in the composition of the board (2018) depends on moving the funding decisions previously taken by the board into academic sub-committees – a move which the Academy in fact already made in 2015. In principle, this should allow the board to focus on strategic matters. At this early stage, it is not possible to see any effects of that change

30 See Figure 29

31 See section 3.3, p. 26f, Figure 11, and Figure 12

32 See cluster analysis in Figure 28, p. 62.

- The administration of the Academy was also streamlined in 2018 by the creation of divisions for Strategic Planning and Analysis, and Research Funding Development. Again, it is too early to see effects of this on processes, beyond the recognition that they are in line with international good practice

The Academy took the major productivity gains available from moving to electronic proposals and grant management before the period under consideration. The staff has itself achieved subsequent efficiency gains. However, this has been at the cost of not significantly innovating in processes or instruments.

- The share of the budget devoted to administration is very low by international standards[33] and is too low to be compatible with the continued management and development of a high-quality research funder

- The Academy published its strategy and values in 2015 and updated these in 2020 to include references to the need to contribute to addressing societal challenges. As a result, there have been changes in the character of some funding instruments and proposal assessment criteria have been broadened. The Flagships and the Strategic Research Council-projects, as well as Academy programmes, respond to the strategy's aim to engage more deeply in addressing societal needs

- There was no fresh money for change-management and implementation[34], reform processes or the integration of new tasks

- Questions of science transfer and science communication play a certain role in the Academy, as for instance in contributing to the Year of Research-based Knowledge 2021. But, possibly due limited resources, it is not a priority, despite the need to engage in this debate in an increasingly science-sceptical context.[35] New approaches like citizen science are not on the agenda

33 Table 5, p. 32.

34 Table 4, p. 31.

35 See section 5.4.5, p. 80

- The Academy maintains a range of non-thematic funding instruments[36], whose individual value has not or insufficiently been evaluated. Some of them have their origins in the time before the Academy became a research council in the current tradition. There is a need for reflection on the following
  - The Academy Professorships appear to be held by well-recognised and established professors and in effect can 'buy out' the grant-holder from teaching. During the period of the grant, the university therefore saves most of the professor's normal salary. It is not clear that much additionality is involved, and it is arguable that, in the context of the current system of funding universities and research careers, the responsibility for these professorships should be folded into normal university appointment processes
  - The other personal grants are more additional to what the universities already can provide. In some funding systems, it is felt to be useful – partly by increasing competition – to have both university-based fellowships and externally-funded fellowships, allowing the best researchers to be funded and to some to degree to be able to move resources from weaker to stronger research groups
  - The Academy instruments distinguish between 'young' researchers and others. The ERC and some other national funders distinguish three career stages. There may be merit in investigating the usefulness of such a three-stage approach at the Academy, to strengthen the hands of mid-career researchers in funding competitions

- The Academy runs several thematic research programmes, which consume close to 25% of funding.[37] Evaluations of these are mainly inward looking and explain little about the value added to the portfolio. The Academy programmes are now under revision. They could be used for renewal, supporting important new fields, building capacity, or even reviving fields that are important but have become sub-critical in Finland

- The Academy's assessment and funding processes follow good, international practice relying on international peer review and selection panels.[38] They are proportionate, in that more is demanded of applicants and the assessment process for long and large grants than for short and small ones. All assessment processes are based on peer review, with processes being

36 See sections 4.1 to 4.3, p. 40f

37 See Figure 15, p. 41.

38 See section 4.7, Figure 19, p. 47.

modified as necessary in line with the specific needs of individual instruments and programmes. Impact statements are used in different roles for different instruments and can be expected to raise consciousness about the desirability of thinking about impact when choosing a research topic. Impact statements are often used as 'tie-breakers' to choose among otherwise similarly good proposals

- Success rates in funding competitions are alarmingly low:[39] They vary among instruments, and while the average appears to be just above 20% (which is internationally regarded as the lowest sensible success rate), the core bottom-up instruments have success rates about half this level, undermining the competitive processes and the credibility of the Academy. There may be a case for requiring the universities and institutes to quality-assure proposals before submission

- The Academy is successfully funding a high number of interdisciplinary research projects, including within the fields covered by the new research council. It has implemented promising reforms to enhance the selection process for the growing number of inter-disciplinary applications, for example via the creation of cross-council panels.[40] According to our bibliometric analysis of the links between research fields, however, economics appears isolated. Given the potential importance of the field in relation to the societal challenges and policy more widely, it would be useful to explore opportunities to integrate economics better with other disciplines

- We see no evidence of gender bias in the Academy's funding decisions.[41] There is a gender imbalance in the research community, which the neutral processes of the Academy as an 'aggregation machine' then reproduce in the pattern of grant awards.

- More broadly, the Academy of Finland Equality and Non-Discrimination Plan 2019-202, which sets out a list of measures in the Academy's research funding, human resources and administrative operations, has increased the internal priority of tackling gender and other inequalities

39 See section 4.5

40 See section 5.2, p. 58

41 See section 4.6

6.3 Output, outcomes, impact contribution

The Academy has an important impact on the quality of research in Finland.

- Stakeholders, including university rectors, testify to the important role of the Academy as a unique public funding organisation in Finland, supporting and enhancing the quality of scientific research by, in effect, demonstrating to the national research community what the required standard of quality is

- International peer panellists and reviewers' reports confirm that a high proportion of applications to the Academy are at the kind of quality level that would be expected in their home organisations

- Bibliometric analysis confirms that Finnish research performs well, and has some fields of outstanding strength, especially in natural and social sciences, and some fields of medical science. International cooperation in publications has increased beyond the international average and is now comparable to other small open economies like Denmark or Austria

Universities account for the great majority (89%) of Academy funding awarded in the 2011-2020 period. The main effects of the Academy's work are in the university sector and are substantial.

- The university system is becoming more concentrated, with the greater part of research being done in the five largest universities, and they together also take the lion's share of Academy funding.[42] The universities of applied sciences (UAS) benefit little from Academy funding[43] but more from BF and regional development money in line with their mission to support innovation at regional level

- Overall, the university sector's teaching capacity has been rising while its research capacity has not kept up[44]

- The PROFI university profiling programme has been successful in allowing universities to adjust their pattern of specialisation.[45] This has been done bottom-up and in competition, so benefits of coordination may have been

42 See Figure 9, p.18

43 See Figure 16, p. 42

44 See Figure 10 Development of staff by position Figure 10, page 19

45 See section 5.4.3, p. 76

missed. By and large, the new parts of the profiles have been staffed with tenure-track academics, creating a structural reason to expect the new specialisations to remain in place. This kind of structural intervention should be time limited. At a certain point the rectors should be able autonomously to define and implement strategic change, even if this requires university governance to make them more empowered. It would be useful to ensure the next evaluation of PROFI considers this issue and the degree of change that would be needed in the universities for the programme to be regarded as having succeeded

- In parallel, drastic cuts of 37% (€109m) have been made in the institutional funding of the research institutes[46] (which are a mixture of RTOs and government labs). This has only to a small degree been compensated by project-based funding from the new SRC.

- The Academy has via the Flagship programme to a small degree moved into the 'policy space' created by the system-wide decline in funding for applied research.[47] However, in line with the Academy's mission, the Flagships only fund the academic side of what are intended to be academic-industry competence centres. There is scope for greater mutual support between the Academy and BF (and potentially others) in areas ranging from strategic intelligence and foresight, through programme design and proposal assessment to joint funding – especially if government takes up the use of missions or similar instruments in its policy

- Whereas the Academy and BF have interacted a lot in the preparation phase of the Flagship programme, and BF experts are present in the selection process, there is no funding cooperation between the Academy and Business Finland (BF) on this programme or in relation to other activities of BF, such as its ecosystem programme. Because of this lack of formal cooperation (which could usefully include monitoring of the BF ecosystems), Finland runs the risk of underinvesting in areas, where the technology gap is a problem

Evidence on international collaboration is divergent. At the level of Finland as a whole, we observe an above average increase in international co-publications, but underperformance in Horizon 2020 participation in international comparison. The Academy certainly contributes to Finland's participation in international research and

46 See section 2.5, p. 19f

47 See section 5.4.2, p. 74

programmes, and would be better able to realise this potential if the management and administration budget were bigger

- The Academy actively contributes to internationalisation via the increased foreign participation in its bottom-up programmes, as well as its growing role in multilateral programmes and cooperation with the USA

- Internationalisation support functions at the Academy lack resources, so increasing the budget for management and administration would be expected further to increase Finland's international role in research

- The Academy's role in promoting in promoting research quality is one of several drivers lying behind Finland's improving position in international scientific co-publication. Other drivers are likely to include the Academy's work with internationalisation, use of international peer reviewers and panellists, Finnish participation in the Framework Programme, Finnish research-performing organisations' own efforts to improve quality and the national performance-based research funding system, as well as trends in scientific publication

- The engagement in renewed bilateral and multilateral agreements as well as the downsizing of bilateral agreements is promising but too recent for a specific impact assessment

One of the Academy's roles is to be an advisor on research policy to the government, and thus indirectly to society.

- The Academy has an important role in analysing the state of scientific research in Finland. It produces data on research personnel, funding, and publications, including bibliometric indicators and including international comparisons. There is room for development, for example with respect to internationalisation and in taking a portfolio view of funding instruments and beneficiaries. If, based on current political developments, Finnish R&I policy once more becomes more holistic or systemic, there should be growing demand from government and the RIC for information about R&I that includes but also goes well beyond the Academy's current focus on narrowly defined research

- There is scope for the Academy to play a more visible role in science communications and the social and political legitimation of research. The current pandemic as well as the role of 'science denial' as a strand in the growth of authoritarian movements internationally make this more urgent than before

- As long as there is underinvestment in the classical role of the Academy, any new role will de facto be under stress. Opening up to the international level, to industrial players and to societal stakeholders will need investment not only in funding but also in organisation

7 Recommendations

As with any organisation, the performance and impact of the Academy depends not only on what it does but also what is happening in the context. That is as true of the future as it is of the past. The most recent OECD review of innovation policy in Finland (OECD, 2017) argued that the context for innovation policy was problematic. It is refreshing to see, at the time of writing, that the current government and parliament are now studying the situation in the light of the so far unrealised aim of spending 4% of GDP on R&D, and that there is a prospect that the OECD's concerns about policy may be met with changes in the near future.

One of the OECD's concerns was that Finnish policymakers have yet collectively to decide on a national approach to the societal challenges. This decision should have a decisive effect on the way research and innovation policies are conducted in future, and on the structures and organisations through which this decision is implemented. We therefore offer the following proposals.

1. *Recommendations to the government about the overall R&I system*

2. *Recommendations to the Ministry of Education and Culture and the Academy of Finland that apply irrespective of how the government decides to tackle societal challenges*

3. *Alternative paths for the Academy and its role, depending on the approach to societal challenges that is eventually chosen*

7.1 Recommendations to the government

'Research councils' or 'national science foundations' like the Academy obtain their legitimacy in the research community from the fact that they respond to investigator-generated research ideas and use scientists to take funding decisions based on peer review. This is regarded as a form of self-governance within the 'Republic of Science' (Polanyi, 1962) that guarantees academic freedom and quality-assures the research funded. Traditionally, the community regards any attempt to impose thematic priorities as anathema or unwarranted political interference with academic freedom. Nonetheless, in practice, bottom-up proposals often crowd into new, fashionable, or societally important thematic areas, as the Academy has shown for example in relation to climate change and other issues of major importance.

