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PUBLIC RESEARCH FUNDING IN SWEDEN

OPTIMISING THE SYSTEM IN RESPONSE TO MULTIPLE DEMANDS

OECD SCIENCE, TECHNOLOGY AND INDUSTRY
POLICY PAPERS
May 2023 **No. 148**

OECD
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OECD Science, Technology and Industry Policy Papers

This paper was approved and declassified by written procedure by the Committee for Scientific and Technological Policy (CSTP) on 5 May 2023 and prepared for publication by the OECD Secretariat.

Note to Delegations:

This document is also available on O.N.E under the reference code:

DSTI/STP/GSF(2023)6/FINAL

Foreword

This report includes suggestions and options for change for the public funding of research and innovation in Sweden. It is an input to the review committee U 2022:06 and is designed to inform a broader dialogue that is taking place amongst different national stakeholders. The Swedish government established the review committee in 2022 to analyse the current state of public funding for research and innovation and propose changes to existing funding structures and mechanisms to effectively promote research excellence, support innovation, and address societal needs.

The current report provides an outside view of the challenges and opportunities for the Swedish research and innovation system, which is faced with similar challenges to those of many other OECD countries. Illustrative examples from these countries are included, where appropriate. Options for change to improve public research funding are included in the report to stimulate discussion. Many of these actions would need further refinement before they could be implemented.

In 2016, an OECD review provided a comprehensive analysis of the Swedish STI system, including some of its major policy initiatives at that time, and identified areas for improvement and associated policy actions. The recommendations in the OECD review focused on 4 key areas: 1. strengthening university research; 2. linking research and innovation; 3. STI to address societal challenges; and 4. priorities, strategies and governance. These four areas align well with the remit that has now been given to the review committee U2022:06 and hence provide a good starting point for the analysis in this report. The report takes into account contextual changes in Sweden since 2016 and builds on recent and ongoing work conducted by the Global Science Forum (GSF) and the Committee for Science and Technological Policy (CSTP) of OECD. However, it does not pretend to be a detailed in-depth analysis of the whole Swedish STI system.

In 2022, the OECD CSTP launched a cross-cutting initiative, named S&T Policy 2025, that focuses on enabling socio-economic transitions through science, technology and innovation (STI). The initiative aims to provide systematic guidance for driving reform, on the premise that a gap exists between the current STI policy framework and what is needed to realise policy objectives such as sustainability, resilience and inclusiveness. This includes the combination and design of new policy instruments addressing critical aspects of the functioning of STI systems, including: funding; human resources; research infrastructures (RIs); coordination mechanisms; and evaluation and measurement. The initiative aims to build on recent OECD work in each of these areas. Although the systematic guidance for S&TP2025 has not yet been fully developed, the question of what it means for public research funding in Sweden is directly relevant to the current analysis.

This work was commissioned and paid for by the review committee U 2022:06. It was drafted by the GSF Secretariat Masatoshi Shimosuka, Carthage Smith and Frédéric Sgard with input from Michael Keenan, Philippe Larrue and Blandine Serve.

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Executive Summary

The demands and expectations for publicly funded research are increasing. Science is expected not only to be a major source of knowledge creation and innovation, but also to address societal challenges. The Covid-19 pandemic has made it clear how research and innovation impact the whole socio-economic system. Breakthroughs in science and innovation, are urgently required to enable sustainable societal development within critical planetary boundaries. Science has a vital role to play in underpinning societal transitions and improving resilience and, as intermediaries between the government and research providers, funding agencies are expected to play a leading role. At the same time, public budgets for science are limited. Those involved in public research funding are faced with the difficult task of finding ways to meet these growing demands and expectations.

The OECD review of innovation policy in Sweden in 2016 ('OECD 2016 review') provided a comprehensive analysis and recommendations relating to 4 key aspects of the STI system: strengthening university research; linking research and innovation; dealing with societal challenges; and, prioritisation, strategy and governance. The current report builds on the OECD 2016 review and provides options for change and case studies on how the public funding system can effectively promote research excellence and innovation and address societal needs. The options for change and examples combine the results of recent work done by the OECD Global Science Forum (GSF) and the Committee for Science and Technological Policy (CSTP).

This report is organised under five pillars: 1) university excellence, taking risks and addressing societal needs, 2) research infrastructures, 3) supporting societal transitions and resilience, 4) STI strategy, and 5) governance and structures. The issues and solutions that arise under the different pillars are interrelated and need to be considered both individually and systemically.

1. University excellence, taking risks and addressing societal needs

Universities are the critical players in publicly funded research and innovation activities in Sweden. This is evident from the fact that public research funds are largely invested in universities. Therefore, responding to the growing demands and expectations from science in the Swedish context means nothing less than maximising the capacity of universities to meet these demands and expectations. The OECD 2016 review noted challenges with leadership and strategy implementation in the university system.

Public funding agencies need to provide universities with the necessary support and incentives to help them overcome this strategic deficit and embrace new priorities and research approaches.

Options for change 1: for university excellence, taking risks and addressing societal needs

- Incentivise universities to take on a strategic leadership role and implement institutional changes that enable risk-taking and challenge-driven research. Competitive funding awards from funding agencies can either directly support such change or be conditional on change taking place.
- Consider the need for linking societal challenges and/or innovation performance of universities to the allocation of General University Funds (GUF).
- Foster High-risk/High-reward (HRHR) research by introducing a portfolio approach at the programme level and designing competitive funding initiatives and performance monitoring processes that incentivise researchers and their universities to take more risk and develop more inter- and trans-disciplinary research.
- Research funders and universities need to work together to develop and adopt research evaluation criteria and processes in line with DORA and other such declarations that recognise not only

research excellence in disciplines but also risk-taking and contributions to resolving pressing societal challenges.

2. Research infrastructures

Research infrastructures (RIs) are essential enablers for research and innovation activities and can play an important role in supporting and facilitating challenge driven research. As is the case in Sweden, RIs are often funded through a variety of different funding schemes, which can make it difficult to take a strategic approach. Although RIs were not specifically addressed in the OECD 2016 review, the survey that has been conducted as part of the ongoing Swedish government U2022:06 review, revealed considerable concern in the research community with regard to how RIs are managed.

An extensive corpus of OECD work, including analysis of individual RI cases from Sweden, has led to a number of options for change, concerning key aspects of RI management, that are relevant in the Swedish context.

Options for change 2: for research infrastructures

- Develop a national RI portfolio management strategy for better decision-making (including on national vs international investment), resource allocation and optimisation of synergies.
- Set up a dedicated, long-term funding mechanism for RIs that enables long-term visibility/commitment and participation in relevant international RI projects.
- Provide support (by research funders to the promoters of new RI projects) for establishing robust business plans, covering the whole RI life-cycle.
- Support the development of user-base optimisation strategies by individual RI managers.
- Develop, in consultation with all relevant stakeholders, a consensus impact monitoring toolbox that can inform funders/decision makers and RI managers.

3. Supporting societal transitions and resilience

Societal transitions and resilience are increasingly important targets for public research investment. In Sweden, a number of challenge-driven research and innovation initiatives have been initiated following the the Lund Declaration in 2009. Some of these were considered in the OECD 2016 review and a number of common challenges were identified that have been confirmed in more recent programme reviews. A critical issue has been ensuring the involvement of different stakeholders at different stages of prioritisation, programme design and project implementation

Options for change 3: for supporting societal transitions and resilience

- Strengthen the government's, and other critical stakeholder's, engagement in the agenda- and priority- setting process of challenge programmes, such as the Strategic Innovation Programmes (SIPs) and National Research Programmes (NRPs); establishing agendas and priorities at the cross-government level should enhance the national commitment to research on societal challenges and facilitate deployment of various policy instruments including regulations.
- Learn from past experience and build on existing expertise in further developing SIPs and NRPs or other challenge programmes, while using a portfolio management approach at the agency and national level. Different initiatives should be linked or coordinated through effective bridging mechanisms, potentially including a common governance system (see ahead).
- Adapt research management and funding processes, including evaluation of the proposals, monitoring of projects and assessment of impacts, drawing on good practices for implementing challenge programmes in different countries.

- Promote funding programmes to support capacity building within universities to address societal challenges (see 1.).
- Provide support to existing centres of excellence to network with other research institutions to develop solution driven transdisciplinary research initiatives and build related capacity.

4. STI Strategy

Each of the 3 pillars of university excellence, research infrastructures and societal transition and resilience need to be addressed by a set of policy tools and involves multiple stakeholders. Effective collective action requires a shared vision and strategy. In addition to highlighting an overall lack of strategy within the Swedish system, the OECD 2016 review specifically identified a lack of coherence in policy, planning, governance, and processes.

The Swedish research system includes a large variety of actors, including multiple funding sources. This appears to encourage an opportunistic rather than strategic approach and makes it difficult to implement new approaches and initiatives at a significant scale.

Options for change 4: for STI Strategy

- Establish an overarching national strategy for developing the research and innovation system, with public research funding organisations playing a central role and all research actors, particularly universities, being consulted. The strategy should integrate excellence and socio-economic benefits and make explicit the role of academic research and universities in addressing complex and urgent societal challenges.
- Introduce an inclusive and transparent muti-stakeholder process for setting high-level research priorities and engage the research community and institutions from the outset to strengthen their commitment. Part of this process might include public consultation.
- Clarify the remit of different funding organisations while ensuring the alignment of funding initiatives through portfolio management at the (cross-) agency and national levels.
- Pursue deeper strategic alignment between public research funding agencies and foundations, and establish effective coordination mechanisms with major private foundations.
- Align the national strategy and priorities, and implementation activities at the research agency level, with EU research priorities and leverage EU support to facilitate change at the national level.

5. Governance and structures

Sweden has a diversity of public research funding agencies that each have their own remit, culture and ‘users’. The challenges faced by the Swedish research system (1-4 above) are systemic and cut across these different funding agencies and so it is timely to ask whether the current governance and structures for public research funding are optimal to effectively respond to these challenges. Already in the OECD 2016 review, the issue of rationalisation of funding bodies was raised. Since then the experiences with the various challenge programmes have emphasised the need for more effective cross-agency governance.

Two potential scenarios for restructuring research funding are presented for consideration in this report. The incremental change scenario proposes more effective coordination across the existing agencies. The radical change scenario involves the merger of several agencies and the preservation of the Research Council but with a new remit and governance structure. There are obvious variations of these scenarios that might be more interesting in the Swedish context. What is most important is that any change in structures is driven by a clear strategy and aims that these have buy in from key stakeholders, including, in the case of Sweden, the universities. Form should follow function rather than vice-versa.

Options for change 5: for governance and structures

- Give serious consideration to reforming the governance and structures of the public funding organisations in Sweden. The rationale for reform is to create and implement more coherent policies that align with a shared national strategy and address the need to more effectively support STI that enables socio-technical transitions. Such reform could include modifications to the remits and coordination mechanisms for existing funding agencies, and/or might include more radical structural changes and mergers.

Introduction

In common with many other countries, there are increasing demands and expectations for publicly funded research in the Swedish context. In addition to producing excellent basic research and new knowledge, science systems are expected to underpin innovation and provide solutions to complex societal challenges, including those embedded in the UN Sustainable Development Goals (SDGs). There is growing recognition, that meeting these inter-related but distinct expectations, requires an evolution in the way funding agencies operate, in how STI strategies are developed and implemented and in how universities and research infrastructures perform and are assessed.

Since the OECD review of the Swedish STI system in 2016 ('OECD 2016 review'), two major global disrupters have emphasised the critical importance of both basic and applied science in addressing complex societal challenges. The COVID-19 pandemic required rapid and unprecedented mobilisation of science and, as countries emerge from the pandemic, a series of hydrometeorological crises across the world have highlighted the urgency of addressing environmental changes, including global warming and biodiversity loss. STI has a critical and urgent role to play in promoting societal resilience and sustainability and this is becoming a central aim for STI policy and research funding.

The COVID-19 pandemic has significantly impacted all sectors of society, including science systems. While science alone cannot solve complex societal challenges, the pandemic has illustrated how science is inseparable from society and needs to work with, and meet the needs of, multiple stakeholders, including policy makers and civil society. The development and provision of vaccines in record time was dependent on long-term investment in fundamental research and effective collaboration between academia and industry. In other areas, such as engagement with policy makers and the public, science struggled and the limits of conventional STI policy were sometimes starkly apparent. Scientific advancement requires policy support in many areas, including data and information, research infrastructures, and science-industry collaborations. Effectively integrating scientific evidence into policymaking and building societal trust and engagement are now high on the agenda for science policy makers and research providers.

Environmental issues, including climate change and biodiversity loss, require urgent attention that goes beyond increased scientific understanding to providing comprehensive socio-technological solutions. Taking climate change as an example, Sweden adopted a new climate policy framework in 2017, which includes a climate act, climate targets and a climate policy council, in order to meet the targets of the Paris Agreement that were set in December 2015. These targets will not be achievable without a combination of technological innovation (re. excellent basic research) and societal and behavioural transitions (re. transdisciplinary research and innovation) and the timeline for meeting these targets is now very short.

These two massive global disrupters – COVID-19 and the environmental crisis – strongly emphasise the importance of research and innovation systems in supporting, and in some cases leading, socio-economic transitions to sustainability and resilience. This means that STI systems themselves need to be resilient. Public research funding agencies and research providers, including universities and research infrastructures (RIs) need to be both the drivers and implementers of the necessary transformations.

While universities play a very significant role in research and innovation in Sweden, questions were raised about the strategic leadership in universities in the OECD 2016 review. Although the collegiate management of universities has its advantages, a lack of leadership and strategy can be problematic not only for promoting high-risk research and research excellence but, more significantly, for addressing complex societal challenges. Traditional research support systems and universities do not incentivise researchers to pursue transdisciplinary research (TDR) and high-risk/high-reward (HRHR) research, or

mission oriented research, all of which are required for addressing complex societal challenges (OECD, 2020[1]; OECD, 2021[2])

Research Infrastructures (RIs) and the services that they provide are critical enablers of both fundamental and solutions focused research and, as was seen during the COVID-19 pandemic they can play a major role as intermediaries that bring together different disciplines and actors. Networks and clusters of RIs or RI ecosystems are essential for addressing complex societal challenges. Establishing and maintaining a comprehensive national RI portfolio requires strategic planning and sustainable long-term investments. Whilst RIs were not an area of focus for the OECD 2016 review, it is notable that in the recent survey conducted for the ongoing Swedish Government review, there was a high level of dissatisfaction/concern with how RIs are managed in the Swedish research system.

Socio-technical transformations require more than the creation of new knowledge and technologies. They need societal support and behavioural changes. Achieving this requires an agreed vision and a combination of policy actions and institutional changes. It requires a holistic, cross-sectoral approach to STI policy development, combining not only financial support but also regulation and capacity building. It also requires the engagement of diverse stakeholders and the introduction of innovative policy tools at both the strategic and operational levels, i.e. new initiatives that go beyond traditional policies for promoting research and innovation.

Research funding organisations have to work within limited budgets and given the multiple demands and expectations from research, they need to be strategic, establish priorities and make choices. They need to balance the demands of the research community, with the needs of policy makers and the expectations of society. Research excellence and rigour need to be balanced, or integrated, with research relevance and urgency. Research is international and strategic alignment of national priorities, research strengths and needs with international priorities, notably at the EU level in the case of Sweden, can leverage additional resources and expertise for mutual benefit. Linking, or coordinating, public research funding with private or philanthropic funding can also help ensure that the multiple demands from research are met. Structures and processes need to facilitate connections between different funders, limiting barriers and maximising complementarities.

The governance and structures of funding organisations should be designed to efficiently and effectively deliver the multiple demands from research. In so doing they need to leverage and provide support to research providers, and in particular universities. Silos between funding agencies and within universities are increasingly seen as a challenge for addressing complex societal challenges or mission-focused research that cuts across different sectors or domains. Similarly, the tendency towards disciplinary conservatism is an obstacle to risk taking in research as new scientific breakthroughs often emerge at the boundaries between different fields. As evidenced in many countries during COVID-19, effective planning and coordination across multiple research agencies is not easy. Several countries have recently established new coordination and joint programming initiatives and in some instances are fusing different agencies. It is timely to ask whether similar action is necessary in the Swedish context.

This paper is structured into five sections: university excellence, taking risks and addressing societal needs; research infrastructures; societal transitions and resilience; STI strategy; and, governance and structures. Each section begins with the relevant recommendations from the OECD 2016 review as a starting point, then describes the key contextual changes since 2016, and provides analyses and options for change for the public funding of research and innovation in Sweden, illustrated with case examples from other countries. It is important to note that the different sections, and options for change, are closely interrelated. Basic cross-country comparative data on research systems and some aspects of their performance is provided in appendices and is referred to in the text of this report where appropriate.

Analysis and Options for Change

1. University excellence, taking risks and addressing societal needs

In the Swedish research system, the role of universities is essential and the majority of the governmental appropriations for research and development is allocated directly to universities. As the main research providers in Sweden, universities have to maintain research excellence, facilitate scientific breakthroughs and risk-taking and generate the knowledge and innovations that are required to address societal challenges. Meeting these three expectations from research is no easy challenge. The recommendations of the OECD 2016 review in this regard were:

- to address the governance and leadership weaknesses of the university system,
- to ensure that the increase of general university funds (GUF) is combined with sustainable improvement in research performance,
- to avoid extending the Strategic Research Area (SFO) without addressing the weaknesses in universities' strategies and leadership,
- to amend GUF allocation to link it to performance and rewards and incentivise the third mission,
- to encourage the improvement of human resources,
- to promote specialisation for universities, and
- to change external third-party funding (TPF) to give larger grants with fewer beneficiaries and rationalise the number of funding organisations.

With regard to traditional measures of excellence, Sweden does reasonably well in terms of total research publication outputs and highly cited publications, when compared to other OECD countries, although there is some concern that increased investment over the past decade is not reflected in corresponding increases in productivity/performance. Relative to certain benchmarks countries, such as the Netherlands or Switzerland, Sweden is perhaps lagging behind when it comes to traditional bibliometric performance indicators or league tables (see appendix, figs 1,2,4 and 5).

Weighing the merits and disadvantages of using different bibliometric measures to assess research performance is not the main focus of this report, but the OECD 2016 review referred to a relationship between performance and the implementation of university strategies. Specifically, '*Sweden's "good but not sufficiently excellent" scientific performance points to a failure by university management to be selective, combined with sub-optimal mechanisms affecting the allocation of funds (whether from TPF, with its medium-sized instruments, or from the way the universities allocate GUF internally)*' (OECD, 2016[3]). The creation of internationally competitive research fields requires commensurate support, which often involves a reallocation of resources within an organisation. Only universities themselves can decide to reduce or discontinue activities to strategically refocus their resources. This requires leadership and governance arrangements that enable universities to implement strategies and take risks that may not always have full consensus support internally.

This relationship between the strategic strength of a university and its performance is supported by analysis of the SFO programme, which suggested that universities with long-term strategies are better able to capitalise on funding opportunities than others (OECD, 2016[3]). This in turn relates to choices in terms of allocation of GUF to strategic priorities and these choices depend on university governance processes. In other words, a stronger organisational research strategy and its implementation have implications for supporting research excellence. The ability to develop, implement and modify strategies is also a necessary condition for a university to evolve with changing needs and opportunities including in responding to societal challenges. The importance of this cannot be over-emphasised in the case of Sweden, where universities play such a critical role in state-funded research.

As in most OECD countries the university landscape in Sweden is not homogeneous. Sweden has a relatively small number of traditional research universities with a long history and a larger number of relatively young university colleges that have limited research activity. In the SFO initiative, strong specialised research universities dealing with technology and medicine, whose SFO applications and institutional strategies were closely linked, were more successful than their less-focused counterparts. This again highlights the link between strategy and excellence – at least in terms of competitive funding success.

The level of GUF compared to the total research budget of universities is a hot point of discussion in Sweden as it is in many other OECD countries. On one side, the argument is that increased GUF enables universities to be strategic, support more core staff and take long-term risks. On the other side, more competitive funding is said to promote research excellence and ensure a level playing ground across universities/research groups. Cross country comparisons reveal no correlation between the proportion of GUF and bibliometric research performance (see appendix, fig 3). According to the OECD 2016 review, *'there is no clear evidence that, if the Swedish universities do have a "research problem", it is caused by the GUF level'*. Certainly, there was no evidence in 2016 that increasing GUF was enabling Swedish universities to be more strategic – indeed those institutions that did best in the SFO competition tended to have lower levels of GUF.

At the same time, bibliometric indicators are increasingly criticised as measuring only one aspect of excellence and narrow pursuit of higher performance against these measures of academic success is unlikely to lead to better delivery of the multiple outputs that are demanded from public research. Traditional academic and university structures, organised in disciplines and focusing predominantly on publication outputs, struggle to effectively support high-risk research and inter- and trans-disciplinary research to address complex societal challenges. Pressure to publish and precarity in research careers and funding tends to promote conservatism in research choices – favouring safe short-term incremental research over higher risk or uncertain longer-term research. This conservatism is often embedded in, and encouraged by, the traditional funding distribution systems for both GUF and competitive research funds (OECD, 2021[2]).[1]

Redirection of universities

Whilst governments establish the overall framework in which universities operate, respect for academic freedom and university autonomy limit the influence of governments and research funding agencies on the internal operations and structuring of universities. Change has to come from within. As summarised in a recent cross-country analysis of policies to promote transdisciplinary research (OECD, 2020[1]), public research funders can play an important role in incentivising and supporting such change, promoting strategic leadership and providing significant funding for high risk and challenge driven research linked to clear criteria.

Sweden can learn from initiatives in other countries that link public funding provision to university reforms and incentivise the implementation of non-traditional research cooperation across different institutions (See box 1). These cases show how strategic leadership in universities can change conventional research environments to simultaneously support societal transition and innovation activities as well as research excellence. It is important to note that in these cases, reorienting the university and working to improve its

[1] It is noteworthy that in a recent OECD working paper on new High-Risk High-Reward (HRHR) indicators (Machado, 2021[20]), Swedish performance when analysed as a share of top 10% most novel publications worldwide was above average during the 2005-2017 period, and Sweden also had an above average level of international collaboration, suggesting a fairly satisfactory performance for these aspects of the research system.

societal value is not in conflict with research excellence, but rather compatible with it, and in fact leads to the extension of research excellence.

Reforms in universities are affected by a complex combination of different measures that need to operate synergistically within a unified overall strategy. In this context, the fundamental importance of having appropriate research evaluation criteria and processes should be recognised. The behaviours of researchers, especially early career researchers, are dictated by tenure, promotion and career advancement policies and the behaviour of research institutions is strongly influenced by how they will be assessed. The need for improving the way in which the publicly funded research and researchers are evaluated is recognised in the San Francisco Declaration on Research Assessment (DORA) that was developed in 2012 and has subsequently attracted a lot of international support from within and outside academia. Some countries are now taking active measures to follow up on this declaration (see Netherlands example, box 1) and the European Commission is also promoting reforms.

Many universities across the world, and in Sweden, have established Centres of Excellence, which are often multidisciplinary, and mission driven. Many of these carry out world-leading research and they often attract significant external funding from both public and private donors. However, they tend to remain as 'add ons' and often have little real influence on the overall direction and operations of their university 'hosts'. This limits their effectiveness and their capacity to act as change agents within the research system as a whole. In Sweden, the Stockholm Resilience Centre (SRC) is notable in this regard. It is a world-leading institute established within a historical university, supported mainly by the Swedish Foundation for Strategic Environmental Research (Mistra), with competitive third-party funding from multiple other public and private donors. There seems to be considerable unexploited potential from both the University of Stockholm and the Swedish research system as a whole to leverage the expertise and resources within the SRC to promote research excellence and risk-taking whilst addressing societal challenges.

The Swedish experience with SciLifeLab (Science for Life Laboratory) is interesting in this regard. The SciLifeLab, which provides access to cutting-edge life science research infrastructures, was launched in 2010 as a joint effort of four universities (Karolinska Institute, KTH Royal University of Technology, Stockholm University and Uppsala University), and was awarded status as an official national infrastructure for molecular biosciences in 2013. It is funded by a combination of government grants, funds via the universities through the SFO framework, and external funding, e.g. from the Wallenberg Foundation. The SciLifeLab operates not as an internal centre of a single university, but as a collaborative platform for cross-disciplinary, basic and applied research that engages non-academic partners. This experience of scaling up a federated initiative to the systemic level could provide valuable insights for amplifying existing scientific excellence and implementing substantial change across the Swedish research system to address complex strategic priority areas.

Box 1. Combining research excellence and societal relevance in universities

Arizona State University (ASU) and its Decision Centre for a Desert City (DCDC) (USA)

ASU embraces an overall mission to address societal challenges and is organised into colleges with more than 170 cross-disciplinary centres and institutions. The university is one of the top ranked universities for research and innovation in the US, and many of its centres actively engage with non-academic stakeholders to pursue solutions for complex real-life problems.

The DCDC exemplifies what ASU is about. It was established in 2004 with an investment from NSF through the Decision Making Under Uncertainty programme. The centre aims to provide the knowledge and technologies for transitions to sustainable water management, and a cross-sectoral team of social, behavioural, economic and sustainability researchers are working in partnership with 'external' stakeholders. Both formal and informal approaches have been taken in the design, implementation and evaluation of the project to ensure that knowledge from outside academia is incorporated into research

and solutions. In addition to workshops and collaborative transdisciplinary research an External Advisory Committee includes representatives from key decision-making bodies.

This type of transdisciplinary research generally takes a long time before it can be published in scientific journals and the research itself may be less scientifically impactful (in the short-term) than more fundamental research, which is a disincentive for young researchers who need to develop their careers. For this reason:

- the centre provides specialised training and post-doctoral research mentorship programmes, and
- all post-docs are required to participate in regular mentoring meetings and evaluations as well as submit an Individual Development Plan.
- the centre has worked with university management to reform promotion and tenure review procedures, and "conduct use-inspired research" has became one of the Eight Design Aspirations of the university.

Source: (OECD, 2020[1])

Aalto University (FIN)

Aalto University was established in 2010 through the merger of three universities – Helsinki University of Technology, Helsinki University of Economics and Helsinki University of Art and Design – with the aim of becoming a 'world-class innovation university' as envisaged by the 2004 Brunila Report. The vison was to 'create a new innovative university merging science and technology, design and art, and business and economics'. It has focussed on cross-disciplinary areas that build on the capacity and competencies of the original three universities. Hence its activities now focus on seven key areas – 1) ICT and digitalisation, 2) materials and sustainable use of natural resources, 3) arts and design knowledge-building, 4) global business dynamics, 5) advanced energy solutions, 6) human-centred living environments, 7) health and wellbeing – which combine four core competences in the fields of ICT, materials, arts and design and business together with three grand challenges related to energy, living environment and health.

In order to develop a multi-disciplinary university with an international perspective, the university adopted approaches that were relatively unusual in Finland such as

- offering both bachelor's and master's programmes in English,
- introducing competency-based tenure track mechanisms to increase international staff, and
- engaging more deeply with industry to support international research partnerships.

As a result, the university is ranked globally as one of the best performing universities, founded in recent years. Also, the introduction of tenure-track positions has been an effective mechanism for increasing the proportion of foreign staff: as of 2019, 38% of the teaching staff were foreign, an increase of 111% from the 2010 ratio.

Aalto University is legally defined as a non-profit foundation rather than a public corporation, and the university has capital endowments with funding from the private sector. In addition, the government invested merger funds and provided significant additional financial support including matching funds that are added to the private funds raised by the university.

Source : (OECD, 2021[4]) ; https ://www.aalto.fi/en/aalto-university/history; https ://www.aalto.fi/en/research-art

Technical University of Berlin (GER)

The technical university has developed a transdisciplinary research strategy that is promoted by the University's Executive Board as well as at the highest leadership level. To promote cooperation with non-academic partners, consultation workshops and trialogues are organised by specialised university teams, leading to the identification of topics and project ideas and funding applications. A Pre-Research Forum has been organised in collaboration with Freie Universität Berlin, Humboldt Universität zu Berlin and Charité – Universitätsmedizin Berlin and a number of transdisciplinary trialogues focussing on urban development have also been held. These bring together stakeholders from science, politics,

business and civil society to address specific urban themes, such as migration, mobility, growth and tourism.

Source : (OECD, 2020[1]) **;** https://www.tu.berlin/en/topics/knowledge-exchange/2020/mai/citizen-science-researching-with-society

World Premier International Research Centre Initiative (WPI) (JPN)

The WPI was launched in 2007 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) aiming to promote university reforms as well as industry-academia collaboration and interdisciplinary research. Specifically, the WPI supports the establishment of globally open, state of the art, research centres for 10 years. These are deigned to attract talent from all over the world and must comply with a number of criteria:

- each centre to expand new leading-edge and new interdisciplinary domains,
- each centre to secure comparable outside research resources through other competitive funds, donations, in-kind contributions, etc., and
- the centre's host institution to clearly define the centre's role within the institution's strategy and commit to providing comprehensive support to the centre.

For each centre, a monitoring system is in operation. An international Programme Committee, Programme Director and Programme Officer conduct an annual two-day site visit to assess project progress and advise on necessary corrective actions.