Experience with bottom-up proposal processes, however, also shows that the disciplinary pattern of the funding granted tends to reflect that of the proposals submitted, creating path dependency and inhibiting change. The most experienced researchers tend to write the best proposals, so the old (men) are likely to get most of the money (Rip, 2000). Without incentives to build critical mass, research communities remain fragmented. Research councils therefore use non-thematic instruments such as young researcher grants or centres of excellence funding to correct these problems. Many research councils, including the Academy, also run small thematic programmes, to kick-start new areas of research or to rebuild strength in areas that are failing. They become the stewards of the health of the research community, a function that is baked into the instructions for the Academy.

It would be reasonable to ask why the research community is allowed to spend taxpayers' money in its own interest, without much detailed control. The answer is systemic: the bottom-up research system is the necessary complement to the thematically steered funding system, which aims directly to satisfy social needs. It produces unexpected or un-requested knowledge that is not necessarily sought by thematic funders but that often turns out to be necessary. It is also understood to be among the best training schools for researchers of all kinds. This combination of systemic purpose and legitimacy in the research community is why all advanced countries need a strong research council. **No matter which way the government decides to shape future R&I organisations and policies, it is important to maintain the Academy within the system and to ensure that the research community as well as wider society feels ownership of it.**

For the period up to about ten years ago, Finland was renowned and much copied in international circles for its ability to set policies across the R&I sphere that were systemically coherent, thanks to the Research and Innovation Council and its predecessors acting as an 'arena' for policy debate but also as a 'referee' with the power to take decisions in the national interest. Keys to its success included its access to independently created strategic intelligence about the national innovation system and the leadership of successive prime ministers who could lift the discussion above the level of the individual ministries' focus on their own sectors, while taking account of the needs of industrial and research stakeholders.

Some ten years ago, partly because of the austerity policy that followed the financial crisis, and we speculate also partly due to the loss of national confidence after the decline of Nokia's mobile phone hand-set business, this holistic leadership function stopped working properly. Among other symptoms, are the emergence of a 'technology gap' in R&D funding as Tekes' R&D funding was run down and the SHOKs were de-funded, and an inability for the Finnish policy system to make a structural response to the societal challenges.

If the 'innovation systems' paradigm under which the RIC succeeded required holistic policy, tackling the societal challenges or 'third generation' R&I governance does so even more. **The government needs to establish a way to perform the 'arena and referee' function above the level of the ministries and to establish how to adapt policies not only to the systemic nature of the innovation system but also to third-generation needs.** This could involve re-establishing the RIC function under the Prime Minister or establishing a different mechanism.

Government also needs to **plug the technology gap in R&I funding**. In system terms, it is incoherent to fund basic research without also ensuring that research can be done in applied, strategic and technological areas that on the one hand depend on knowledge and capabilities in basic research and that on the other hand generate knowledge and skills for use in economic and societal innovation. **Business Finland should have an explicit goal of funding technology programmes and other research and innovation programmes, such as those needed to address societal challenges. The need for such programmes did not decline over the last decade in line with the reductions in funding for them at Tekes and Business Finland. Restoring such funding is likely to be a pre-condition for achieving the 4% goal, based in part on an effective interplay with the work funded by the Academy.**

Government also needs to **decide how to tackle the societal challenges**, via new or additional cooperations, organisations and programmes. It is important to recognise that, because they require demand-side engagement in deciding how to intervene as well as making changes in socio-technical systems across society, the societal challenges extend outside the sphere of traditional R&I policy. They need to involve other ministries and actors, but also to be understood as extensions to industry policy when setting priorities, because they define future market opportunities.

7.2 Recommendations to the Ministry and the Academy

The Academy has been given responsibility for a growing number of tasks during the past decade and has largely been allocated money with which to fund them. The PROFI, infrastructure, and SRC tasks, for example, have come with new money, though the Academy has funded the Flagships from its normal budget. The budget for management and administration has not increased commensurately and now lies well below what is needed or, indeed, international norms. While the Academy has made economies and reorganised to support and maintain high level of administrative efficiency, the lack of resources has less obvious effects. There has been no time to refresh the Academy's funding instruments, to take the more proactive roles in advice-giving or science communications agreed with the Academy following the last evaluation. There has been too little time for the Academy to support the intended increased effort in internationalisation by becoming prominent in some of the more labour-intensive cooperation activities, and little capacity to implement the aim of helping address the societal challenges introduced in the Academy's 2020 strategy. **The Ministry and Academy should negotiate a substantial increase in the budget for management and administration**, otherwise important functions of the Academy will 'freeze up'. The negotiation should be based on the activities needed. It is therefore not for us to specify the result. However, we do note that increasing the budget by a full percentage point would still leave the Academy among the cheapest research councils to administer, internationally.

Addressing the government target of spending 4% of GDP on R&D requires that business fund most of the increase. But achieving that increase in turn depends on industry recruiting many research-trained people to do the work, and on increases in the knowledge produced via fundamental and applied state-funded research. There is therefore need for government to spend more on both the Academy and on applied research and technology programmes in order to reach its target: industry will not do it alone.

The success rate for applications to Academy programmes is in many cases around 20%. However, in the core, bottom-up programmes it is often below 10%, at which point the cost-benefit balance of writing a proposal is questionable and both researchers and panel members start to regard it as a lottery. In the context of the big cuts to the Tekes R&D budget and the core funding of the government institutes over the last decade, the total amount available for external funding has at best stagnated. **Both to support the 4% goal and to tackle the success-rate problem at the Academy, the Ministry and Academy should argue for research funding budget increases for the Academy. The Academy itself should also consider implementing further measures to increase the success rate, such as requiring the applicants' employers to quality-assure applications.**

Finnish participation in the Framework Programme is lower than that of comparable countries. The Academy and Business Finland should be funded to work together to improve this.

While the infrastructure programme is an important new task for the Academy, the budget is well below the level of need. **The Ministry and Academy should together**

assess the level of need and seek to raise the infrastructure funding budget to an appropriate level.

While it has a strong record in field and programme evaluations, which judge the research done by others, **the Academy does not appear to evaluate its own instruments sufficiently rigorously. It – or the Ministry – should evaluate the non-thematic instruments, to determine their continued relevance, adherence to good practice and impact.** One objective of the evaluation should be to consider which instruments have outlived their usefulness and can be retired. Potential examples include the Academy Professorships, which since the university reform do not appear to us to play a useful economic role – though they do provide excellent opportunities to recognise outstanding scientific achievement – and the thematic programmes, whose impact on the health of the research system should be explored. An important gap is the lack of evaluation of the long-standing centres of excellence instrument, especially in the light of proposals eventually to replace the profiling instrument by larger centres of excellence funding.

A second objective Is to obtain a portfolio perspective so that the additionality of Academy programmes can be better understood, and to generate more systemic knowledge about the research community. A more comprehensive monitoring system should create needed strategic intelligence by addressing needs such as (a) a mapping of university profiles compared to their performance in other funding instruments (bottom-up, infrastructure, thematic, SRC and Flagships), (b) internationalisation of research staff, funding and cooperation, (c) gender and career development, diversity in central roles in different funding instruments, (d) annual thematic analysis prepared for the state of science report, on knowledge ecosystems, in cooperation with BF and other stakeholders.

There may also be value in thinking about whether the Academy should think and **fund in relation to three career stages, rather than two** – as, for example, the ERC and NWO do.

7.3 The future role of the Academy

The Academy plays a foundational role in the Finnish R&I system and should continue to do so. We see future extensions to the role of the Academy as depending upon (a) whether and how it proves possible nationally to refocus on R&I as a driver not only of economic growth but increasingly of sustainability, (b) the unique skills and status of the Academy in the Finnish system, and (c) how (and whether) the government chooses to change the organisational context to adopt more holistic R&I Policies that bridge across government to address societal challenges. These are fundamentally international, as is the scientific community, and increase the needs to interact with international stakeholders.

One possibility, occasionally discussed, is to merge the Academy with Business Finland. While it might have been interesting to discuss 10 or 20 years ago whether there would be benefits from combining the Academy and Tekes, in the style of the Research Council of Norway, a merger with BF now would in our view be unhelpful.

- The transaction costs of an Academy-Tekes merger would have been huge, including strong opposition from the research and industrial communities, a period of paralysis as the organisations are changed, and many years to learn to operate the new structure well. It might have been possible that these costs were worth paying under second-generation governance, but the societal challenges and third-generation governance require further extensions to the scope of the work. That ship has, in any case, sailed

- As regards BF, while there is skill and client overlap and a degree of common understanding between a research council and an innovation agency, there are none between a research council and a business and trade support agency, so the synergies available to an Academy-BF merger are close to nil. The research community would see a merger with a business support agency as completely illegitimate, undermining the current tasks of the Academy

The government's options for dealing with transitions and missions appear to us to depend as a first step on closing the technology gap – otherwise there is no prospect of doing the R&D at higher TRLs than the Academy can handle, which would be needed for implementing systemic change. As we understand it, government and the parliament are discussing how to do this. The obvious possibilities would be to rebuild the functions needed to support strategic R&D, applied R&D, and cooperation between the research sector (universities, institutes) and industry either within BF or in a new organisation. We would be very sceptical of a proposal to try to build something like a Tekes function onto the side of the Academy because that would involve combining the difficulties of building a new organisation from scratch with those of bringing the research and innovation cultures together, which themselves are considerable.

All the advanced-country R&I systems with which we are familiar are trying to work out how to tackle transitions at the national level. There is growing enthusiasm for 'missions' (following the European Commission's lead). The genius of Mazzucato's report to the Commission about missions was to make the transitions programmable; a mission tackles a 'pillar' within a transition rather than the whole thing. This is more tractable at the national level. But, especially in a small country, even one mission is an ambitious undertaking. We expect countries eventually to tackle at most a handful, and to mainstream the remainder of the societal challenges into more routine policy. The few should be chosen based on a combination of what the country brings to the party and the extent to which it can benefit economically from the mission.

We are not alone in arguing that missions or transitions need to be handled via multi-level governance that can reach across multiple ministries and other societal stakeholders and therefore must be anchored at the government level – perhaps even at the RIC or something like it. Thus, we would expect to see a high-level 'platform' approach to the big things and a more routine agency-based approach to the rest, probably based on cross-agency cooperation (in the style now widely practised in Sweden, for example). This includes stakeholders and agencies abroad, including multilateral agreements as already in place.

As we indicated in Section 3.2, there is a variety of ways in which government can try to structure efforts to run third-generation interventions, and we are not in a position to second-guess the Finnish government in this respect. While not forgetting that the Academy's existing (first-generation) role remains essential, we envisage the Academy as being able to contribute to third generation work at least in the following ways, provided there is extra budget for funding and administration in each case.

- Running thematic bottom-up programmes in areas that support transitions, missions, or other R&I policy priorities
- Quality assurance in project application assessment
- Running a bottom-up research module in a bigger programme
- Supporting the use of bottom-up research within an integrated research / innovation / implementation programme
- Joint funding of academic-industry collaboration programmes or centres
- Scientific needs analysis and foresight
- Funding Pasteur's Quadrant thematic programmes of use-orientated fundamental research
- Running programmes to connect Finnish thematic priorities to international science, both inside and outside the EU Framework Programme

Most if not all approaches to third-generation policy depend on some level of inter-ministerial cooperation. Historically, this has worked well in the exceptional situation where there is fresh money to be distributed,[48] but has proved to be harder in times of 'business as usual'. While the RRF and the national 4% effort may provide temporary sources of additional money, in the longer term **the key challenge is to strengthen the resilience of the Academy in its major role, namely quality based funding and quality assurance of research.** Based on that, the Academy will be able to reach out to other stakeholders to cope with new tasks, such as steering of universities via profiling programmes and infrastructure funding, enhancing the dialogue between research stakeholders to address societal challenges better, preparing the ground for better science-industry relationships, and further enhancing international visibility and integration of the Finnish research community.

From an organisational development perspective, the steps taken at the Academy in the last decade were smart and relevant but cannot be repeated in the same way in the future. The Academy reorganised and managed the organisational renewal through efficiency gains. The reserves for such efficiency gains have been exhausted and further improvement or differentiation requires organisational investment with fresh money. While the Academy's performance is still high in selection processes, and the kick-off phase of new instruments worked very well, alarms are ringing when looking at selection rates in traditional funding instruments, support measures for participation in European programmes, science communications activities to get in contact with societal stakeholders, closely linked to a profound understanding of "societal impact", and a systemic analysis of the Academy's funding data.

To further strengthen the Academy as a central player, **its ability flexibly to link with other actors in the research system, both nationally and internationally, needs to be strengthened**. It must be made clear that given appropriate budget, the Academy can contribute both money and management effort to the pursuit of joint activities with other actors – not by abandoning its principles as a basic research funder but by integrating basic research components into interventions ranging from innovation ecosystems to missions. In such relationships, the key identity of the Academy will continue to be its capacity to select research proposals of any size and complexity based on international peer review. **Assessment criteria over and above scientific excellence must therefore be subordinate to it. To handle non-excellence criteria, there needs to be a minimum level of cooperation with stakeholders whose core competences correspond to the new focus.**

48 There was a brief period of intensive collaboration and coordination between the Academy and Tekes in the late 1990s, spending a temporary additional government appropriation for R&D, but the joint activities evaporated as soon as the money did

The Academy should continue and expand its role of creating strategic intelligence and providing expert advice expert about the Science system. First, this is needed to support the Academy's traditional responsibilities and provide appropriate advice to government about them. Second, making third-generation policies for missions and transitions requires even more of such information from both the national and the international level, coupled to the ability to develop foresight and do scenario thinking. The information base needs to be strengthened by a **renewal of the use of the Academy's own funding data for analytical and forward-looking purposes,** as these become increasingly comprehensive, based on individual, project, cluster, and infrastructure funding, to develop an unprecedented description of knowledge ecosystems. This needs investment in data base design and monitoring capacity.

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Appendix B Frame of reference of the evaluation

Recognising the role of research funders as change agents, the evaluation needs to pay special attention to changes in both the external and the internal drivers of change, in the Academy's behaviour and performance, and in its impacts. This evaluation therefore needs a framework spanning organisational performance and impact evaluation (as shown in Figure 1).

Organisational performance evaluation frameworks normally try to explain how internal and external influences affect organisational performance. This approach can highlight how the influences may be adjusted to improve performance. There are many possible frameworks for this:

One comprehensive example is the Institutional and Organisational Assessment Model, which was designed to help the Inter-American Development Bank and IDRC improve the performance of organisations they funded (Lusthaus, et al., 2002). It uses three drivers (each with several sub-components) – organisational motivation, external environment and organisational capacity – to explain organisational performance

Impact evaluation tends to use a theory of change – an explanation of how an intervention such as funding research leads to the production of outputs such as knowledge and publications, which in turn trigger outcomes such as innovations or better-informed policies, eventually contributing to impacts in society

Inspired by these two approaches, we have devised a hybrid framework tailored to the specific situation of the Academy (Figure 36) that is designed to address both organisational performance and impact.

Figure 36. Evaluation Framework

Drivers

Ministry of Education, Science and Culture

Is steering effective and consistent with good international practice? How are changes in national and sectors strategies reflected in R&I system governance, especially of the Academy?

What is the quality of the steering dialogue and indicators used?

How well does the division of labour between the Academy, Ministry and other funders work in generating and implementing science policy? How well is the Academy engaged in the broader dialogue?

Context

How well does the Academy address the need to focus on societal challenges while maintaining necessary funding continuity?

How has the Academy handled reforms in other parts of the structure of national support for research and innovation? Including

- Reform of the research institutes, 2013
- Creation of Business Finland
- The profiling programme

How well does the Academy react to other changes in national and European science policy?

How rapidly and effectively can the Academy react to urgent changes or emergencies like COVID-19?

International Cooperation

How well does the Academy maintain, update and implement an effective and nationally beneficial international strategy?

How well does the Academy develop and exploit international research infrastructures in the national interest?

Academy Performance

Is the internal governance and organisation of the Academy (Board, Research Councils and Admin office) consistent with policy needs and international good practice?

How well has the Academy managed organisational changes since the 2012/13 evaluation? These include

- Hosting the Strategic Research Council
- The university profiling initiative
- The reforms of the Academy in 2018
- Introduction of the Flagship initiative

Is the portfolio of funding instruments and programmes appropriate to changing needs and international good practice? Is there innovation in instruments?

Are proposal assessment and funding decisions fit for purpose and consistent with good international practice in terms of processes?

Is management and administration cost-effective, compared with other relevant funders internationally, and improving? How have changes in organisation and governance affected the Academy's performance?

Does the Academy have adequate processes in place to monitor the state of science in Finland, guide its own activities and provide the government with high quality science policy advice?

Does the Academy play an adequate role in knowledge exchange and science communications?

Does the Academy have adequate measures for supporting researchers' career development?

How has the Academy responded to the 2012/13 evaluation?

Does the Academy have appropriate measures in place to support high national participation in the Framework Programme and other international programmes?

Outputs, Outcomes, Impact Contribution

What have been the effects of Academy reforms since 2012/13 on the national research and innovation system in general? And in particular

- The strategic development and performance of the universities and the research institutes
- Their ability to address societal challenges
- And their links to industry and other knowledge users

What have been the effects of changes in the Academy's repertoire of instruments in the national research and innovation system?

What are the overall effects of Academy funding on the quantity and quality of research in Finland?

Does the Academy contribute to the development of a national science policy?

What are the effects of the Academy's support on research careers? Does the Academy's continued support of fellowships contribute?

Does Finland play an adequate role in the division of labour in international research programmes? Do the activities of the Academy positively influence he level of national participation in international scientific collaboration? Is that level satisfactory, overall?

Appendix C **Support group**

Anita Lehikoinen, Permanent Secretary, Ministry of Education and Culture

Erja Heikkinen, Director, Division for Science Policy, Ministry of Education and Culture

Paavo-Petri Aahonen, Ministry of Education and Culture

Soili Vasikainen, Ministry of Education and Culture

Heikki Mannila, President, Academy of Finland

Johanna Myllyharju, Chair of the Board, Academy of Finland

Anne Heinanen, Counsellor of Science, Academy of Finland

Kirsti Vilén, Ministerial Adviser, Ministry of Employment and the Economy

Ilmari Absetz, Business Finland

Appendix D Expert Panel

Sylvia Schwaag-Serger (chair) is Vice-rector for education and internationalisation and professor of research policy at the University of Lund and was formerly international director of Vinnova. Research includes international R&I cooperation, Chinese R&I policy and operationalising work on the societal challenges at research funding and performing organisations

Ben Martin is a leader in the field of research on R&I and the links between research and society, an authority on research evaluation and a former director of the Science Policy Research Unit (SPRU) at the University of Sussex

Dorothea Sturn has been managing director of FWF (the Austrian equivalent of the Academy), head of quality at the University of Vienna, and ran the first Austrian competence centres programme (Kplus) at FFG. She is currently lead author of the Austrian Research and Technology Report and researches on research management and ethics

Rolf Tarrach was formerly president of the Spanish research council CSIC, became the first rector of the University of Luxembourg and then the president of the European Universities' Association until 2019

When CET	EET	What	Who
Monday 21.6.			
16.00	17.00	Welcome, overview of the panel visit	Erik Arnold, Sylvia Schwaag Serger
16.30	17.30	Background information on the development of the Finnish research system in the last 10 years	Kimmo Halme
17.15	18.15	Discussion on strategic questions	
18.00	19.00	End of day	
Tuesday 22.6		**Presentations and interviews: Academy of Finland, Universities**	
9.00	10.00	Official start, Welcome by the Academy	Heikki Mannila
		Presentation of the SER: overview	AcaFin Team

When CET	EET	What	Who
10.00	11.00	Q&A	Sylvia Schwaag Serger
10.30	11.30	Break	
10.50	11.50	Discussion on new instruments and their impact and links to innovation • Flagship • Infrastructure • Links to Business Finland	Heikki Mannila AcaFin Team
12.00	13.00	Lunch break	
13.00	14.00	Discussion on internationalisation and new instruments with a focus on universities and societal challenges • SRC • Profiling	Heikki Mannila AcaFin Team
14.30	15.30	The impact on universities – funding, profiling	Keijo Hämäläinen, Chair of Universities Finland UNIFI Jukka Mönkkönen, President of University of Eastern Finland Ossi Naukkarinen
16.30	17.30	Break	
17.00	18.00	Debriefing	
18.00	19.00	End of day	
Wednesday 23.6		**Stakeholders**	
9.00	10.00	The user's perspective	Maja S. Peltola, President of the Finnish Union of University Researchers and Teachers
9.30	10.30	Ministry of Education and Culture, the role and performance of the Academy	Anita Lehikkonen, Permanent, Secretary of the Ministry of Education and Culture
10.00	11.00	Short debriefing & break	
10.45	11.45	The user's perspective	Flagship directors Markku Kulmula, Atmosphere and Climate Competence Center Samuel Kaski, Finnish Centre for Artificial

When CET	EET	What	Who
11.15	12.15	The user’s perspective	Antti Vasara, President & CEO, VTT Technical Research Centre of Finland
11.45	12.45	Short debriefing and lunch break	
13.00	14.00	Research and innovation funding stakeholders	Kimmo Nuotio, chair of the Strategic Research Council
13.30	14.30	Research and innovation funding stakeholders	Hannu Kemppainen, Executive Director, Business Finland
14.00	15.00	Panel discussion on evaluation questions	
16.00	17.00	Break	
		Preliminary conclusions	
16.30	17.30	Feedback to AcaFin and Ministry	AcaFin Team, Ministry of Education and Culture
17.30	18.30	End of the day	