The WPI has produced high quality research outputs, with the percentage of top 1% cited publications by the five WPI centres supported in the early years being higher than that of the world's top universities. The initiative has also been well received by the industry and other stakeholders. At the same time there are some challenges, such as ensuring the continuity of the centres after the initial public funding support come to an end.

Source: (OECD, 2018[5])

Research Assessment Reform (NLD)

In the Netherlands, public research funders, jointly with universities and research institutions, published a position paper in 2019 entitled 'Room for everyone's talent: towards a new balance in the recognition and rewards for academics'. The position paper is supported by the 3 main public research funders: KNAW (Royal Academy of Arts and Sciences), NWO (Netherlands Organisation for Scientific Research) and ZonMw (Netherlands Organisation for Health Research and Development).

A Strategy Evaluation Protocol (SEP) for 2021-2027, which has been adopted by VSNU (Association of Universities in the Netherlands), KNAW and NWO, emphasises the use of qualitative assessments and paying attention in evaluations of contributions to: open science, academic culture, human resource policy and PhD policy.

Furthermore, NWO and ZonMw have committed that they will no longer request, or take account of, bibliometric indicators in funding applications, and they will modify the research outputs template on curricula vitae and application forms to include broader outputs and narratives.

Source: https://www.nwo.nl/en/position-paper-room-everyones-talent; https://sfdora.org/resource/room-for-everyones-talent/; https://stip.oecd.org/stip/interactive-dashboards/policy-initiatives/2021%2Fdata%2FpolicyInitiatives%2F99993910; https://stip.oecd.org/stip/interactive-dashboards/policy-initiatives/2021%2Fdata%2FpolicyInitiatives%2F99993908

As discussed previously, public funding for research in universities consists of both competitive funding from funding agencies and General University Funds (GUF). Whilst much of the policy discussion focuses on the relative proportions of these funds, the criteria for allocation of GUF are potentially another tool for promoting institutional change. For example, a certain percentage of the GUF research allocation could be linked to the delivery of research for societal challenges, risk-taking and innovation. Sweden has some previous experience of this with the SFO, an initiative under which universities received additional

institutional research funding for five years on the condition that this was linked to strategic research areas identified by the government. The SFO was a policy designed to ensure that a certain percentage of research funding was used to generate societal benefits or solve societal challenges. As has been discussed earlier, the success of the SFO, depended on universities' ability to make strategic choices, which many institutions found difficult. It has also been noted that some of the SFO's objectives were not clearly integrated into the criteria and requirements, which governed its implementation (OECD, 2016[3]). Currently, in Sweden a certain percentage of the GUF continues to be allocated based on research performance (quantity and quality of scientific publications, and external funding). The experience of the SFO could be leveraged now to link the allocation of GUF to reforms in university governance and effective strategic leadership. New performance assessment frameworks that incentivise innovation, risk-taking and dealing with societal challenges would complement this.

Funding mechanisms for novel research

There is concern across OECD countries that research is becoming too conservative and that short-term incremental research is being favoured over long-term risk-taking. Many countries are developing specific initiatives to promote High-Risk/High-Return (HRHR) research. There are three distinct but inter-related rationales for this: 1. To encourage breakthroughs and the emergence of new scientific paradigms (often at the borders between disciplines); 2. To provide new insights to address complex societal challenges; 3. To accelerate the emergence of novel technologies and disruptive innovations (OECD, 2021[2]). Whilst inter-disciplinarity is not an absolute pre-requisite for HRHR research it is a feature of many HRHR projects and an important consideration, when designing policies to promote HRHR.

Whilst some of the responsibility rests with universities, public funders themselves need to address growing concerns that the traditional research management and peer review process favours established, low risk ideas over novel research (OECD, 2021[2]). From the public funding perspective, fostering high-risk/high-reward (HRHR) research requires different policy instruments and funding processes (See box 2). Promoting HRHR research – as well as transdisciplinary research (much of which is high risk) – is a shared responsibility between governments, research institutions and funders as discussed above.

Promoting highly novel research cannot be effectively achieved simply by increasing research project funding but requires integration of carefully designed programmes, including appropriate review and monitoring processes, that facilitate structural change in research providers. Developing appropriate performance indicators and measures is critical to incentivise the necessary changes.

Box 2. Funding mechanisms for HRHR research

Evaluation and funding allocation mechanisms

While the traditional mechanism for project selection and research funding is based on peer review, most HRHR programmes have modified review procedures or use different selection processes that give programme managers more authority.

Modified peer review approaches relate mainly to the review criteria, the composition of review panels and the way that these panels operate. At one end of the scale simple criteria specifying HRHR requirements may be included in existing funding schemes. Moving up the scale, more explicit selection criteria (and specific weights in the evaluation score) might be developed for dedicated HRHR schemes. Examples include those used in the NIH's New Innovator Award, Canada NFRF Exploration and the Netherlands' Off Road programme. A further step is to anonymise proposals prior to review as is done in the NIH's Transformative Research Awards and Swiss NSF's Spark programme.

The authoritative programme manager model empowers individual managers to allocate research funding based on their own expert judgement rather than through a peer review process. This approach

is exemplified in DARPA in the US and other initiatives incorporating the DARPA model including the Moonshot R&D programme in Japan and the new Advanced Research and Invention Agency (ARIA) in the UK. It depends on having expert programme managers who are empowered to take risk – and to manage those risks.

Source: (OECD, 2021[2])

US DARPA (Defence Advanced Research Projects Agency) model

The DARPA model, which focuses on breakthrough technology development, can be characterised as follows:

- Leadership by knowledgeable and innovative programme managers (PMs). PMs are not research implementers but managers and are hired for three- to five-year terms often from the outside government with new ideas. PMs have broad authority over the adoption of research and the allocation of funds, and provide leadership based on their own knowledge. Expertise in specific technical fields, budget management skills and the ability to communicate with a range of stakeholders are important.
- Independence as a funding agency: DARPA operates with a high degree of independence from the ministries that have direct needs. This is necessary to avoid investing in short-term and traditional technology extension projects and to invest in long-term technologies with disruptive potential.
- Moving away from the traditional system of peer review: whilst complying with strict rules regarding conflicts of interest, PMs can directly manage the project selection process through the agency's internal procedures. This allows PMs to make decisions on projects under their own authority, rather than on projects that have achieved a high average score in the community based on predefined criteria. There are often no open calls for project proposals.
- Proactive project monitoring and portfolio management: the DARPA model is known to favour 'fast failures' and the PM may ask the study implementer to try a different approach or terminate the research. They may also adopt several projects tackling the same issue and have them compete or create opportunities for knowledge exchange such as closed workshops. With this practical approach, PMs facilitate the creation of new communities across disciplinary and sectoral boundaries, especially when disruptive innovations are needed that cannot be produced by existing technologies and players. Project portfolio management also enables risk reduction and the trialling of different possibilities in situations of high uncertainty.

Source: (OECD, 2021[2]); (Larrue, 2021[6])

Portfolio approach and the Japanese Moonshot R&D initiative:

A major obstacle to HRHR is the traditional risk-averse policy of many funders, who are accountable for spending public money. Adopting a portfolio approach to risk management at the programme level rather than the individual project level can help mitigate this fear of failure. In a portfolio approach, funders spread the risks over different R&D projects or programmes testing different pathways and methods to meet a specific target. Not all projects will succeed but those that do will have a major impact. This is similar to how venture capital investments are managed.

The portfolio approach is at the core of the programme manager model as used by DARPA and the Japanese Moonshot R&D initiative. The Moonshot initiative funds research projects that contribute to achieving seven Moonshot Goals, which themselves are derived from three over-arching grand challenges. In order to manage the risk, a package of projects is constructed for each goal, and the approach is to assess the potential of achieving the goal at the level of this package rather than at the level of individual projects. This strategy is reflected in the programme design, with a programme director appointed for each Moonshot Goal being charged with developing a portfolio plan, including selecting projects from an open call for proposals. The programme director is required to select research projects that try different routes and methods to achieve each goal. In the first funding round between 3 and 13 projects were initially selected for each of seven moonshot goals (see box 4 also for programme governance).

Note: see also section 4. STI Strategy for the portfolio approach at an agency and national level
Source: (OECD, 2021[2]); (Larrue, 2021[6])

Impact evaluation of HRHR programmes:

Although impact evaluation is one of the undeveloped aspects of HRHR funding, some dedicated HRHR programmes assess not only scientific, economic and societal impacts but also the programmes' capacity to foster risk taking in research. New "novelty" indicators may also be used alongside, or instead of, traditional bibliographic indicators to assess risk taking and map this against scientific impact in terms of citations.

The NIH evaluated their HRHR programmes by explicitly assessing researchers' willingness and ability to move beyond traditional incremental research. In assessing the capacity of the INSPIRE (Integrated NSF Support Promoting Interdisciplinary Research and Education) programme to foster HRHR, the NSF evaluated whether projects submitted, reviewed, and awarded under INSPIRE were different to those under other NSF funding schemes (70 percent of INSPIRE PIs reported that they had not submitted their INSPIRE project to another funding mechanism and thought that it was unlikely or very unlikely that their project would have been funded outside of INSPIRE.)

Source: (OECD, 2021[2])

Contextual factors

In addition to policies for funding and evaluating research, there are contextual factors that can provide a supportive environment for HRHR research and non-funding policies that can be implemented to create a more conducive environment to perform HRHR research. These contextual factors and supporting policies, although insufficient by themselves to foster HRHR research in the absence of the necessary research funding, can strongly influence the success of HRHR research funding schemes. Critical factors include long-term political support for risk-taking in research, and tenure, promotion, and career advancement policies at academic research institutions.

Source: (OECD, 2021[2])

Options for change

- Incentivise universities to take on a strategic leadership role and implement institutional changes that enable risk-taking and challenge-driven research. Competitive funding awards from funding agencies can either directly support such change or be conditional on change taking place.
- Consider the need for linking societal challenges and/or innovation performance of universities to the allocation of GUF.
- Foster High-risk/High-reward (HRHR) research by introducing a portfolio approach at the programme level and designing competitive funding initiatives and performance monitoring processes that incentivise researchers and their universities to take more risk and develop more inter- and trans-disciplinary research.
- Research funders and universities need to work together to develop and adopt research evaluation criteria and processes in line with DORA and other such declarations that recognise not only research excellence in disciplines but also risk-taking and contributions to resolving pressing societal challenges.

2. Research infrastructures

The OECD 2016 review did not analyse research infrastructures (RIs), although they represent a substantial proportion of public investment in research in Sweden and play a critical role in supporting research excellence and innovation. 37% of the Swedish Research Council's expenditure was dedicated to RIs in 2021 – compared with ~31% in the previous four years. As demonstrated during the COVID-19 pandemic, RIs also have a central role to play in ensuring the resilience of science systems and in enabling challenge-driven research.

There is no single definition of what constitutes a research infrastructure, but for this report, it is understood as an organisational structure dedicated to deliver data or services for basic or applied research, excluding equipment that only used by a very small community of users with specific needs and/or which is not open to users outside the host organisation. RIs are distinct from research and technology organisations or technology infrastructures, such as the RISE institutes in Sweden, which are primarily focussed on the applied research needs of different industry sectors[2].

In a survey carried out as part of the ongoing U 2022:06 review, "effective financing of infrastructure" was given the lowest rating relative to other aspects of the research system, suggesting some real challenges in the overall strategic management and support for research infrastructures in Sweden.

Currently, the Council for Research Infrastructures (RFI) at the Swedish Research Council establishes a long-term plan based on a four-year cycle which starts with a biannual "inventory" that is created through a call for proposals to address RI needs. Proposals can be submitted by higher education institutions, public authorities, research funding bodies and researcher teams. This leads to a sort of roadmap called "The guide to Research Infrastructures". Up to 50 per cent of the funding for individual RIs is allocated via this call for proposals, with host institutions (typically universities) being responsible for the other 50%, which may come from a variety of sources. Special budget lines and funding processes may be set up for large RIs such as MAX IV and ESS. Participation in international RIs is supported through Swedish membership with either dedicated funds for the specific RIs or subscriptions taken from RFI's baseline budget. RFI also directly operates some national RIs, including a national data network, and covers their full costs.

Feedback regarding the current Swedish RI funding system, collected during several recent OECD-GSF RI policy studies, identified a number of specific challenges, some of which are shared with other countries:

- The difficulty to ensure long-term engagement/sustainability with short-term funding commitments (allocation from the government is made on a yearly basis)
- Difficulties in participating to international RI projects, linked to timing mismatches between national and international partners regarding funding decisions. There can also be difficulties in reconciling Sweden's bottom-up decision-making process with the more top-down approaches of international partners, and the lack of flexibility on specific issues, such as variations in exchange rates.
- Difficulties in prioritisation within the budget (weighing up the benefit of long-term engagement against the need for renewal and turnover in RIs)

[2] The role of the RISE institutes is not within the remit of this report. Although their major focus is on the needs of industry, it is noted that these public research institutes are important players in the overall research ecosystem in Sweden and, in a similar way to RIs, can play a critical mediator role in bringing together different actors to address shared scientific and/or societal challenges (Larrue and Strauka, 2022[22]).

- Difficulties in reconciling different approaches between stakeholders to valuing and measuring the potential societal impacts of RIs

Although RIs are diverse and include single-sited, distributed or networked facilities of local, national or international dimension, some common policy issues have been identified in previous OECD work. The main challenges are typically related to

- Overall strategy,
- sustainability (e.g. risk management, data access/management, user communities, upgrades phasing out...), and
- impact assessment (scientific excellence and attractiveness, economic and innovation, education and training, societal challenges, support to policymaking…).

To address these issues, a series of options for change have been developed for consideration by funding agencies and other relevant stakeholders (See also box 3 for case studies). How these options for change are implemented is context specific and some are likely to be more relevant that others in the case of Sweden. With this proviso, the main options for change include:

- Develop a RI portfolio management strategy for better resource allocation, decision-making and optimised synergies;
- Provide dedicated, long-term funding for RIs so that they have long-term visibility and commitment on budgets;
- Establish robust business plans for individual RIs covering the whole life-cycle, including plans for phasing out;
- Develop risk assessment/mitigation policies and processes for all RIs;
- Integrate data access and data management into RI operations, and provide the necessary support to implement policy demands, e.g. for open data. Data management plans should clarify the roles of individual RIs as well as their links with other cyber-infrastructures or e-infrastructures and how these are supported;
- Optimise the user-base of each RI and integrate new users into RI business plans;
- Determine and agree on reasonable expectations of impact with all stakeholders; and
- Develop robust and diverse impact indicators for the whole RI life-cycle and institutionalise data collection processes to inform these indicators.