Appendix E Interviews

Academy of Finland:

Heikki Mannila, President

Savunen Liisa, Director, Strategic Planning and Analysis

Riitta Maijala, Vice President for Research

Johanna Hakala, Manager of International Affairs

Anne Heinanen, Counsellor of Science, Academy of Finland

Jaana Roos, Senior Science Adviser

Kata-Riina Valosaari, Counsellor of Science

Johanna Myllyharju, Chair of the Board

Otto Auranen, Senior Science Adviser, Strategic Planning and Analysis

Jussi Alho, Senior Science Adviser, Strategic Planning and Analysis

Ossi Malmberg, Vice President of Administration

Stakeholders:

Paula Eerola, Research rector, University of Helsinki,

Heidi Fagerholm, President, Oulu University of Applied Sciences, Board Member Academy of Finland

Keijo Hämäläinen, President, University of Jyväskylä

Erja Heikkinen, Director, Division for Science Policy, Ministry of Education and Culture

Hannu Kemppainen, Executive Director, Strategic Performance Management at Business Finland

Mervi Karikorpi, Director for innovation environment and renewal at The Federation of Finnish Technology Industries

Kaisa Korhonen-Kurki, Research Coordinator, Helsinki Institute of Sustainability Science (HELSUS)

Johanna Krappe, Head of Collaboration and Development, Turku University of Applied Sciences, Research, Development and Innovations

Matti Latva Aho, Director, 6G-Flagship

Anita Lehikoinen, Permanent Secretary, Ministry of Education and Culture

Reko Leino, Åbo Akademi, University of Turku, Chair Natural Sciences and Engineering research council at the Academy of Finland

Ilona Lundström, Director General of the Innovations and Enterprise Financing, Ministry of Economic Affairs and Employment

Tapio Määttä, Research rector, University of Eastern Finland,

Marja Makarow, Director, Biocenter Finland

Tomi Mäkelä, Director, iCAN Flagship,

Per Mickwitz, Pro vice-chancellor for research, sustainability and campus development Lund University, Vice Chairman of the Board, Academy of Finland

Jukka Mönkkönen, Rector, University of Eastern Finland

Ossi Naukkarinen, Research rector, Aalto University

Ilkka Niemelä, President, Aalto University

Kimmo Nuotio, University of Helsinki, Chair of the Strategic Research Council

Erkki Ormala, Profesor of practice, Aalto University

Nani Pajunen, leading specialist in the Sustainability solutions, SITRA

Christopher Palmberg, Head of Developing Market Platform, Business Finland

Antti Pelkonen, Prime Minister's Office

Sami Pihlström, University of Helsinki, Chair of the Research Council of Culture and Society of the Academy of Finland

Ursula Schwab, University of Eastern Finland Head of Research Council for Biosciences, Health and the Environment at the Academy of Finland

Juhani Soini, Vice rector, Turku University of Applied Sciences, Research, Development and Innovations

Liisa Suvikumpu, Managing Director, Association of Finnish Foundations

Antti Vasara, President and CEO of VTT Ltd (Technical Research Center of Finland)

Mari Vuolteenaho, Vice President for Research, Development and Innovation, Laurea University of Applied Sciences

Mari Walls, President, Tampere University, member of the Infrastructure Committee

Group interview with ERC grant holders:

Jukka Pekola, QTF Aalto

Judith Pallot, Aleksanteri Institute

Lauri Aaltonen, University of Helsinki

Volker Heyd, University of Helsinki

Helmi Järviluoma-Mäkelä, University of Eastern Finland

Pekka Martikainen, Population Research Unit, University of Helsinki

Jan von Plato, University of Helsinki

Sarah Green, University of Helsinki

Olli Ikkala, Aalto University

Peter Liljeroth, Aalto University

Craig Primmer, University of Helsinki

Hanna Vehkamäki, University of Helsinki

Zhipei Sun, Aalto University

Appendix F Supplementary data on portfolio and processes

Table 16. Applications and success rates by first research field

Discipline	Total number of applications 2011-2020	Total funded applications 2011-2020	Success Rate 2011-2020
Computer science	2143	426	20%
Physics	2085	577	28%
Electrical engineering and electronics	1943	480	25%
Social sciences	1853	429	23%
Geosciences	1808	473	26%
Biomedicine	1662	517	31%
Ecology, evolutionary biology and ecophysiology	1553	440	28%
Chemistry	1490	357	24%
Materials science and technology	1207	247	20%
History and archaeology	1158	308	27%
Cellular and molecular biology	1096	311	28%
Mathematics	1073	317	30%
Education	1073	175	16%
Environmental science	1063	283	27%
Clinical medicine	887	214	24%
Neuroscience	866	248	29%
Energy engineering	761	177	23%
Linguistics	742	152	20%
Microbiology	731	192	26%
Psychology	728	190	26%
Unclassified	707	580	82%
Public health research	706	158	22%
Business economics	683	128	19%

Discipline	Total number of applications 2011-2020	Total funded applications 2011-2020	Success Rate 2011-2020
Political science	576	153	27%
Biochemistry, biophysics	559	160	29%
Art research	541	113	21%
Law	512	160	31%
Philosophy	509	111	22%
Nanoscience and nanotechnology	507	118	23%
Forest sciences	458	99	22%
Environmental engineering	456	81	18%
Pharmacy	434	118	27%
Communication	424	107	25%
Plant biology	418	121	29%
Economics	408	138	34%
Mechanical engineering and manufacturing technology	406	93	23%
Computational science	388	86	22%
Process technology	378	77	20%
Environmental social science research	374	112	30%
Genetics	374	107	29%
Medical engineering	368	81	22%
Theology	356	89	25%
Human geography	339	84	25%
Astronomy	292	80	27%
Systems biology, bioinformatics	282	77	27%
Literature research	231	48	21%
Agricultural sciences	214	46	21%
Developmental biology and physiology	196	65	33%
Development research	195	44	23%
Construction and municipal engineering	186	26	14%
Industrial management	185	30	16%

Discipline	Total number of applications 2011-2020	Total funded applications 2011-2020	Success Rate 2011-2020
Women and gender studies	170	39	23%
Environmental health research	161	31	19%
Industrial biotechnology	149	46	31%
Food sciences	149	33	22%
Sport sciences	147	29	20%
Nutrition	137	13	9%
Architecture	125	29	23%
Statistics	122	28	23%
Design research	98	9	9%
Dental science	68	8	12%
Veterinary medicine	67	7	10%
Nursing science	53	6	11%
Science studies	42	9	21%
Food engineering	36	10	28%

Source: Academy of Finland

Table 17. Applications and awards by institution

Organisation type and organisation	Number of applications		Number of funded applications		Granted funding (euros)	
	2011–2015	2016–2020	2011–2015	2016–2020	2011–2015	2016–2020
Universities	**15,597**	**18,681**	**3,953**	**4,584**	**€1400M**	**€1815M**
University of Helsinki	4,534	5,259	1,339	1,444	€501M	€586M
Aalto University	1,856	2,421	509	632	€201M	€284M
University of Turku	1,840	2,144	477	527	€147M	€202M
Tampere University	1,784	2,226	385	503	€143M	€205M
University of Jyväskylä	1,468	1,596	384	354	€136M	€128M
University of Oulu	1,538	1,883	317	416	€99M	€153M

Organisation type and organisation	Number of applications		Number of funded applications		Granted funding (euros)	
	2011–2015	2016–2020	2011–2015	2016–2020	2011–2015	2016–2020
University of Eastern Finland	1,247	1,570	281	386	€90M	€144M
Åbo Akademi University	639	627	139	129	€43M	€46M
Lappeenranta-Lahti University of Technology LUT	386	485	60	97	€18M	€30M
University of Lapland	117	175	23	32	€8M	€11M
University of the Arts Helsinki	41	76	8	19	€6M	€9M
Hanken School of Economics	65	94	13	18	€5M	€8M
University of Vaasa	77	110	15	20	€3M	€7M
National Defence University	5	15	3	7	€1M	€1M
Government research institutes	**1,861**	**2,587**	**459**	**775**	**€141M**	**€229M**
VTT Technical Research Centre of Finland	532	812	134	275	€44M	€69M
Natural Resources Institute Finland	308	466	79	146	€22M	€41M
Finnish Meteorological Institute	313	494	75	128	€24M	€36M
Finnish Environment Institute	191	256	54	75	€13M	€27M
Finnish Institute for Health and Welfare	245	225	60	62	€15M	€22M
Finnish Geospatial Research Institute (FGI) in the National Land Survey of Finland	113	139	17	34	€11M	€19M
VATT Institute for Economic Research	23	34	8	10	€4M	€5M
Finnish Institute of Occupational Health	75	51	15	13	€5M	€4M
Geological Survey of Finland	31	81	11	26	€3M	€5M
The Finnish Institute of International Affairs	19	13	6	1	€M	€M
Finnish Food Authority	9	11	0	3	€M	€M
Radiation and Nuclear Safety Authority	2	5	0	2	€M	€M
University hospitals	**204**	**282**	**51**	**65**	**€10M**	**€15M**
Universities of applied sciences	**31**	**141**	**11**	**49**	**€2M**	**€10M**
Other organisations	**302**	**422**	**165**	**188**	**€29M**	**€36M**
Totals	**17,995**	**22,113**	**4,639**	**5,661**	**€1583M**	**€2105M**

Source: Academy of Finland

Appendix G Business Finland research-related funding instruments

- Funding instrument for **challenge-driven research**: Business Finland's 'Challenge Finland' was the funding programme (€ 22 m in 2017–2018) for promoting the emergence of radical innovations.

- Development of innovation capacity and commercialisation activities in research organisations: Business Finland's '**Innovation Scout'**/KINO programme 2015–2017. The volume of funding channelled through the programme was € 7.2 m. It was linked to the TULI-programme 'Creating Business from Research' that started in 1993 and is still on-going, albeit after several redesigns, under the present name of Research-to-business. In 2012–2017, the volume of funding channelled through the programme was some € 138 m.[49]

- Development of **enterprise-driven business ecosystems**: Business Finland's 'Growth Engines' funding (€ 60 m in 2018–2019) aimed at creating PPP-based cooperation networks to support new business activities that strive e.g., to create new growth sectors.

- The longest standing instrument or funding service and the main vehicle for funding enterprises has been the (Technology) **programmes**.

- **RDI grants and loans for enterprises**, on application without a relation to a predetermined programme. These are projects that are initiated by enterprises, and they have often at least one partner. Research organisations are welcome and encouraged as partners.

- The long-standing triad of services specifically for ROs was introduced 2012 including Strategic Research Openings (SROs) and 'Public research [that is] networked with enterprises' (hereafter Networked Research or EVET). SROs and Research networked with business (Elinkeinoelämän kanssa verkottunut tutkimus, EVET) were directed for public research organisations,

49 Valtakari et al. 2018

in practice universities, colleges and research institutes, but EVET required that enterprises participate in funding (up to 10 percent share) of the project and participate as potential users of the results. The SROs were either small projects of maximum € 350 k over two years, or large projects of 5–10 year and up to roughly € 10 m, applied research projects conducted mostly by research institutions that were focused on developing new technologies, services and business models that would have significant economic impacts. The networked research grants in turn were similar to technology programmes, and by default parallel or related to the programme themes, in that they were shorter applied projects with at least two enterprises who would also fund at least 10 percent of the total project volume. The calls for applications for SROs and EVET were originally tied to the programme themes of the time, but EVET calls were changed in 2015 to broader thematic calls.

- The third component in the public research funding portfolio is the **New Business from Research Ideas (TUTLI**) funding that offers smaller de minimis grants for researchers planning to commercialise their inventions and the eligible uses were pre-commercialisation activities such as IPR and market studies.

- **Finland Distinguished Professor Programme** (FiDiPro) was a joint instrument with Academy of Finland for inviting distinguished foreign academics for research stays in Finland. This has been discontinued on the grounds that it was largely ineffective at promoting the internationalisation of Finnish research

- **Co-Creation** is aimed as a demonstration and feasibility study for research organisations aiming to prepare for a Co-Innovation project. Co-Creation is similar to strategic openings in its goals, with a stated goal to engage in scientifically ambitious research with enterprise partners based on a jointly developed idea. It has a maximum duration of 4–6 months and a budget of maximum 100 thousand euro.

- The aims of **Co-Innovation** are to develop new solutions and to develop them towards the markets, with a consortium of at least three enterprises and a number of research organisations and teams. The maximum duration is 2 years. Co-Innovation projects are administratively Joint Actions where at least one research organisation and three enterprises participate, at least two of whom have applied for Business Finland funding. The administrative arrangement is similar to the previous Group Projects. The new programmes stress equal footing between researchers, industry and societal interest, which marks a difference in tone compared to the earlier industrial focus.

Appendix H Dominant scientific fields in Finland – methodology and findings

A shortened version of this Appendix appears as Section 5.2.2 in the main report, above.

Whereas Section 5.2.1 was based on declarations of applicants, we now move to the analysis based on publication data that provide information on research fields identified ex post by algorithms. The goal is to understand in which scientific fields researchers publish their work funded by the Academy of Finland, and how these fields are interconnected. The 5.2.2 analysis is based on a rather recent tool provided by Microsoft Academic, that identifies with artificial intelligence algorithms one 'top field of study' per publication (therefore creating differences, even if papers combine scientific fields). On a 'lower' level, following a tree-like structure, further fields of studies are identified by the algorithm. We apply this classification to a dataset of Academy-funded publications with the aim of providing a data-based evaluation of dominant research fields and clusters of research fields.

H.1 Data Used

The data used in this chapter were retrieved from four main sources:

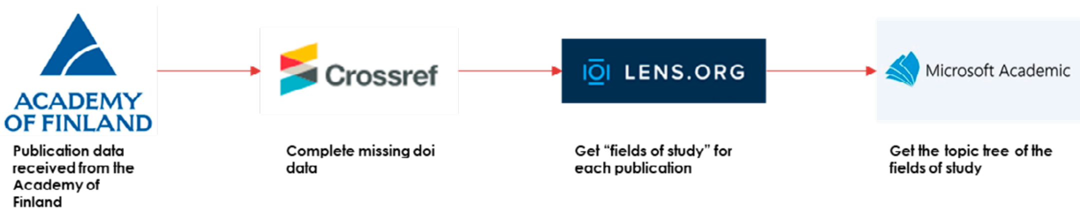
- *Publication data provided by the Academy of Finland*: We received two datasets from the Academy of Finland, containing publication data for publications that resulted from Academy of Finland-funded research projects. Each of the datasets contained approximately 30k individual publications, but also e.g. conference presentations. Furthermore, there was a large number of duplicates contained across the two datasets. The data was structured by 57 distinct columns, most notably by publication (doi), funding instrument and grant year. In total, the period covered by the grant years was ten years (2011–2020) and there were 14 funding instruments

- *Retrieving doi's*: Since information on the doi's was not complete, information about doi's was retrieved via web scrapping the platform 'crossref'

- *Retrieving fields of study*: To match individual publications to specific research fields, the doi's were used to scrape lens.org. Lens.org provides an academic database listing the fields of study according to the classification provided by the platform Microsoft Academic

- *Retrieving the 'topic tree' from Microsoft Academic:* The assignment of fields of study by Microsoft Academics is organised along a tree-like structure, such that every publication is assigned only one top-level field. Each of the lower-level fields can have multiple top-level fields. Microsoft Academic is a free database that collects and classifies information about academic publications. Its classification system is based on an artificially intelligent system, which algorithmically assigns fields of study to each of the publications. Overall, there are >700k topics listed on Microsoft Academic. The advantage of the classification system is that the topics are organised in a tree-like structure: every field of study is assigned to one specific level within that tree, thus a hierarchy of fields is created. There are 19 top-level fields (see below), approximately 290 first-level fields and around 10,000 second-level fields. This structure is the basis upon which our network analysis below is conducted. Note that for our purposes, we collected information on only the top-level fields and the first-level fields, as this already allows us to create a large-scale network of Academy of Finland publications.[50]

Figure 37. Data retrieval pipeline



Source: Technopolis

Having retrieved the data in the above-described manner, the data cleaning process was relatively straightforward. First, the data provided by the Academy of Finland was conjoined with the data retrieved from other sources. This resulted in a list of about 45k

50 See Wang et al., 2019 for a detailed description of the MS Academic tree structure

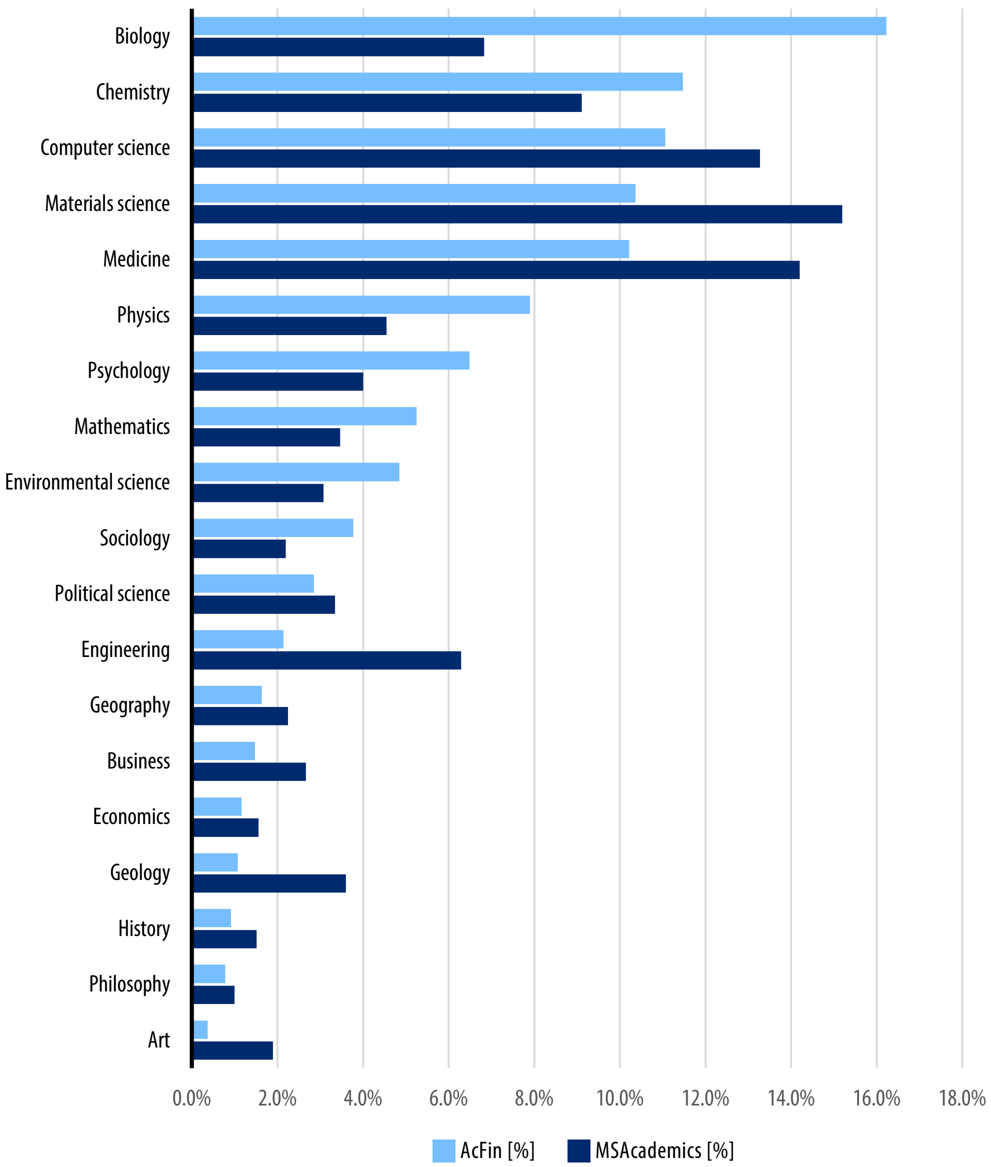
publications (out of the initial 2 times 30k provided by the Academy of Finland), where the publications for which no doi could be found were removed. Next, those parts of the data were removed, for which no assignment to research fields could be carried out, after which 42k publications remained. In the next step, duplicates had to be removed. Apart from perfect duplicates (which resulted mainly from joining the two datasets we received from the Academy), there were some publications for which multiple grant years and/or funding instruments were given. With regard to duplicates in the grant years, the more recent datapoint was kept, while the rest were removed. As we had to focus on the analysis of the Academy overall,[51] duplicates in the funding instruments were also removed. After the complete data cleaning process, we were left with >31k distinct publications (i.e. unique doi's).

51 I.e. there was not enough data to proceed with the analysis on the level of individual funding instruments.

H.2 Evolution of AcFin funded publications according to MS Academic top-level fields

Over the entire ten-year period (2011–2020), the following distribution of publications in different top-level fields assigned to the publications from the Microsoft Academic topic tree can be found, compared with the distribution of top-level research fields of the overall MS Academics database:

Figure 38. Distribution of top-level fields: relative total share in publications comparing Academy of Finland and MS Academics Database

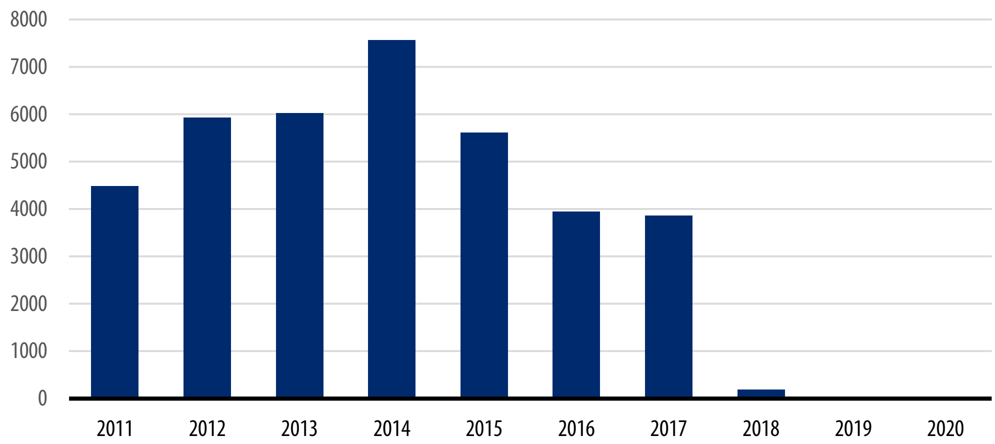


Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

Very clearly, natural sciences (biology, chemistry, physics, environmental science) are not only locally important, but they also have a weight above average compared with other fields. On a lower level, but still with a specific pattern, this also holds for psychology and sociology. In contrast, engineering, geology, material sciences and medicine are less represented in the Academy of Finland publications than in the global average identified by Microsoft Academic.