Box 3. Strengthening and optimising the functioning RIs

Strategic investment and management strategy: the Korean National Facility and Equipment Centre (NFEC)

NFEC is a non-profit organization under the MSIT (Ministry of Science and ICT) overseeing Korea's science technology research development budget. NFEC is tasked with setting up a comprehensive plan for Korean research infrastructures (i.e. science technology research & development facilities and equipment), budget allocation & adjustment, budget management, performance analysis, etc.

NFEC responsibilities cover a range of domains:

- Present a vision for the national RIs and formulate specific policies,
- Improve laws and the legal framework related to national RIs,
- Research and analyse the domestic & overseas RI landscape and trends,
- Prepare a roadmap and investment portfolio for national RIs,
- Promote international cooperation related to the national research infrastructures,
- Operate financial support project for the jointly utilized (e.g. by academia and industry) RIs,
- Request and allocate the national RI budget,
- Support the relocation of idle or under-utilized equipment,
- Manage operating cost accounts of national RIs,

- Conduct ethics training and support the dissemination of a rigorous science culture,
- Operate a professional training system for the RIs,
- Operate a comprehensive information platform for national RIs (ZEUS), and
- Actively oversee the development of large RIs (feasibility, cost adjustment, project management…).

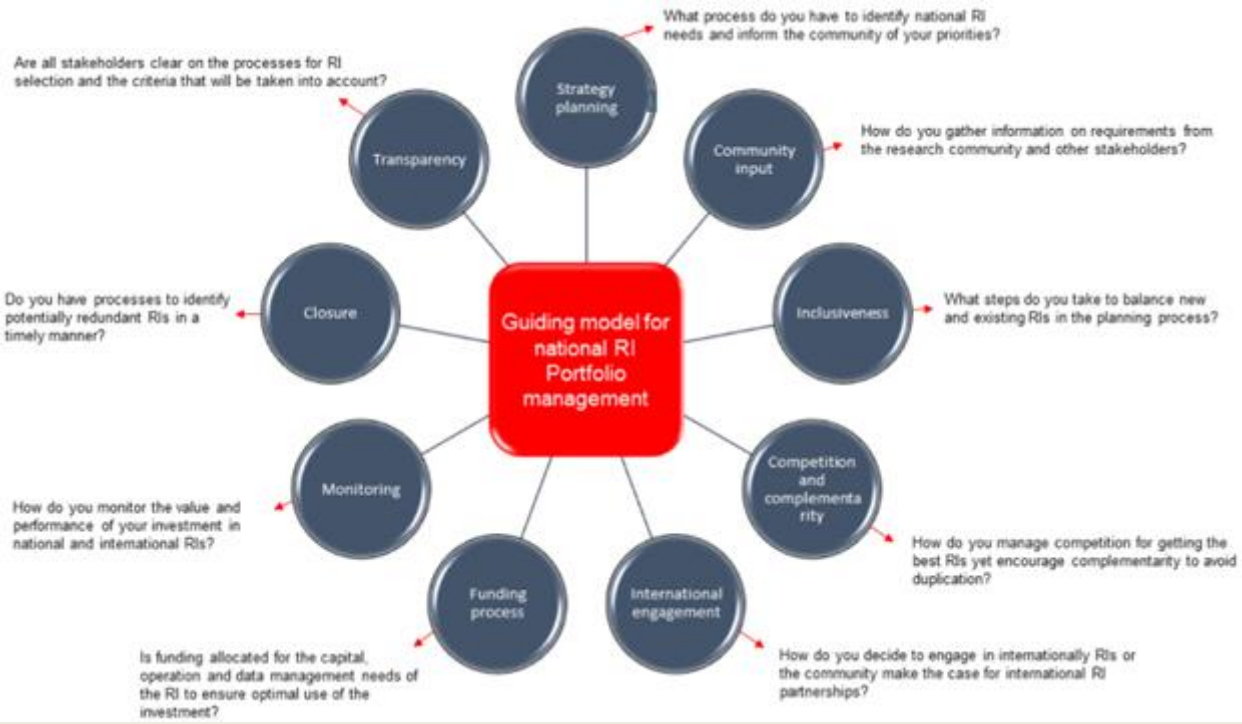
RI portfolio management strategy: Canada Foundation for Innovation (CFI)

Canadian RIs are funded, managed and operated by a complex mix of national, regional and local stakeholders. As RIs become larger and more complex, while overall research budgets are limited, there is a need to manage the rich Canadian RI portfolio in a rational way as well as to optimise the user base.

The CFI is a public body that embraces a portfolio management approach for RIs funded under its Major Science Initiatives Fund. An important part of this is the maintenance of an open on-line catalogue, the CFI Research Facilities Navigator, which provides information on Canadian RIs (https://navigator.innovation.ca/en) (OECD, 2017[7])

Although the CFI does not have a formal roadmap, it identifies RI needs through regular stakeholder consultations and communicates with its communities through a process of stakeholder representative reviews and workshops. The CFI also takes a lifecycle approach to portfolio management and makes decisions, including closure of RIs, based on merit reviews and funding availability.

As described in a recent OECD activity (OECD/Science Europe, 2020[8]) the CFI's approach is consistent with the OECD RI portfolio management guiding model which was developed as a tool to help optimise national RI processes:



Source: (OECD/Science Europe, 2020[8])

Long-term visibility and commitment: Australian National Collaborative Research Infrastructure Strategy (NCRIS)

While research budgets are set on a one-year basis in most countries, several OECD countries and funding agencies have created mechanisms to commit to continuous funding over a longer period. This enables RIs to be operated more strategically.

An OECD report (OECD, 2017[9]) highlighted the case of the NCRIS, which provides USD 1.5 billion over 10 years for RI funding. The funding assures a long-term and sustainable operational base to support world class science and research in Australia and removes some of the financial uncertainty around the planning of future RI investments.

Funding is provided through a renewable two-year agreement, ensuring that currently supported facilities are operational until the end of the two-year period and are ready for subsequent periods based on long-term plans for national research infrastructure.

RIs funded through NCRIS are expected contribute not just to the activities of host institutions but to the wider research and innovation system. Funding and eligibility rules encourage collaborative research and co-investment.

Source: (OECD, 2017[9])

Risk-benefit analyses and risk assessment/mitigation policies: Department of Energy (DoE) and NSF contingency management

RIs are costly investments and their planning needs to be complemented by adequate risk assessment and management which should be integrated into their business plans. RI components are often at the cutting edge of technological development, which means that technical challenges can affect schedules at each stage of design, implementation and operation and drive-up overall costs. Changes in decision-making by the government, funders and stakeholders are also a risk for RIs, particularly in the early life-cycle stages.

As an approach to contingency management, the DoE and NSF have developed detailed manuals for risk management in large RI projects. In addition, DOE and NSF provide funding for contingencies during the construction phase, with a percentage of the overall budget set aside for contingencies based on the detailed ex ante risk assessment.

For example, in the case of the DoE-supported National Synchrotron Light Source II (NSLS-II) project, the cost was estimated more than 4.25 million man-hours and $912 million, and it included state-of-the-art technology at the start of the project in 2005. During the estimation process, potential cost, schedule and technical risks were quantitatively assessed based on their likelihood and potential to impact the progress of the project. A bottom-up risk assessment process was integrated with a top-down assessment to identify 28 key risks with a manageable and actionable response. The mitigation strategies were used to inform decision-making during the project and, as risks were reduced or eliminated, the strategies were updated to optimise scientific capacity within the overall project.

Source: (OECD, 2017[9])

Optimising the user base: Nanotechnology Platform in Japan

Many RIs are intended to be used by a diversity of researchers and in order to maximise their effectiveness, it is necessary to have a user base strategy, which is likely to evolve over time.

The user assessment methods adopted in the Japanese Nanotechnology Platform follow closely the guiding model developed by OECD (OECD/Science Europe, 2020[8]). This includes the following key elements:

- Monitoring of the user base,
- Optimising use potential,
- Clarity of access mechanisms,
- Accessibility of data,
- Promotion of data sharing and monitoring of secondary access,
- Optimised costs of access, and
- Provision of user support.

User monitoring is carried out through analysis of the reservation system and an ID card system for logging

into the equipment. The use potential is optimised by increasing the throughput of machines, improving their use in parallel and diversifying the users. Potential users can consult a platform manager to understand technical options and related charges before applying for use. Subsidies and technical assistance are provided for first-time users. The development of an open data policy is underway and this will include access to appropriate metadata, including the experimental conditions and a dedicated open database with experimental data. Users who make their data open and publish research results have preferential access charges compared with those – often from industry – who do not wish to share experimental outputs.

Source: (OECD/Science Europe, 2020[8])

Impact indicators: European Social Survey (ESS) European Research Infrastructure Consortium (ERIC)

The ESS is a new international RI that is still in construction phase, but its potential socio-economic impact (SEI) was embedded in the design from the start. Its strategic mission is not just to enable scientific breakthroughs but also to address major societal challenges. ESS developed an impact assessment model, derived from the OECD reference framework (OECD, 2019[10]) that takes into account the whole impact pathway from input to impact throughout the full life cycle of the infrastructure. Thus, impacts are already being assessed during the construction phase: 42 SEI indicators and metrics were determined for the construction phase, and 41 for the operation phase, which partially overlap. These indicators include co-publications between member countries, new partners in grant projects, the number of new suppliers etc. They had to be developed in line with the expectations of the different ESS stakeholders. Some initial lessons learned from this exercise include:

- SEI can be measured from the concept phase through the complete lifecycle of a RI
- SEI/KPI parameters should not be static and need to be fine-tuned:
  - When phase milestones are achieved
  - If context or surrounding parameters have changed
- SEI should be seen as a continuous project for a RI with fixed reporting dates e.g. on an annual basis
- SEI does not have the same shape and form for all RI stakeholders:
  - ESS created narratives for each member country
  - A translation of SEI along the lines “what does it mean for you” is necessary for different stakeholders
  - SEI can be seen as an abstract and agile currency depending on the “customer”

Source: (OECD, 2019[10])

Options for change

- Develop a national RI portfolio management strategy for better decision-making (including on national vs international investment), resource allocation and optimisation of synergies.
- Set up a dedicated, long-term funding mechanism for RIs that enables long-term visibility/commitment and participation in relevant international RI projects.
- Provide support (by research funders to the promoters of new RI projects) for establishing robust business plans covering the whole RI life-cycle.
- Support the development of user-base optimisation strategies by individual RI managers.
- Develop, in consultation with all relevant stakeholders, a consensus impact monitoring toolbox that can inform funders/decision makers and RI managers.

3. Supporting societal transitions and resilience

In 2009 the Lund Declaration emphasised the importance of research on societal challenges and the need to go beyond broad thematic approaches in implementing such research. The implicit commitment was that Sweden would play a leading role in developing research and innovation to address societal challenges. The Challenge-driven Innovation (CDI)[3] programme was launched in direct response to this. The Strategic Innovation Programme (SIP) was then introduced in the 2012 Research and Innovation Bill, which 'intended to create preconditions for sustainable solutions to global societal challenges and to increase competitiveness in fields of high relevance to the Swedish economy' (Tomas Åström, 2020[11]). Although Sweden is closer to achieving most of the 2030 SDG targets than the average of OECD countries, there is still some distance to go to reach these targets (see appendix, fig 6) and a concerted effort will be required to do so.

In the OECD 2016 review, which considered both the CDI and SIP initiatives, the following suggestions were made with regard to STI and societal challenges:

- develop a national research and innovation strategy regarding societal challenges,
- integrate this strategy with the wider research and innovation strategy and with wider policy areas (e.g. energy, transport),
- increase agency efforts to play a leadership role at a European and even global level,
- expand the scale of the CDI programme and refine its scope,
- develop more and broader policy instruments,
- consider the involvement of a broad mix of stakeholders who operationalise project results,
- with specific regard to the SIP initiative, consider increasing funding and participation so that it is of the scale necessary to support disruptive, as opposed to incremental, change.

Since 2016, the CDI programme has been phased out. A recent analysis of this programme (Vinnova, 2022[12]), identified a number of obstacles or weaknesses that are common to many such challenge-driven initiatives. These include: unclear or ambiguous value offers; legal barriers; lack of an organisation taking responsibility for the uptake or dissemination of project outcomes; and challenges with governance at the programme and project level. The assessment emphasises the importance of developing regulatory systems, building customer bases and new business models in addition to developing technological solutions. At the same time, it notes that traditional research evaluation methods that focus on short-term outputs are not adequate to assess the impact of this type of programme, and the long-term effects of knowledge sharing, capacity building and networks need to be considered.

The Swedish National Research Programmes (NRPs) were launched as a new 10-year initiative in 2017 following the 2016/17 Research Bill (and after the OECD 2016 review). The aim of the NRPs is to support research based on strategic societal challenges agendas. The initiative is administered by three funding agencies – the Research Council, Formas and Forte – and was established based on priority areas proposed by these three councils, in a process that included consultations with and beyond the research community. In a report commissioned by the three councils in 2022 (Erik Arnold, 2022[13]), the NRP scheme was described as being different from traditional programmes in that it adopts some of the mechanisms for implementing challenge-based programmes, such as the use of multi-stakeholder programme committees and a relatively large budget allocation for individual projects. On the other hand, the report concluded that the challenge orientation of the programmes and their emphasis on knowledge utilisation is insufficient to address societal challenges. This is reflected by the limited and declining involvement of programme committees and 'outsiders' including problem-owners, weakly defined needs and priorities, an over-focus on basic research and a gap between knowledge-generated and knowledge required to address societal challenges. The report concluded that the operation of the programme is strongly

[3] Utmaningsdriven innovation (UDI) in Swedish

influenced by the strategy, rules and traditions of the funders and that the core missions and operational regimes of these funders need to be re-considered to effectively implement societal challenge research.

A meta-evaluation of SIPs was carried out in 2020 at the request of its three funders, Vinnova, Formas and the Energy Agency. In that report (Tomas Åström, 2020[11]), the SIPs were assessed as positive overall, with high expectations of future commercial benefits for companies and the publication of high-quality scientific papers, as well as system-level benefits such as the diffusion of technologies across sectoral boundaries and the establishment of spin-offs. Many of the SIP programmes were originally targeted at key sectors of Swedish industry with the aim of improving competitiveness in existing areas of strength. The SIP's five high level impact objectives placed 'increased sustainable growth' and 'improved competitiveness and increased exports for Swedish industry' first, with the looser objective of 'creating conditions' for solutions for societal challenges being last on the list. Nevertheless, the SIPs embrace an ambition to address socio-technical transitions. Several significant limitations were identified when considering the potential of SIPs in this regard. SIPs are led by coalitions of service and technology providers that build socially beneficial capacities by doing what is necessary for them, in the short-term. As a result, the outcomes of SIPs have tended to be incremental rather than radical and risk-taking is limited. They meet the immediate needs of commercial partners but make little contribution to solving wider societal challenges.