To quantify the underlying dynamics in the development of publications in the different top-level fields, we will assess the developments in the changes of the shares of publications in a certain top-level field relative to the total number of publications resulting from grants issued in that year. This trend will be measured by the slope of the linear regression curve of the relative share of publications associated with each top-level field. The reason to use this metric to determine the dynamics of publications is a result from the temporal distribution publications overall, as can be seen in the following figure:

Figure 39. The number of distinct publications (by unique doi's) by AcFi grant year

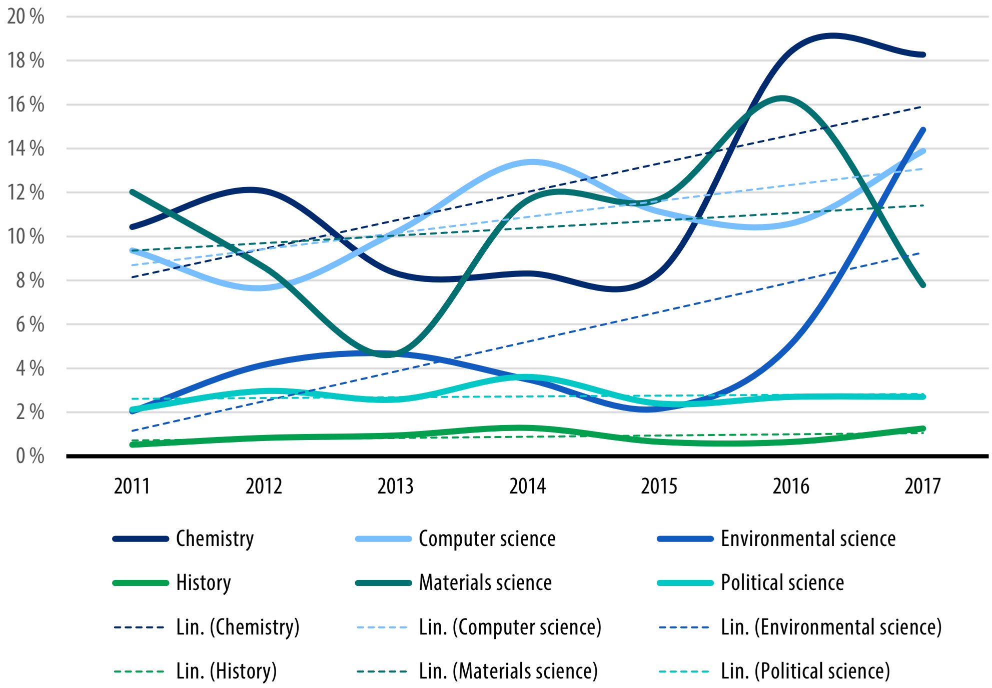


Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

For grants that have been issued after 2017, no publication data is available. This is as expected: there is likely to be a time delay between the grant decision and the resulting publications. An important implication of this fact is that in the data, the number of publications is (marginally) declining. This, however, may not be reflective of actual funding and/or publication activity, but simply reflect the time delay between the issuing of a grant and the publication of results, as well as the reporting practices of the Academy of Finland. In order to smooth out this effect, we use the development in the relative share of publications associated with a particular top-level field (i.e. a measure for the composition of publication across top-level fields) to complement the analysis of the overall trend.

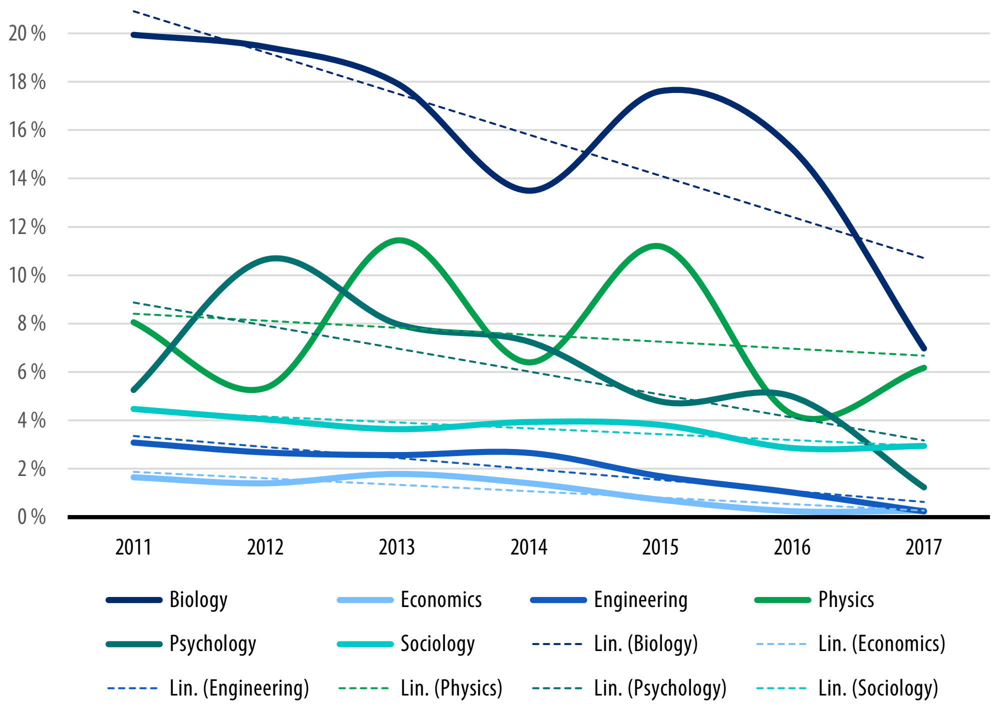
To illustrate the dynamics of publications for different top-level fields, we plot the shares of some top-level fields of study relative to the distribution of all top-level fields in the publications of Academy of Finland-funded research projects. The following figures depict the development of the number of publications for (a) the top 3rd top-level fields whose relative shares are increasing the most, and (b) the lowest 3rd of top-level fields whose relative shares are declining the most.

Figure 40. Top 3rd of research fields with fastest growing shares in publications



Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

Figure 41. Lowest 3rd of research fields with fastest declining shares in publications



Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

We can summarise the main findings from this analysis as follows:

- The fields that are increasing the most are: environmental science, chemistry, computer science, materials science and (to a lesser extent) history, and political science. Especially the latter two are not only increasing at a lesser speed, but also hover around an absolute share of only 1%–3%. What is striking is the very visible recent increase in environmental sciences, which likely reflects the increasing demand that is placed upon researchers to address direct societal needs

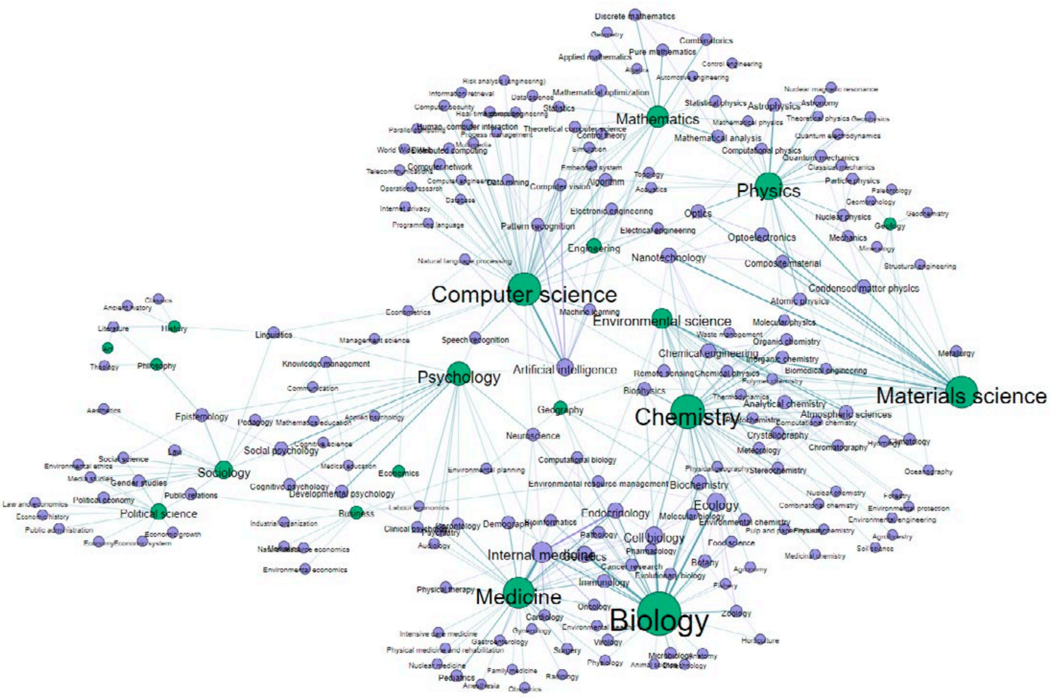
- The fields that are declining the most are: biology (with a particularly strong decline), psychology, engineering, sociology, economics, and physics

The changes are explained both by the evolution of the number of publications and by differences in reporting practices (e.g. a high number of publications being reported in one year for a given research field with a strong thematic focus). To better grasp the structural features of Academy-funded publications, we will therefore proceed to the network analysis, where not only individual fields are shown, but the connections between them become accessible.

H.3 Network analysis, top-level fields and international benchmarking

Figure 42 below represents an excerpt from the network that has been constructed from the dataset of publications from Academy-funded research projects. The nodes of the network are the different research fields, where (a) top-level and lower-level fields are marked in different colours, and (b) the size of the nodes is proportional to the number of occurrences of each field. The edges are created if two fields of study (one top-level and one lower-level) are associated with a publication. Again, the size of the edges is proportional to the number of co-occurrences of the fields in the dataset of publications. Through this methodology, two top-level fields can become 'connected' to each other, if they are both connected to the same lower-level field. The results of this methodology are shown in the subsequent figure. To allow a clearer visual representation, only the largest edges (>25 publications) are shown.[52] This visualisation can indicate the thematic "hot-spots" of Finnish research and surrounding thematic areas in knowledge production (i.e. larger nodes mean more publications, thicker edges mean higher co-occurrence of two fields).