For SIPs to be used to address more systemic issues, they need to involve more actors representing the needs and demand side rather than the provider side. Solving problems might then be translated into economic demand, creating business opportunities, such as new markets. Systemic transitions require the engagement and evolution of downstream policy frameworks including rules, norms, markets, practices and skills. To achieve this, strengthening both policy engagement and the input of key social actors in programme governance are required and the programmes need to focus on more clearly defined priorities.[4]

These analyses of recent Swedish initiatives indicate the need to be attentive to 4 critical factors with regard to STI policies and funding to address societal challenges: 1) agenda setting and design of research programmes, 2) operation of funding programmes, 3) missions and structures of funding agencies themselves, and 4) contextual factors that enable the necessary research to be conducted.

This section will discuss the planning of research programmes, and the operation and management of these programmes since they relate to planning and implementation in the funding agencies. The mission and structure of the funding agencies themselves are discussed in the last section of this report, which focuses on governance and structure. Effective implementation of research initiatives to address societal challenges extends beyond the traditional grant management function of funding agencies and is highly dependent on contextual and enabling factors within and beyond research institutions and universities. Such challenges require the integration of research and knowledge from different disciplines and stakeholders, although the disciplinary and reward structures that are prevalent within academia are not conducive to inter- and trans-disciplinary research with uncertain outcomes (see previously). The Swedish dependency on universities exacerbates these issues as discussed in section 1.

Research programme agenda setting and design

Regarding societal transitions and resilience, the SIP and NRP schemes may not have been wholly successful to date but they should be considered as valuable assets. The implementation of challenge-driven or mission-oriented research and innovation policies (MOIPs) is context specific and the most effective initiatives often "result from a gradual process with a dedicated effort to make existing policies

[4] At the time of writing, the next generation of the Strategic innovation programmes, called Impact Innovation, was already being designed and is expected to implement the lessons learned from the evaluation in 2020 to enhance the ambition to promote more systemic socio-technical transitions.

better oriented and coordinated" (Larrue, 2021[6]). As noted above, while the SIPs and NRPs have different characteristics, they also share a major challenge: agenda setting is neither sufficiently balanced between bottom-up and top-down nor prioritised. In the SIP, agenda setting is a bottom-up process with no top-down government involvement. At the funding agencies level, Vinnova, the Swedish innovation agency, encourages and supports target-setting by multiple stakeholders rather than leading or proactively guiding the construction of targets. A similar point can also be made for the NRPs, which are largely implemented via the traditional bottom-up competitive funding processes of the research agencies. However, bottom-up consensus building approaches are "inherently conservative" (OECD, 2016[3]), and sponsors or funding agencies can play an important role in maintaining a balanced risk portfolio and ensuring attention to potentially disruptive areas of future interest. At the programmatic level, the active engagement of different ministries, in addition to funding agencies, in the agenda-setting process could contribute to the establishment of a more comprehensive and risk-balanced programme scope (Larrue, 2021[6]). This would also enable societal challenge research and innovation to be promoted using a broader range of policy instruments, the need for which was pointed out in both the OECD 2016 review and the Vinnova CDI assessment report. National government commitment would be expected to strengthen the engagement with the SIP from both the research community and other actors.

Several countries have developed and adopted mission or challenge driven agendas at the cross-government level, albeit with a major focus on innovation and industry. Examples include the Top Sector and Innovation Policy in the Netherlands, the Hightech Strategy 2025 in Germany, the Moonshot R&D Programme in Japan and the National Acceleration Strategies in France (See box 4). The Netherlands established its Top Sector targets in a centralised way but at the same time obtained a strong commitment from multiple stakeholders – initially the industrial sector and more recently other public sector and civil society actors. Buy-in from essential stakeholders is important for the success of any challenge programme and was a weakness in the CDI and NRPs initiatives as highlighted in the recent assessment reports (discussed above). The German Hightech Strategy facilitates the coordination of various policy instruments and acts as an umbrella for federal government initiatives. It defines priority areas and specific missions for government-wide initiatives, although there is no specifically designated budget for implementing the strategy. In Japan's Moonshot Programme, the Cabinet Office (CAO) led the establishment of the programme targets consulting across multiple ministries and the funding agencies managed by these ministries, while the same funding agencies are in charge of the detailed project implementation. Each of the French National Acceleration Strategies has a dedicated interministerial coordinator.

In terms of programme design, it can be seen that the SIPs and NRPs have different limitations. In the SIPs, it is necessary to aim for long-term and radical results rather than incremental ones, and to shift emphasis from the specific service and technology providers to more systemic issues. In the NRPs, the focus of the programmes' activities has been largely on knowledge creation with little emphasis on the utility and utilisation of research results, and it is necessary to build a system of cooperation that goes beyond the academic sector and involves service providers as well as the problem-owners. These differences in the evolution of the two initiatives can be understood from the fact that the SIPs have been led by Vinnova, with its remit for innovation, whereas the NRPs have been managed by the research council and sectoral agencies. The different funding agencies have distinct areas of expertise and work with different communities (see ahead table 1). As addressing complex societal problems requires the integration of knowledge and expertise across different domains, experience and lessons from the SIPs and NRPs need to be shared across agencies. Common governance and/or formal coordination mechanisms across the two initiatives might be considered and could help to capture attention from a greater number of research performers and other actors (see ahead section 5).

Programme implementation, management and evaluation

Challenge driven research projects, which require collaboration across multiple disciplines and stakeholders, do not fit with normal academic review criteria and funding allocation processes (which has

been one of the issues for the NRPs). The expected outputs include new scientific knowledge, which is often communicated in scientific journals, but the principle aims and impacts may be policy changes, informed-decision making, design and adoption of practical socio-technical solutions or establishment of long-term networks. There are no standard processes for assessing the merits of such challenge driven project proposals, although considerable experimentation is taking place in this respect and accepted good practices are starting to emerge (OECD, 2020[1]). For example, the selection and evaluation of the "Co-Create" programme at the Brussels Institute for Research and Innovation (Innovir) is done by both a mixed panel of experts in the related domain and a jury composed of citizens. The NSF convergence Research Programmes uses a 'college' of specially trained leading researchers to assess its highly inter-disciplinary proposals. A 10-step proposal review process has been proposed for transdisciplinary research (OECD, 2020[1]) but implementing this requires a significant change in both the culture and operations of research funding managers.

It is not only the ex ante evaluation of research projects that needs to be adapted for challenge driven projects but also the monitoring and ex poste impact assessment processes. As pointed out in the Vinnova CDI evaluation report, it is important in assessing the impact of such programmes to consider a variety of long-term effects (See box 4: the case of the Centre of Innovation (COI) programme in Japan). Methods for doing this are currently being explored in a number of settings and it is recognised that evaluation should consider the benefits to all stakeholders and use both qualitative and quantitative indicators. Pathways-to-impact and theory-of-change approaches, which are often used in development research, can be adapted to help identify and assess the foreseeable impacts of challenge-driven research although these need to be used flexibly as the most important impacts are not always readily predicted.

Box 4. Multi-sector initiatives for innovation and societal challenges

Mission-driven Top-sector and Innovation Policy (NLD)

The top sector approach has been in place since the early 2000s for and provides an overall framework to promote innovation and increase the international competitiveness of the Netherlands. Tackling societal challenges is gradually becoming more prominent within the top-sector approach.

The Mission Driven Top Sector Innovation Policy (MTIP), initiated by the Ministry of Economy and agreed in 2018, presents strategic agendas that integrate both economic development and societal mission perspectives. Specifically, the MTIP features 25 missions with clear targets across four societal areas. Under this framework, the nine top sectors work together to develop Knowledge and Innovation Agendas KIAs) for each of the four societal themes. The KIA development process engages policymakers and a wide range of other stakeholders in addition to the business sectors. There are additional agendas for two horizontal themes on key technologies and the valorisation of knowledge. These agendas are action roadmaps and contain specific concrete multi-year mission-driven innovation programmes (MMIPs) for each of the 25 missions. Each MMIP defines the research and innovation required to achieve the mission, the role of each partner, financial resources and necessary policy instruments. The latter include a broad mix of regulatory reform, pricing mechanisms and public procurement, in addition to grants and other funding.

Governance is at the overall policy level, in each top sector and also by theme. These sectoral and thematic governance structures involve officials from ministries and regional authorities, along with companies, research institutions and other stakeholders. They play an important role in coordinating policy and regulation.

To ensure the commitment of key partners, four-year Knowledge and Innovation Contracts (KICs) are agreed, with each partner providing in-kind and/or financial contributions; the KIC 2020-2023 has a total annual commitment of EUR 4.9 billion (of which EUR 2.05 billion is from the private sector).

Source: (Larrue, 2021[6])

Hightech Strategy 2025 (GER)

The High-Tech Strategy was launched in 2006 and High-Tech Strategy (HTS) 2025 is the fourth edition. The strategy is led by the Federal Ministry of Education and Research (BMBF) and serves as an umbrella for federal initiatives, facilitating the coordination of diverse policy instruments within specific priority areas.

HTS 2025 is structured around three main areas of action. One of these three, the Grand Challenges, includes 12 mission-oriented policy areas. These 12 areas include global societal challenges as well as economic challenges. The former relates to healthcare, plastic pollution reduction and greenhouse gas emission reduction, while the latter include the creation of advanced national battery production capacities. Within each mission, societal transformation is recognised as being dependent on both technological and social innovation, and the policy instruments are a mix of regulation, capacity building and finance.

The governance structure of this strategy is coordinated through the Secretary of State's Roundtable on HTS 2025. This new intra-governmental coordination mechanism is tasked with defining, steering and shaping the policy agendas of the various ministries in line with the HTS 2025 priorities. The Round Table receives recommendations and expertise from the High Technology Forum (HTF), which was established to engage a wide range of stakeholders in the consultative process that defined the objectives of the HTS. The link between policymakers and the HTF is also supported by the dual role of the BMBF Secretary of State and the Fraunhofer-Gesellschaft as Chair of the HTF. At the operational level, an inter-ministerial committee involving the Federal Government and all ministries monitors and supports the implementation and progress of the HTS.

It should be noted that, as there is no common R&D budget under HTS 2025, in practice, each ministry is responsible for its own activities, which may present challenges over the longer-term in maintaining a mission-oriented approach in the context of fragmented implementation responsibilities.

Moonshot R&D Programme (JPN)

This programme sets ambitious goals to attract talent and promote challenging R&D projects with the aim of resolving difficult societal issues while bringing together the wisdom of researchers. Under this programme, the government formulates ambitious goals (Moonshot Goals) targeting social issues that are difficult to achieve but are expected to have a large impact if realised. [see Box 2 for details of programme implementation].

The seven goals for 2020 were defined by the Cabinet Office in collaboration with relevant ministries – MEXT (Ministry of Education, Culture, Sports, Science and technology), METI (Ministry of Economy, Trade and Industry), MHLW (Ministry of Health, Labour and Welfare) and MAFF (Ministry of Agriculture, Forestry and Fisheries), and the funding agencies managed by these ministries. Each goal may have more than one target, resulting in 14 targets as a whole. For example, Moonshot Goal 1 is the 'realization of a society in which human beings can be free from limitations of body, brain, space, and time by 2050', which includes two 2050 targets: 'development of technologies and infrastructure to carry out large-scale complex tasks combining large numbers of robots and avatars teleoperated by multiple persons by 2050'; and, 'development of technologies that will allow anyone willing to augment their physical, cognitive, and perceptional capabilities to the top level, and spread of a new lifestyle that will be welcomed by society, by 2050'. Intermediate targets for 2030 have also been established.

The funding agencies are primarily responsible for implementing the Moonshot programme, including the call for proposals and support for portfolio development by programme directors, but they were also involved in the target-setting phase. Specifically, to support target setting, the funders organised a two-day international conference to collect inputs from academia, industry and other stakeholders on the latest trends in research and actual needs. The involvement of the funding agencies at the target setting stage ensured their commitment to the implementation of the programme and led to better alignment between the strategic and operational levels.

It should be noted that during the implementation phase of research projects, in addition to the funding agencies' management R&D to address specific targets, a committee consisting of representatives from relevant ministries and agencies oversees all targets to ensure consistency and cross-governmental

support.

Source : https://www8.cao.go.jp/cstp/english/moonshot/top.html

Centre of Innovation (COI) programme (JPN)

The program was launched by MEXT in 2013 and is managed by a funding agency, Japan Science and Technology Agency (JST), to tackle vision-driven transdisciplinary innovation challenges by promoting collaboration between the industrial and academic sectors through joint leadership. The challenges were derived through a back-casting co-design approach focused on societal challenges for the next decade. The overarching challenges that emerged from this approach were: aging, living environment and sustainability.

To design and implement COI projects, networks of industry, academia and societal stakeholders were established around shared visions and values. Procedures for effective collaboration, such as intellectual property agreements, were agreed at the outset. These established networks and cooperative practices were leveraged in responding to COVID19 and made substantive contributions in a number of areas, including:

- Sharing of 3D data through GitHub to facilitate the rapid production of face shields by SMEs,
- The development of wearable devices for medical check-ups to reduce physical contact, and
- Development of portable devices to support telemedicine for pregnant women

Source: (OECD, 2020[11]); OECD GSF work for Mobilising science in response to crises: Lessons learned from COVID-19

National Acceleration Strategies (FRA)

Acceleration strategies (ASs) are a new instrument in the Investments for the Future programme (PIA) - launched by the French government in 2010 and now integrated in the French recovery plan (France 2030). One of the key objectives of ASs is to provide support to specific technology areas via integrated support across all stages of the innovation chain, from exploratory research to market deployment. Each strategy has its own structure of governance, with a dedicated inter-ministerial coordinator. Although the initial focus of the ASs is on technological development/industrial strategy, social innovation is likely to take an increasingly prominent role, as has happened with the Top Sector and HighTech approaches in Netherlands and Germany respectively

The Carbon-free Hydrogen AS has set targets for 2030, including the installation of a carbon-free hydrogen production capacity of 6.5 GW by electrolysis, the saving of more than 6 Mt of CO_2 and the creation of 50,000 to 150,000 direct and indirect jobs in France. The task of the coordinator is to lead the inter-ministerial coordination and monitoring of all the actions implemented using a collectively developed roadmap as guideline. The Carbon free Hydrogen AS has a budget of EUR 3.4 billion during the period 2020-2023, and EUR 7 billion are planned until 2030. The Strategy covers all aspects related to the establishment of a hydrogen value chain from research to production, pipelines and markets. The Acceleration Strategy also aims to develop key technologies and components through pilot projects for different types of usages and markets.