Figure 42. Network of research fields from Academy of Finland-funded publications



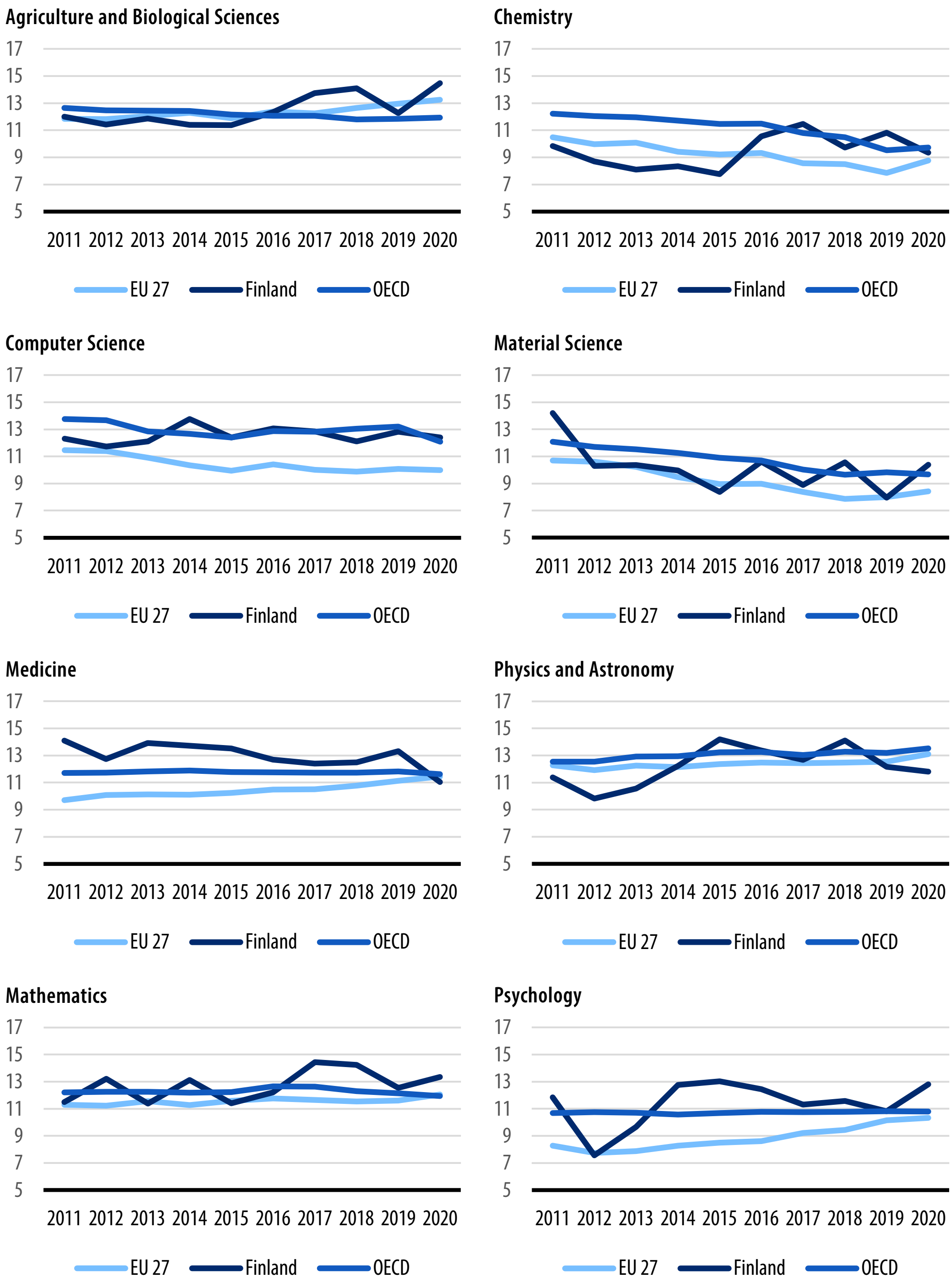
Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

52 NB: This means that only around 10% of the edges of the total network are visualized in the graph. For the statistical analysis below, all the edges are considered.

The major nodes in the network are biology, computer science, chemistry, medicine, and materials science. Biology and medicine share a large number of lower-level fields, while biology is also strongly interlinked with chemistry. What is also visible is that computer science (the second largest field) has a high number of lower-level fields, which have weaker connections to other top-level fields. As a first interpretation, this means that computer science is both strongly represented and has a high degree of (mono-disciplinary) specialisation. Of course, various important subfields of computer science are also strongly tied especially to mathematics and physics. The remaining major node is materials science, which has strong ties especially to chemistry and physics. To the left, a smaller cluster can be seen, which contains the humanities, social sciences, and economics, where especially sociology has strong ties to psychology.

The cluster analysis does not refer to any impact indicator of the publications: we therefore came back to more classical bibliometrics, using Scopus data on the percentage of scientific publications among the world's 10% top-cited publications. Figure 43 compares the Finland's performance with the OECD and EU27 averages in selected fields that most closely correspond to the dominant top-level fields identified by the cluster analysis.

Figure 43. Percentage of scientific publications among the world's 10% top-cited publications, selected fields, Finland, OECD and EU-27, 2011-2020



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 5.2021, September 2021.

The results show that Finland performs well, most often above the EU27 average, and most of the time close to the OECD average.

H.4 The importance of thematic clusters in Finland based on interconnectedness

In the next section, the underlying structural patterns of the network will be identified in more detail, to be understood as the 'interconnectedness' of different top-level fields via sub-level fields and the specific network characteristics. This will allow us to identify 'thematical' clusters or patterns within the network graph. On a high level, the idea behind the approach used is thus based on the notion of 'distance' between top-level fields. In order to put this conceptual frame to use, it will be critical how this notion of 'distance' will be operationalised. The idea behind the metric is that two fields are more similar, if they share a larger fraction of lower-level fields. Put differently: In a set of three top-level fields A, B and C, A will be closer to B than it is to C only if A shares a higher number of lower-level fields with B than it does with C. One reasoning is that a publication in a sub-level field that is connected to multiple top-level fields can be seen as being itself more interdisciplinary (as it literally is a field within the 'overlap region' of multiple top-level fields).

To implement this technically, we need to calculate a so-called distance matrix for the network. Various methods for this approach are known.[53] The one that has been chosen is based on the Pearson correlation coefficient of the columns in the adjacency matrix of the matrix.[54] This captures our degree of 'closeness' of two top-level fields within the network: correlation equal to 1 means that two fields share all and only their subfields; correlation equal to -1 means that the two fields do not share a single subfield (every lower-level field that is a subfield of one top-level field is not a subfield of the other top-level field and vice versa). The actual distances between research fields are calculated by subtracting the correlation matrix from 1 (so that the resulting matrix satisfies the axioms of a distance

53 http://ccicada.org/wp-content/uploads/2017/06/Community-Detection-with-Hierarchical-Clustering-Algorithms-Feb-3-2017.pdf

54 While this represents an element of choice in the methodology, using Pearson correlation over some alternatives (cosine similarity, Euclidean distance) has some merits. Very roughly: The correlation coefficient is a more direct measure of similarity, whereas e.g. Euclidean distance also measures the effect of "how many" lower-level fields there are (statistically speaking: when the number of lower-level fields overall increases, so will the Euclidean distance between the column vector, but not correlation). This is advantageous because we don't want to reduce the effect of two fields being placed very far from others on the basis of having more subfields.

matrix).[55] The resulting distances provide one possible lens through which to gauge the interconnectedness of publications in each top-level field.

Of course, all quantitative measures for interconnectedness of research fields are proxies, and therefore to understand the underlying patterns of cooperation between fields. Therefore, in Table 19, different metrics are used to characterise each of the top-level fields from the Microsoft Academic topic tree:

- The mean, maximum and minimum distance as well as the standard deviation of the distance scores for each top-level field. A low mean distance (in particular) signifies a higher degree of interconnectedness on average. To understand the structural patterns, the maximum and minimum distances as well as the standard deviation in the distances also provide a useful way of assessing whether the top-level field is part of a more isolated cluster of research fields (high maximum distance, low minimum distance, and high standard deviation) or whether it is 'more central' in the network (low maximum distance, higher minimum distance and low standard deviation)

- The degree centrality for each node. Degree centrality is a network-based metric, that quantifies the fraction of nodes that a node is connected to. Hence, the higher this value, the more important a node is for a network. However, this does not serve as a direct measure of interconnectedness between top-level fields, as a node might be connected to many mono-disciplinary lower-level fields to which no other top-level field is connected (and thus have high degree centrality without being interdisciplinary). Degree centrality, in other words, provides a measure for how 'specialised' a research area is

- The number of publications, and the developments in the relative share of publications (as measured by the linear regression curve of relative shares in the period 2011–2017; compare the discussion in 5.2.1).

55 https://en.wikipedia.org/wiki/Distance_matrix#Metric_distance_matrices

The results of this assessment are summarised in the following table:

Table 18. Summary of quantitative metrics derived from publication data

	Mean distances	Max distances	Min distances	Distances std.dev.	Degree centrality	# Publications	Trend in share
Geography	0.861	1.227	0.681	0.152	0.314	505	▲
Sociology	0.880	1.368	0.377	0.287	0.301	1.165	▼
Engineering	0.891	1.090	0.640	0.113	0.414	662	▼
History	0.894	1.225	0.488	0.204	0.194	283	▲
Mathematics	0.900	1.169	0.618	0.144	0.327	1.622	▲
Political science	0.904	1.312	0.377	0.284	0.246	881	▲
Psychology	0.904	1.206	0.495	0.200	0.405	2.003	▼
Biology	0.910	1.085	0.656	0.120	0.472	5.011	▼
Philosophy	0.922	1.197	0.420	0.216	0.097	242	▲
Art	0.926	1.177	0.420	0.230	0.087	113	▲
Computer science	0.932	1.100	0.640	0.137	0.589	3.415	▲
Business	0.948	1.231	0.348	0.241	0.262	455	▼
Economics	0.958	1.282	0.348	0.256	0.243	358	▼
Environmental science	0.962	1.211	0.654	0.201	0.307	1.498	▲
Physics	0.966	1.249	0.563	0.223	0.343	2.440	▼
Medicine	0.972	1.176	0.495	0.170	0.388	3.155	▼
Geology	0.979	1.200	0.654	0.179	0.172	332	▲
Chemistry	0.986	1.368	0.440	0.253	0.382	3.542	▲
Materials science	1.014	1.336	0.440	0.261	0.369	3.202	▲

Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

From these results, there are some main takeaways:[56]

- The fields that are trending upwards are – on average – also the ones that are more interconnected (have lower average distance) to other top-level fields and research that is funded (measured by total publications) leads to publications that share more lower-level fields with other top-level research areas. In quantitative terms: there is a positive correlation between the mean distances and the trend in relative shares (corr = 0.38) of the research fields as well as with the total number of publications (corr = 0.33).