Options for change

- Strengthen the government's, and other critical stakeholder's, engagement in the agenda- and priority- setting process of challenge programmes such as SIPs and NRPs; establishing agendas and priorities at the cross-government level should enhance the national commitment to research on societal challenges and facilitate deployment of various policy instruments including regulations.
- Learn from past experience and build on existing expertise in further developing SIPs and NRPs or other challenge programmes, while using a portfolio management approach at the agency and national level. Different initiatives should be linked or coordinated through effective bridging mechanisms, potentially including a common governance system (see ahead).

- Adapt research management and funding processes, including evaluation of the proposals, monitoring of projects and assessment of impacts, drawing on good practices for implementing challenge programmes in different countries.
- Promote funding programmes to support capacity building within universities to address societal challenges (see section 1).
- Provide support to existing centres of excellence to network with other research institutions to develop solution driven transdisciplinary research initiatives and build related capacity (see section 1).

4. STI Strategy

In the OECD 2016 review, recommendations related to priorities, strategies and governance were as follows:

- to recognise the lack of coherence in policy, planning and governance structures and processes,
- to implement a national visioning mechanism that can build greater consensus about major priorities,
- to set priorities regarding challenges, areas of technology, clusters and value chains without pre-judging market results,
- to deploy an effective mechanism for coordinating policies across different sectors,
- to promote the university reforms that are needed for them to perform with more flexibility and strategy,
- to retain academic competence in the governing bodies of research agencies, while ensuring that academia does not represent the overwhelming majority,
- to require the research councils and Vinnova to seek a balance in the use of internal expertise versus input from its beneficiaries in their decision-making processes and operations, and
- to review current policy governance and coordination mechanisms.

These can be summarised as a need for prioritisation across different areas and topics and integration of these priorities into an overall R&I strategy (and issues related to the governance of the overall system, which are dealt with in the next section). In Sweden, the problem is not that prioritisation has not occurred, but that strategy development has not been open and inclusive, and as a result, there is weak alignment across various sectors, agencies and initiatives as seen in SFO, SIP and CDI (OECD, 2016[3]). The same issue was found in the operation of NRPs, even though the original intention was that NRPs would complement already existing initiatives (Erik Arnold, 2022[13]).

Prioritisation is important not only for research to address societal challenges and innovation in specific sectors but also for fundamental research because it is difficult to establish a critical mass without prioritisation when resources are limited. Sweden is fortunate in this regard in that its investment in research as a percentage of GDP is high relative to most other countries (see appendix, figs 1 and 2) but nevertheless it cannot expect to compete in all research areas with much larger economies. In the OECD 2016 review the smaller absolute financial support in centres of excellence was criticised relative to other like sized countries where prioritisation is more robust (OECD, 2016[3]). The tendency in Sweden has been to provide limited direction, with broad thematic priority areas then being subject to bottom-up implementation, allowing considerable room for interpretation and alignment with existing research and ideas rather than favouring new approaches.

This section considers the development and implementation of an overall national STI strategy. As laid out in the OECD 2016 review several key factors affect the successful formulation and implementation of national strategies including: alignment, inclusiveness, transparency and communication, and governance. In the case of Sweden, which has several funding agencies with partially overlapping remits as well as a number of major public and private research donors, the issue of alignment is particularly important.

Overarching strategy

Sweden should seek to establish an overarching national vision and strategy for research and innovation that provides clearer top-down direction. The process for achieving this needs to fully engage key societal stakeholders, across different sectors as well as the research community and universities. Promoting bottom-up research excellence will undoubtedly be a substantive part of this strategy but it needs to be integrated into a broader vision of research and innovation to promote societal transitions and resilience.

As a recent example of the development of a holistic national research vision and strategy, the case of New Zealand is insightful (See box 5). The latest Japanese Basic Plan is another interesting example of a national research vision and strategy, where STI policies were systematically reconfigured through a vision of the future society that depends not only on economic development but also on the resolution of societal challenges.

Box 5. Comprehensive national STI visions and strategies

Te Ara Paerangi — Future Pathways White Paper 2022 (NZL)

The comprehensive strategy for STI in New Zealand was published in 2022 by MBIE (Ministry of Business, Innovation and Employment), which was formed through a merger of the Department of Building and Housing, the Department of Labour, the Ministry of Economic Development, and the Ministry of Science and Innovation, in 2012.

The strategy includes high-level targets (visions), policy directions, and plans with implementation timelines and has four key objectives: 1) creating new futures by establishing national research priorities and growing global connectivity including with the EU, 2) embedding Te Tiriti including advancing Māori aspirations in the RSI system, 3) valuing our people through expanding fellowship schemes and supporting diversity, and 4) building system agility including clarifying the roles of government agencies, developing a system-wide infrastructure roadmap, considering institutional reforms of public research organisations, and introducing new funding approaches to support the wider goals of the reform.

Feedback from 903 submissions and over 1,000 people attending workshops and seminars was taken into account in developing the strategy.

Source : https ://www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/te-ara-paerangi-future-pathways/te-ara-paerangi-future-pathways-white-paper/

Introduction of Society 5.0 as a future society: Japanese STI Basic Plan

Society 5.0 was initially proposed in the 5th basic plan of 2016-2020 as a future society that Japan should aim for. The definition is “a human-centred society that balances economic advancement with the resolution of social problems in a system that highly integrates cyberspace and physical space”. This is seen as the next step following on from the hunter-gatherer society (Society 1.0), agricultural society (Society 2.0), industrial society (Society 3.0), and information society (Society 4.0).

The underlying rational is that as economic development progresses, the trade-off with social issues that are difficult to deal with in the current socio-economic system are becoming increasingly complex. The aim is to create a new society that balances economic development and the resolution of social issues by incorporating advanced technology into all industries and aspects of social life.

In the current plan (2021-2026), which describes the government’s STI policies to be implemented over five years with a view to 2030, the policies are organised to realise Society 5.0 from three perspectives: the vision of society as a result of innovation and social transition; capabilities to explore the frontiers of knowledge; and human resources development to support STI.

Source : https ://www8.cao.go.jp/cstp/english/society5_0/index.html

Although the government can lead the development of an overall national science and innovation strategy, public research funders need to be included in the process of establishing the strategy and play a lead role in its implementation. Funding agencies are positioned between the government and research performers and play the central role in translating a national vision and strategy into research programmes that support and incentivise research providers, including universities, to implement the necessary research and innovation activities.

Alignment across key research funders

With regards to alignment, Swedish public funders should give further consideration to how their different funding programmes align with each other to address shared priorities. Implementation of a shared strategy can be facilitated by introducing a portfolio management approach at the agency and cross-agency level. The case of the Research Council of Norway (RCN) is an instructive example (See box 6). This management approach is remarkable not only because it enables higher-level strategic steering and interdepartmental cooperation within the funding agency, but also because simplifying and streamlining the funding schemes reduces both the administrative burdens in the agency and the peer review and opportunity costs to researchers.

In addition to the alignment across Swedish public agencies, the relationship between these agencies and other national R&D funders, specifically foundations, and the EU, should be explicitly considered as part of the national strategy development and implementation. This is evident from the fact that the councils and government agencies account for less than half (47.6%) of the research grant income to universities in Sweden, with 9.9% from the EU, 6.0% from public research foundations and 26.9% from private foundations and other non-profit organisations (NPOs) (see appendix, table 3). Apart from the research council (23.4%) which is the largest single source of competitive research funding, Formas provides the next largest government amount (5.2%).

The high level of research investment from public and private foundations is a unique characteristic of the Swedish research environment and has a major influence on what research is conducted and how research providers behave. Public funding agencies should adopt alignment mechanisms that assure strategic cooperation with public foundations, which go beyond simple recognition of each other's portfolios. While there may be some barriers to partnerships with private foundations at the operational level, strategic synergies need to be identified and exploited. Promoting mutual participation in prioritisation and agenda setting and participation in the portfolio management exercises of funding agencies could be one way to enhance strategic alignment and identify common interests and/or research gaps (See box 6).

Relative to many other European countries, Sweden is not overly successful in securing EU Framework research funding (see appendix, fig 7). The OECD 2016 review emphasised that there is an unexploited opportunity for the national research funding agencies to play a leadership role at a European level. There are opportunities not only to influence the European research agenda but also to use this agenda to help give direction to national research funding efforts, e.g. EC missions can provide inspiration and additional resources for national challenge-driven research. There are also opportunities to more closely align national and European research management processes to relieve some of the burden on researchers and encourage them in applying for EC funding (see Box 6, RCN example).

Box 6. Alignment within and across funders

Portfolio management at the agency level (NOR)

The RCN has introduced portfolio management as an institutional rather than a programme level. This involves more than 50 initiatives being organised into 15 cross-functional portfolios. This has transformed the RCN's organisational structure and funding operations including calls for proposals and

evaluation processes. Efficiency gains and cost savings have been achieved by streamlining and standardising procedures across the organisation. The revised portfolio plan for 2021-22 was the subject of a public consultation and was well received by the research and innovation community.

On the other hand, the lack of a shared budgeting process to support this portfolio approach is a challenge. The introduction of a process to ensure coordination of budgeting across multiple portfolios would enable more effective portfolio management.

Source: (Larrue and Santos, 2022[14])

Collaboration between UKRI-MRC and the Wellcome Trust (UK)

The Wellcome Trust is a major independent charitable foundation in the UK. The UKRI – Medical Research Council (MRC) is the public funding agency for medical research and has a history of co-investment in strategic priority areas with the Wellcome Trust. The Human Genome initiative is a notable historical example of this. The two organisations also co-initiated a number of vaccine trials in response to the 2014 Ebola outbreak. More recently, The MRC strategic delivery plan 2022 to 2025 emphasises collaboration with funders including the Wellcome Trust. For example, it describes partnerships with other funders and industry in relation to a major investments portfolio. It also states that the MRC will "set and deliver ambitious targets to achieve net zero for our estate and operations before 2040 and work with partners including within UKRI, ... Wellcome and others". The UKRI-Engineering and Physical Sciences Research Council (EPSRC) has also entered into a strategic partnership with the Wellcome Trust.

Source: https://www.ukri.org/publications/mrc-strategic-delivery-plan/mrc-strategic-delivery-plan-2022-to-2025/; https://www.ukri.org/what-we-offer/browse-our-areas-of-investment-and-support/infections-and-immunity/; https://www.ukri.org/what-we-offer/supporting-collaboration/supporting-collaboration-epsrc/strategic-partnerships/; (Ketels Christian, 2020[15])

Consistent call for proposal procedures with EU Framework Programmes (NOR)

RCN has adopted new call for proposal procedures across all research areas that align with the EU Framework Programmes' selection criteria. The consistency with EU criteria is expected to make it easier for Norwegian applicants to participate in EU calls and simplify the coordination between the national calls and EU calls.

Source: (Larrue and Santos, 2022[14])

Stakeholder engagement in the development of strategy

Looking beyond government, research funders and universities, a national science strategy should engage multiple stakeholders both in defining priorities and in ensuring commitment to address those priorities. Strategy development should use open and inclusive processes with comprehensive stakeholder communication (See box 7). The development of the Netherlands National Research Agenda is often cited as an example of how to engage civil society in a dialogue on the roles and priorities for science from basic research through to societal challenges. The case in Ireland, with its campaign on future research in 2021 in light of the COVID-19 pandemic and the urgency of the climate change challenge, can also provide inspiration.

Research, innovation and societal transformations can be facilitated by the government and/or public funders but they need to be enacted by other stakeholders including universities, companies and civil society. These actors need to be engaged in co-designing and, in some cases, co-producing, the knowledge, technologies and other innovations that are required to address complex societal challenges.

Box 7. Broad engagement of stakeholders

Dutch National Research Agenda

The Dutch Government launched a new strategy for science in 2014, the National Research Agenda. One of the key features of its development was a major public consultation, which was undertaken in order to maximise support from diverse groups in society. The public consultation was carried out using a website, via which everyone living in the Netherlands could 'ask a scientist a question'.

In total, around 12,000 questions were gathered and analysed to create 248 clusters. In creating the clusters, the following criteria were used:

- Is the research related to the question likely to produce results within 10 years?
- Is the research challenging and ground-breaking?
- Are there outstanding research groups in the country working on the issue? If none exists, is there a strong rationale for investing in capacity building to solve the question.

Three thematic conferences, focused on 'science4science', 'science4competitiveness' and 'science4society', were then organised to further consolidate the 248 clusters. A total of 900 people attended the conferences, which had disciplinary and multi-disciplinary discussion groups. 195 clusters emerged from these discussions and an expert panel then further narrowed down the questions to 140.

These 140 questions were tied to the priorities of national research organisations and divided into five chapters of the National Research Agenda: i) man, the environment and the economy, ii) the individual and society, iii) sickness and health, iv) technology and society, and v) fundamental of existence. The agenda also shows the relevance of the 140 questions to the themes of the EU Horizon 2020.

Each research organisation was put in contact with those who submitted questions relevant to the agendas and they were able to communicate directly with them. By the time the National Research Agenda was published, more than half of those who submitted questions had received invitations from research organisations to lectures, public meetings and online forums.

In 2018, NWO, the main research funding agency in the Netherlands launched the first funding round for the Dutch National Research Agenda (NWA) programme. The programme encourages broad-based multidisciplinary consortia to submit research proposals that align with 25 NWA 'routes' and supports the entire chain of fundamental to applied research.

Source: (OECD, 2017[16])

Ireland's Creating Our Future campaign

The Creating Our Future campaign was launched by the Irish Department of Further and Higher Education, Research, Innovation and Science (DFHERIS) in 2021. It was designed to solicit ideas from the public on how research can be used to create a better future in the context of the COVID-19 pandemic and the urgency of the climate change challenge, both of which highlight the critical role of research and innovation. The campaign aimed to engage people in the discussion about research and innovation, and to gather ideas that would inspire future researchers, catalyse research in new areas and encourage new forms of collaboration.

Between July and November 2021, 18,062 submissions were collected through a combination of an online portal and various in-person events. The submissions were analysed by an Expert Committee with the assistance of seven expert groups (data analysis teams, five multidisciplinary working groups, and a research design team) through a seven-stage approach. The approach consisted of 1) data validation, 2) data allocation, 3) bottom-up qualitative analysis by the five working groups, 4) data-driven analysis by the analysis team, 5) top-down qualitative analysis by the five working groups, 6) design thinking analysis by the design research team and 7) the summary of findings and recommendations by the Expert Committee.

The process finally resulted in the identification of 16 priority themes. These include themes, such as:

building a more inclusive society; resilience in our country; and innovative housing solutions. The Expert Committee also made five recommendations on areas where research should start first, and six associated recommendations on developing a research system that delivers value for the public. These included the need for more focus on establishing an inclusive research system and investing in multidisciplinary, transdisciplinary and interdisciplinary research.