- However, there are noteworthy peculiarities, especially concerning the fact that the some of the most strongly increasing fields (especially chemistry and materials science) rank near the bottom of the list (which is ordered by average distance to other fields). The interesting pattern for those fields is that although their minimum distance is low (only about 0.44) their maximum distances are relatively high (leading to a high standard deviation in the distances to other fields). Compare this to the case of geography, which has a low standard deviation in the distances to other fields, a comparable degree of centrality and most importantly a higher minimum distance than chemistry or materials science. The interpretation is that (prosaically speaking), geography reaches 'wider' into the network, while chemistry and materials science form a smaller unit or cluster with closer interconnections within that cluster and fewer to the outside

One therefore needs to look deeper into the network structure to understand the dynamics of interconnectedness between top-level fields. As the case of chemistry and materials science illustrates, there may be research areas that interact locally (i.e. that are 'interdisciplinary' in that narrow sense) but that form relatively isolated units when considering the research landscape as a whole.

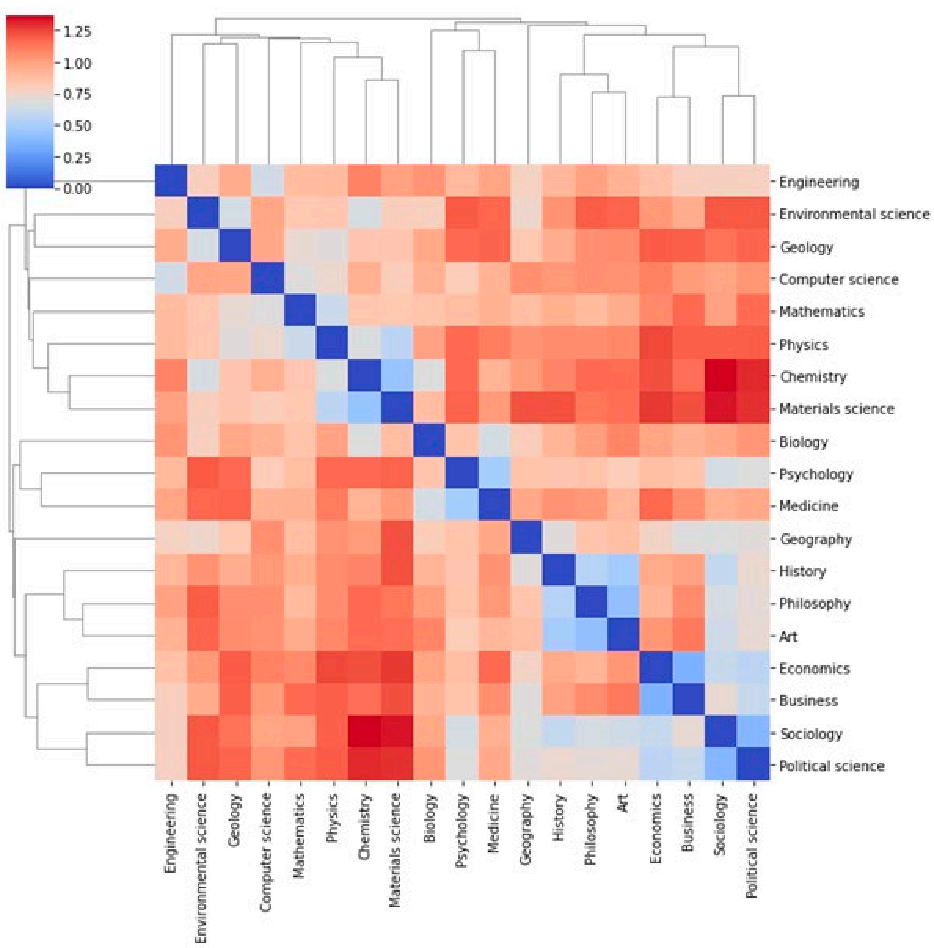
To achieve this identification of groups of research fields that emerge in Finland based on funding of the Academy of Finland, a clustering of research fields has been applied using a hierarchical clustering algorithm based on the distance matrix. Hierarchical clustering is a (non-supervised) clustering algorithm, and a popular method for identifying clusters within networks.[57] The results of this clustering are shown in Figure 44 below. It represents

56 On a methodological note: there is no correlation between degree centrality and average distance, which means that interdisciplinarity does not increase with the number of subfields a top-level field has. This is suggestive of the fact that the proposed average distances, as calculated above, provides a good measure for interdisciplinarity.

57 https://en.wikipedia.org/wiki/Hierarchical_clustering_of_networks

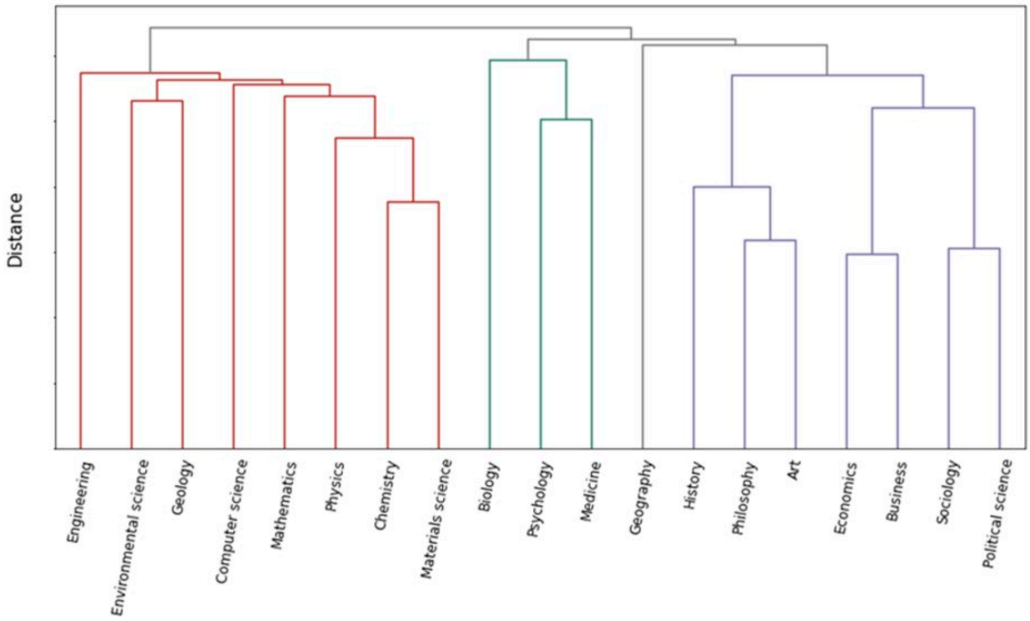
a heatmap of the distance matrix, where research fields are clustered along the x- and y-axis based on relative distances (as is visible in the dendrograms on both axis). Higher relative distances are marked in red, lower distances in blue. In Figure 28, the different resulting clusters are highlighted: the dendrogram (i.e. the clustering into groups) is shown for the case of determining three distinct clusters.

Figure 44. Clustering of research fields based on the relative distances to each other



Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

Figure 45. Visualization of the main clusters (dendrogram) from a high-level



Source: Data: Academy of Finland, MS Academics, Calculation and presentation: Technopolis

The largest distance is between chemistry/materials science and sociology/political science. Other fields in the natural sciences also have weaker links to the social sciences and the humanities. Engineering and computer science, however, have the lowest distances to fields outside the natural sciences. Overall, **three major** clusters of similar top-level fields can be discerned, which follow relatively traditional groupings, with geography being outside/in-between the major clusters.

- Cluster 1 – '**Natural Sciences**'. The first and largest cluster contains the natural sciences (top-left corner of the heatmap). The strongest connection can be found between chemistry and materials science, which were already seen to be strongly interacting above. The closest field to chemistry and materials science is physics, with mathematics being the field that interacts most strongly with physics. Furthermore, environmental science and geology also form a sub-unit within the cluster of the natural sciences. Engineering is the most isolated field within this cluster.

- Cluster 2 – '**Health and Life Sciences, Biology**': In this cluster (central in the heatmap), medicine and psychology interact most strongly, while biology also interacts with the adjacent cluster of the natural sciences. Psychology has a relatively low distance to fields in the humanities and social sciences (especially sociology and political sciences), and has the widest reach outside of that cluster in this direction (following the horizontal line for psychology in the heatmap to the right).

- Cluster 3 – '**Social Sciences & Humanities**': Within this cluster (bottom-right of the heatmap), there are three fragmented groups: (a) philosophy, art and history, (b) economics and business, and (c) sociology and political science. From the heatmap, it can be seen that sub-cluster (c) is the main 'link' within this group: both sub-clusters (a) and (b) lie relatively close to (c), while being at a greater distance from one another.

- '**Geography'**: Geography is the stand-alone case in the network of publications. Although it has the lowest average distances, it does not have any particularly strong ties to any other remaining fields, and is therefore not part of any specific sub-cluster. As was remarked above, this is related to the low average distance of geography to other fields (geography reaches 'deep' into the network) without there being any particularly strong connections to specific fields. In other terms: many of geography's subfields are also subfields of other research areas, however, this distribution is relatively equal across the remaining research fields.

This configuration in three clusters is particularly interesting, as the Academy has reduced the number of Research Councils from four to three in 2019. Thematic analysis of publications based on Academy funding from the years 2011–2017 supports the fusion of biology and medicine in one research council, however, environmental sciences are rather positioned in the cluster of natural sciences.

H.5 Methodological approach of a bibliometric study of the Academy of Finland

In 2021, the Academy of Finland published its own bibliometric review – Katja Mankinen and Yrjö Leino: *Identifying research topics and collaboration networks in Finland: topic modelling of scientific publications in 2008–2019* – of publications by Finnish researchers.[58]

The approach by Mankinen and Leino considered all English language publications with at least one author with Finnish affiliation, in order to derive popular topics and trends in the

58 https://www.aka.fi/en/research-funding/programmes-and-other-funding-schemes/flagship-programme/

Finnish research landscape based on a topic modelling algorithm. based upon publication data indexed in the Web of Science® database. The authors applied an unsupervised natural language processing algorithm to the abstracts, keywords and titles of the selected publications, thus deriving a total of >1k research topics (our approach above included 19 top-level fields and ca. 290 first-level fields). Their analysis of thematic areas within the Finnish research landscape, as well as the collaboration networks, proceeds from the result of this topic modelling step.

- The topics that result from the approach by Mankinen and Leino exhibit another hierarchical structure as the topics derived from the MS Academic database. Among other things, their analysis happens on a more fine-grained-level (with topics covering between approx. 55–560 publications)

- Different database: The Web of Science covers the publications of Finnish researchers, whereas the database used above is internally managed by Academy of Finland and represents a subset, related to funding of the Academy

- Focus on high-impact research: Mankinen and Leino focus on the topics with the highest impact, where impact is measured by the top-ten index per topic (i.e. the proportion of publications of a certain topic that belong to the most frequently cited 10% in their respective fields)

- Collaboration was analysed on an institutional level: The network approach by Mankinen and Leino models the collaboration on an institutional level (i.e. a collaboration in their analysis is a co-authorship of authors from different institutions in the same topic)

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