The campaign is linked to a broader national strategy. In Impact 2030 (Ireland's Research and Innovation Strategy), the campaign is described and the Impact 2030's governance groups are expected to provide fora to promote the campaign's outputs. The strategy mentions that relevant government departments will be invited to determine which themes are most relevant for them and how they can contribute to take them forward.

Source : https ://creatingourfuture.ie/reports/; https ://www.gov.ie/en/publication/27c78-impact-2030-irelands-new-research-and-innovation-strategy/#:~:text='Impact%202030%3A%20Ireland's%20Research%20and,innovation%20on%20many%20national%20priorities.

Options for change

- Establish an overarching national strategy for developing the research and innovation system, with public research funding organisations playing a central role and all research actors, particularly universities, being consulted. The strategy should integrate excellence and socio-economic benefits and make explicit the role of academic research and universities in addressing complex and urgent societal challenges.
- Introduce an inclusive and transparent muti-stakeholder process for setting high-level research priorities and engage the research community and institutions from the outset to strengthen their commitment. Part of this process might include public consultation.
- Clarify the remit of different funding organisations while ensuring the alignment of funding initiatives through portfolio management at the (cross-) agency and national levels.
- Pursue deeper strategic alignment between public research funding agencies and foundations, and establish effective coordination mechanisms with major private foundations.
- Align the national strategy and priorities, and implementation activities at the research agency level, with EU research priorities and leverage EU support to facilitate change at the national level.

5. Governance and structures

The OECD 2016 review proposed that success in enhancing research and innovation system performance and the response to societal challenges in Sweden would require reforming governance for the whole system (OECD, 2016[3]). Judicious reform should aim to improve the coordination horizontally across ministries and agencies and vertically between the hierarchy of different actors. The remits, governance, and structures of the public research agencies are at the centre of such reform.

Any re-structuring of the funding bodies needs to start with a consideration of their roles in the specific Swedish context. There are three generic models for research and innovation policy as described in the OECD 2016 review: the linear model, the interactive or coupling model, and the societal challenges model. These three models are complementary to each other rather than alternatives.

In the Swedish context, the linear model is mainly promoted by the Research Council, and the interactive or coupling model corresponds to the role of Vinnova. Vinnova has also increasingly played a role in developing research to address societal challenges, as seen with the CDI and SIP initiatives. This role is shared with other public funders including Formas, Forte and the Energy Agency, although these have a

more limited sectoral remit. The historical mission of the largest research funding agency, the Swedish Research Council, is to promote research excellence by funding bottom-up research proposals and enabling research infrastructures. In contrast to Formas and Forte, the Research Council covers many research fields, provides less top-down direction and is less involved in the implementation and monitoring of individual projects (Erik Arnold, 2022[13]). The remits of councils and agencies are summarised in table 1. Each of these funders has established expertise and processes that align with the different models for research and innovation, and it is important in any re-structuring that this expertise is recognised and valued.

Table 1. The remits of councils and agencies

Councils or agencies	Remit	Regulation	Disbursed funds (2021; Million SEK)
Swedish Research Council	The Swedish Research Council shall support basic research of the highest scientific quality in all fields of science. The Swedish Research Council shall 1. Promote the quality and renewal of Swedish basic research, 2. Support investigator-initiated research, 3. Initiate and support interdisciplinary research initiatives, 4. Allocate funds to research of internationally high quality, 5. Promote and initiate international research cooperation and exchange of experience, and 6. Evaluate research and assess its scientific quality and significance.	Lag (2000:662) om Vetenskapsrådet Förordning (2009:975) med instruktion för Vetenskapsrådet	7,903
Swedish Research Council for Sustainable Development (Formas)	The Research Council for the Environment, Agricultural Sciences and Rural Development (Formas) shall promote and support basic research and needs-driven research in the fields of the environment, agricultural sciences and rural development. The research supported must be of the highest scientific quality and relevant to the Council's areas of responsibility. Formas may also fund innovation activities to a certain extent.	Förordning (2009:1024) med instruktion för Forskningsrådet för miljö, areella näringar och samhällsbyggande	1,782
Swedish Research Council for Health, Working Life and Welfare (Forte)	The task of the Research Council for Health, Working Life and Welfare (Forte) is to promote and support basic and needs-driven research in the field of working life and in social and public health sciences.	Förordning (2007:1431) med instruktion för Forskningsrådet för hälsa, arbetsliv och välfärd	821
Sweden's Innovation Agency (Vinnova)	The task of the Sweden´s Innovation Agency (Vinnova) is to promote sustainable growth by funding needs-driven research and the development of effective innovation systems. Innovation systems are networks of public and private actors where innovations and new knowledge are developed, disseminated and used. In order to achieve sustainable growth and strengthen Sweden's competitiveness, the Agency shall, from a challenge-driven perspective, promote the exploitation of research and the promotion of innovation.	Förordning (2009:1101) med instruktion för Verket för innovationssystem	3,675
Swedish Energy Agency	The Swedish Energy Agency shall promote research and innovation in the form of a strategically designed overall effort spanning the entire innovation system, in close cooperation with, and as a complement to, other energy policy efforts and other policy instruments aimed at achieving climate and energy targets and energy-related environmental policy objectives.	Förordning (2014:520) med instruktion för Statens energimyndighet	1,272

Note: the remit was extracted section 1 of each regulation from the source websites and machine translated, except for the Swedish Energy Agency where the section regarding research is cited.
Note: Disbursed funds are specified according to the annual reports of each of the agencies.

Source : https ://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2009975-med-instruktion-for_sfs-2009-975; https ://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20091024-med-instruktion-for_sfs-2009-1024; https ://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20071431-med-instruktion-for_sfs-2007-1431; https ://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-20091101-med-instruktion-for-verket_sfs-2009-1101; https ://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/forordning-2014520-med-instruktion-for-statens_sfs-2014-520; https ://www.vr.se/analys/rapporter/vara-rapporter/2022-02-24-arsredovisning-2021.html; https ://formas.se/om-formas/vad-vi-gor/formas-arsredovisningar.html; https ://forte.se/publikation/arsredovisning-2021/; https ://www.vinnova.se/publikationer/arsredovisning-2021/; https://www.energimyndigheten.se/nyhetsarkiv/2022/energimyndigheten-sammanfattar-aret-2021/

Given that there are established funding organisations that align with the linear model (promoting research excellence) and the interactive or coupling model (promoting technological innovation), the key questions are: 1. Where to situate responsibilities and funding to address societal challenges, and 2. How to best align and integrate different types of policy initiative using different models, recognising that that they are heavily interdependent.

Vinnova has taken a lead in developing societal challenge research policy, which extends beyond the agency's traditional remit for technological innovation and industry support, and it has established valuable expertise and experience in this area. Forte, Formas and the Energy Agency also have expertise in their specific sectoral domains and the Research Council has more recently played a lead role in several of the NRPs (see earlier). However, the current system for addressing societal challenges is problematic in that it involves several separate agencies and, if it is to be scaled up, this will require a higher level of investment and a more robust organisational structure that manages the balance across various projects and participants (OECD, 2016[3]).

In the following section two alternative scenarios for creating a more robust organisational structure are proposed: 1) an incremental approach, i.e. a more effective implementation of R&I policy corresponding to the three models with the existing structures; and 2) a more radical approach, i.e. restructuring the organisations themselves. These two scenarios involve varying degrees of change to existing structures and there are corresponding costs associated with this. On the other hand, Sweden, like other countries, has been implementing new policy initiatives within the current organisational structure over a long period of time. This has been sufficient for it to build and maintain a well performing STI system, in terms of research excellence and technological innovation. However, there are concerns about conservatism and lack of high-risk, breakthrough research. Moreover, experience to date with the introduction of policy initiatives to address grand challenges, suggest that the current organisational structure may not be sufficient to support the socio-technical transitions that are necessary to address grand challenges.

An incremental approach

The incremental option is to introduce a stronger coordination mechanism for challenge driven research, while maintaining the current agency structures but adjusting their remits where necessary. Under this scenario, all agencies would have shared responsibility for promoting challenge driven research and the associate funding programmes would have joint governance and/or formal coordination mechanisms. As the agency with the broadest experience in designing and running challenge driven initiatives, Vinnova would be an appropriate 'lead organisation' for challenge-driven research, charged with managing the overarching governance and coordination mechanisms, monitoring the overall portfolio of programmes and promoting stakeholder engagement at the strategic cross-cutting level.

In addition to designating Vinnova as lead, it would then be necessary to adjust the remits of each council and agency in order to effectively implement programmes that contribute to tackling societal challenges, including SIP, NRP and CDI (see box 8). This could include the extension of the remit of some agencies to explicitly include societal challenges and commitment to work with Vinnova as the lead agency in this area. This sounds like a minor adjustment but in the recent review of the NRP initiative (Erik Arnold,

2022[13]), it was emphasised that, the respective core missions of the funding agencies have a significant impact on the implementation of the programme (see earlier discussion).

It should be noted that in the NRP initiative, as it currently operates, each theme is allocated to a single funding agency, whereas under this new scenario it would be possible to allocate several funders to a single theme with oversight from the overarching coordination body. This is similar to the way the Norwegian Pilot-E initiative operates, with roles divided between RCN, Innovation Norway and Enova, with RCN focusing on the early phase and Enova on the later stage (Larrue, 2021[6]).

In terms of funding allocation across agencies, this scenario would imply a slight increase in the resources for Vinnova, in order to manage the overall governance and coordination functions. It might also imply the pooling of some funds, e.g. for some NRPs, in joint initiatives and, over the medium to long-term, an increase in the proportion of the funds for all agencies being allocated to support challenge driven-research.

Box 8. Adjustment of the remits and collaboration between public funders

New Directorate for Technology, Innovation and Partnerships (TIP) in the US NSF

TIP was established in 2022 and is the first new NSF directorate to be established in 30 years. It is the eighth directorate in the NSF, and an addition to the seven existing directorates that support science and engineering research and education (Biological Sciences, Computer and Information Science and Engineering, Engineering, Geosciences, Mathematical and Physical Sciences, Social, Behavioral and Economic Sciences, and Education and Human Resources).

NSF's mission is to promote 'the progress of science by investing in research to expand knowledge in science, engineering and education' and to invest 'in actions that increase the capacity of the U.S. to conduct and exploit such research'. Within this mission, TIP is designed to harness 'the nation's vast and diverse talent pool to advance critical and emerging technologies, address pressing societal and economic challenges, and accelerate the translation of research results from lab to market and society' and to improve 'U.S. competitiveness, growing the U.S. economy and training a diverse workforce for future, high-wage jobs'. The directorate builds on the foundation of more than 70 years of NSF support for mainly basic research in universities. TIP is expected to work with the entire agency to leverage ongoing research investments to drive research and innovation and deliver societal and economic benefits more rapidly. A range of potential priority areas have been identified, ranging from trustworthy artificial intelligence systems to biotechnology, cybersecurity, next-generation wireless networks, microelectronics and semiconductors, and quantum computing platforms.

In the directorate, there are three primary focus areas — 1) fostering innovation and technology ecosystems, 2) establishing translation pathways, and 3) partnering across sectors to engage the nation's diverse talent. In addition to launching new initiatives, the NSF has repositioned its existing innovation and translation portfolio into each of three key focus areas.

Source : https ://beta.nsf.gov/news/nsf-establishes-new-directorate-technology; https ://beta.nsf.gov/tip/latest; https ://www.nsf.gov/about/research_areas.jsp; https ://www.nsf.gov/news/special_reports/strategic_plan/

Collaboration agreement between multiple agencies (NOR)

Building upon the cooperation built between the Research Council of Norway, Innovation Norway and Enova since 2016 in the Pilot-E challenge-based scheme, an overarching collaboration agreement has been signed between the three agencies for the period 2021-25 and extended to also include the state enterprises Gassnova and SIVA. The objective of the agreement is to ensure a seamless connection between the different funding instruments of the different agencies to better support sustainable transitions. The Cooperation agreement includes notably the coordination of existing instruments or the development of joint calls for proposals 'where there are concrete societal challenges that need to be

solved, where there are special opportunities for green growth, and where a coordinated effort helps overcome barriers that prevent development from taking place'. Other cooperation may include joint portfolio analyses, development of common knowledge bases and analysis in relevant areas, the identification of areas that may be relevant for joint efforts, joint mobilisation activities and communication with users, sharing of expertise and best practice, implementation of joint assignments for ministries in the green growth area, joint competence development, shared information systems, etc.

Going beyond an incremental approach (radical approach)

Strengthened cross-agency coordination mechanisms can help ensure strategic and operational coherence but each agency has its own user communities and demands and there is probably a limit to how much these can be aligned in practice without combining budgets and programmes[5]. A more radical approach would be to merge Vinnova and the other thematic funders, i.e. Formas, Forte and the Energy Agency, and give the merged agency a more explicit remit for challenge driven research and innovation.

In this 'partial-merger' scenario the Swedish Research Council would remain independent, perhaps with a strengthened operational focus on supporting high-risk/high-reward research and a clearer role in supporting research infrastructures. However, it would operate under the same national research strategy and strong coordination mechanisms, including, where appropriate, joint programming and funding mechanisms, in partnership with the new agency. The remit of the Research Council might also need to be adjusted to more explicitly recognise not only its role in promoting research excellence and break-through research (i.e. risk taking), but also its contribution to solutions for societal challenges (see box 8 and NSF-TIP). An even more radical alternative would be to merge the research council also into the new agency, which might make coordination and integration across different research areas and aims easier. In this case, one might expect that some operational independence between the newly merged units would persist but a joint strategy and capacity to readily move and combine funds from different areas would change the way of operating.

In considering the different scenarios for the organisation of the public research agencies in Sweden, it is critical to consider the impact on research providers and universities. As stated at the start of this paper, the aim is to optimally leverage the research capacity of universities to deliver the multiple outputs that are required from research. A clear national science and innovation strategy combined with a rationalised structure for implementation and increased focus on risk taking and societal challenges would put a strong onus on universities to evolve their own structures and operations accordingly. It would encourage university leaders to develop their own strategies and it would create more opportunities for collaboration between research institutions and with other stakeholders to address urgent and complex challenges. Research excellence will continue to be a major driving force but as the COVID-19 pandemic comes to an end and environmental threats become more acute, perhaps the time it right to look again at how research excellence is defined and measured.

The cases of several countries that have merged funding agencies are summarised in box 9. Whilst several countries have rationalised their structures dealing with research or innovation, the UK is the only country that has merged both research and innovation into a single structure. It is notable that a common rationale for these mergers was concern about redundancy and inefficiency and challenges in coordinating across multiple structures. The mergers in themselves were also seen as a way to disrupt existing systems and set new directions.

[5] Widespread international experience implies that organisations governed by beneficiaries are not well-suited to change (OECD, 2016[3]).

Box 9. Mergers of research funding bodies

UK Research Innovation (UKRI)

UKRI was established in 2018 from a merger of 9 existing bodies, comprising the seven research councils, Innovate UK and Research England, which was formerly part of the Higher Education Funding Council for England (HEFCE). The merger of the research Councils, the innovation agency and the Higher Education Funding Council was aimed at the 'effective formulation of strategy, promotion of research, and engagement with their communities' (Nurse, 2015[17]). It was expected also to provide a strengthened voice for science to the government, enable cross-sectoral strategy development and implementation and simplify transactional operations. The UKRI was until recently managed by the Department for Business, Energy and Industrial Strategy (BEIS) and is now under the new Department for Science, Innovation and Technology.

Note: full details of how UKRI operates are not provided here since the 2022-06 Committee is visiting UKRI
Source : https://www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations; https://www.gov.uk/government/publications/independent-review-of-uk-research-and-innovation-ukri

Research Council of Norway and Innovation Norway

The Research Council of Norway (RCN) was established in 1993 by merging five councils for science and technology, social sciences, agriculture, fisheries, and applied social sciences. It covers all scientific disciplines and both basic and application-oriented research funding and is the only council with special responsibility for public research institutes and an advisory role to the government. The creation of RCN was a response to repeated criticism of the diversity of bodies in different funding roles and their limited capacity to manage their performance, interactions and cross-cutting issues.

Specifically, the mission of RCN is 'to promote a society where research is created, used and shared, and thus contributes to restructuring and enhanced sustainability', which is quite extensive and is unique for a research funding agency in an OECD country. The Research Council's strategy for 2020-2024 has three key objectives – sustainable development, ground-breaking research and radical innovation, and restructuring in the business and public sectors – which are aligned with the Long Plan for Research and Higher Education 2019-2028 in Norway and the EU's framework programme. RCN funding comes from almost all ministries and is allocated to a diverse range of universities, public research institutes and companies. The RCN also deals with coordination between different policy sectors, research and policy evaluation, and strategic advice to the government on science and technology policy issues.

The RCN was complemented in 2004 by the creation of Innovation Norway, which was formed through the merger of four governmental organisations: the Norwegian Tourist Board, the Norwegian Trade Council, the Norwegian Industrial and Regional Development Fund (SND), and the Government Consultative Office for Inventors (SVO). In addition to these two agencies, there is the Industrial Development Corporation of Norway (SIVA) that was founded in 1968, focusing on physical infrastructure to service industry.

Source : (OECD, 2017[18]) ; https ://www.forskningsradet.no/en/; https ://www.forskningsradet.no/en/research-policy-strategy/strategies-plans/

Merger of the Irish Research Council and Science Foundation Ireland

Ireland has announced a plan in Impact 2030 – Ireland's Research and Innovation Strategy- to merge the Irish Research Council (IRC: the largest competitive funder of research in the Arts, Humanities and Social Sciences) and Science Foundation Ireland (SFI: the largest competitive funder of research in Science, Technology, Engineering and Mathematics).

The reform has been prompted by Covid-19, which highlighted the importance of research and innovation in crisis response and the need for collaboration between different research disciplines to transform ideas into impact. It also aims to put R&I at the heart of Ireland's response to important issues

for citizens such as climate change and digital transformation. The merger is expected to help co-ordinate funding activities, improve administrative efficiency and simplify the set of support instruments provided to researchers, while building on the existing capacity, strengths and international brands of IRC and SFI.

Impact 2030 also states that a critical action in the process of establishing the new agency is to take a holistic view of the current IRC and SFI funding in order to identify any duplication or gaps and to improve complementarity with other funding agencies in the broader R&I landscape of Ireland.

At the same time as the merger, the relationship between ministerial policymakers and the public research system, will be strengthened by establishing a new dedicated Evidence for Policy function within the Department of Further and Higher Education, Research, Innovation and Science.

It should be noted that Enterprise Ireland (EI), which promotes business sector R&D activities in Ireland, will not be part of the proposed merger.

Source: https://www.gov.ie/en/publication/27c78-impact-2030-irelands-new-research-and-innovation-strategy/#:~:text='Impact%202030%3A%20Ireland's%20Research%20and,innovation%20on%20many%20national%20priorities

National Research Foundation of Korea and an innovation agency

Korea agreed on a 'one ministry, one specialized institution' approach in 2018 in order to increase R&D investment efficiency. This was seen as a solution to a number of concerns, including: similar/overlapping planning activities by different actors; lack of organic linkage between research results and innovation; the excessive burden on researchers due to different regulatory procedures and management requirements for each institution.

Korea unified agencies under the Ministry of Science and ICT (MSIT) into the National Research Foundation of Korea (NRF):

- Transferred the R&D managed by the National IT Industry Promotion Agency (NIPA) to the Information and Communication Technology Promotion Center (IITP), and
- Made the IITP an affiliated institution within the NRF

Agencies under the Ministry of Trade, Industry and Energy (MOTIE) were unified into a single dedicated agency for industrial technology R&D:

- The Korea Institute of Industrial Technology Evaluation and Planning (KEIT) and the Institute of Energy Technology Evaluation and Planning (KETEP) were merged, and
- The merged agency oversees the overall R&D portfolio of MOTIE.
- The Korea Institute for Advancement of Technology (KIAT) was preserved along with its specific remit and activities for industrial promotion (rather than technology development).

Source: https://policy.nl.go.kr/cmmn/FileDown.do?atchFileId=224326&fileSn=65773

Options for change

- Give serious consideration to reforming the governance and structures of the public funding organisations in Sweden. The rationale for reform is to create and implement more coherent policies that align with a shared national strategy and address the need to more effectively support STI that enables socio-technical transitions. Such reform could include modifications to the remits and coordination mechanisms for existing funding agencies, and/or might include more radical structural changes and mergers. Two alternative change scenarios are presented in this discussion paper but it is recognised that other scenarios may be more appropriate in the specific Swedish context.

Concluding Remarks

Societal needs and expectations regarding public research are increasing. Science systems are now expected not only to produce new knowledge, but also to support innovation and generate solutions to complex societal challenges. Public research funders as intermediaries between governments and research providers are having to adjust their strategies and operations to incentivise the research that is required to respond to these expanded expectations. Universities, as the main research providers (and centres of education and training for future researchers) are increasingly expected to work with funders and other actors to deliver the necessary scientific knowledge and tools that are urgently required to support societal transitions.

The Swedish research system has its strengths and weaknesses, which have been explored in detail in earlier analyses, including the 2016 OECD review. Many of the weaknesses relate the lack of strategic leadership and clear direction across the system, which makes it difficult to break down embedded 'silos' – between disciplines, agencies, sectors and institutions. These are accentuated when it comes to high-risk research or research that addresses societal challenges, which require new approaches that are more inter-disciplinary and inter-sectoral. There are important lessons to be learned from several recent initiatives – SFO, SIP, NRPs - to address societal challenges, which have tested the limits of what is possible within the current system.

This report includes a number of options for change for consideration with a view to improving different aspects of the Swedish public research system. These essentially relate to two issues – strategy and structures – that need to be considered together. There appears to be a strategy deficit across the research system, from the national to the institutional scale, and in the absence of shared priorities and directions, collective action is limited and each actor, from individual researchers to universities to funders, does their own thing. New initiatives are stifled from the outset by the dominant incentives within the system that favour incremental research and short-term academic publication outputs. In the absence of effective coordination, the diversity of different public and private research funding sources in Sweden and the relative availability of funding overall, favour an opportunistic rather than a strategic approach.

It is timely for Sweden to ask the question whether it is satisfied with what its research system is producing in terms of scientific breakthroughs, innovation and addressing societal needs and, depending on the answer to this first question, whether incremental or more radical structural changes are required. This report includes a number of suggestions as to how a more strategic approach can be implemented at different levels and concludes with two potential scenarios for change at the level of the public research funding agencies. The aim is not to prescribe what should be done but to facilitate a discussion about what is required and how it can be best achieved.

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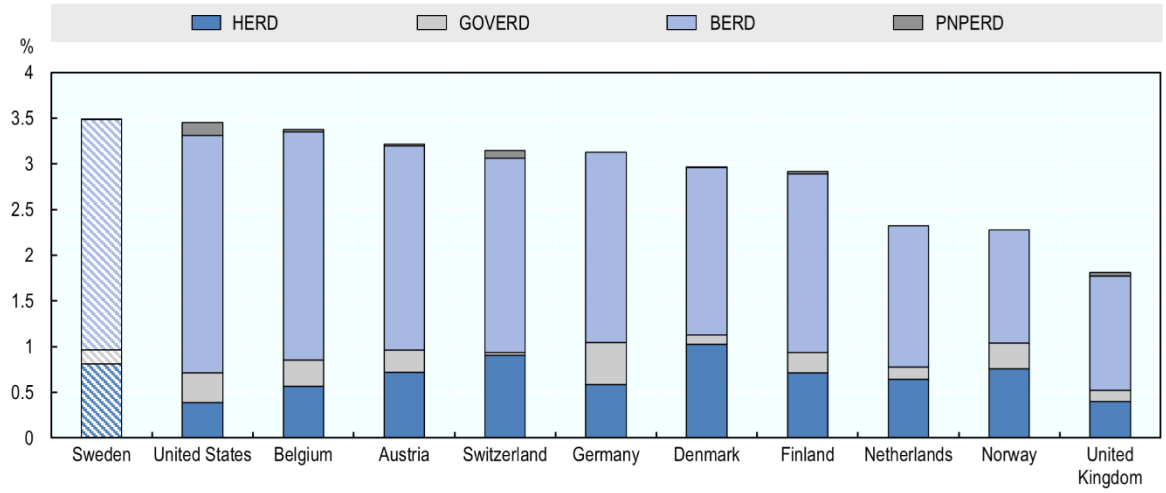
Appendix

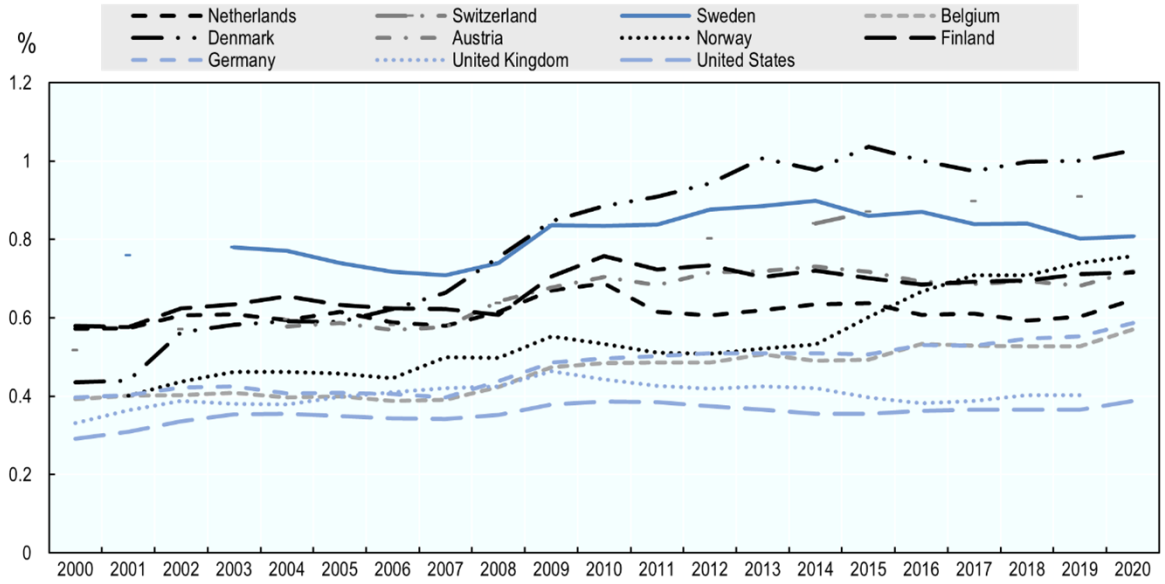
Figure 1. R&D intensity by sector of performance as a percentage of GDP by country

HERD: higher education expenditure on R&D; GOVERD: government intramural expenditure on R&D; BERD: business enterprise R&D; PNPERD: private non-profit expenditure on R&D



Note: the data of 2020 where 2020 data corresponds to 2019 for Switzerland and United Kingdom
Source: OECD (2023), "Main Science and Technology Indicators", OECD Science, Technology and R&D Statistics (database), https://doi.org/10.1787/data-00182-en (accessed on 22 February 2023).

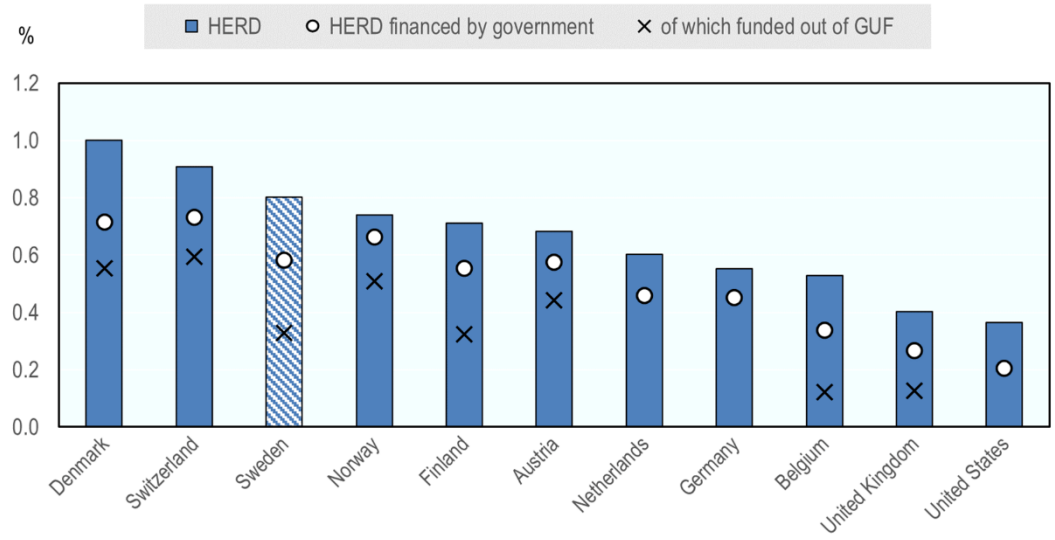
Figure 2. Higher Education Expenditure on R&D (HERD) as a percentage of GDP



Source: OECD (2023), "Research and Development Statistics, OECD Science, Technology and R&D Statistics (database), https://doi.org/10.1787/data-00189-en extracted from OECD STI.Scoreboard platform on 23 February 2023.

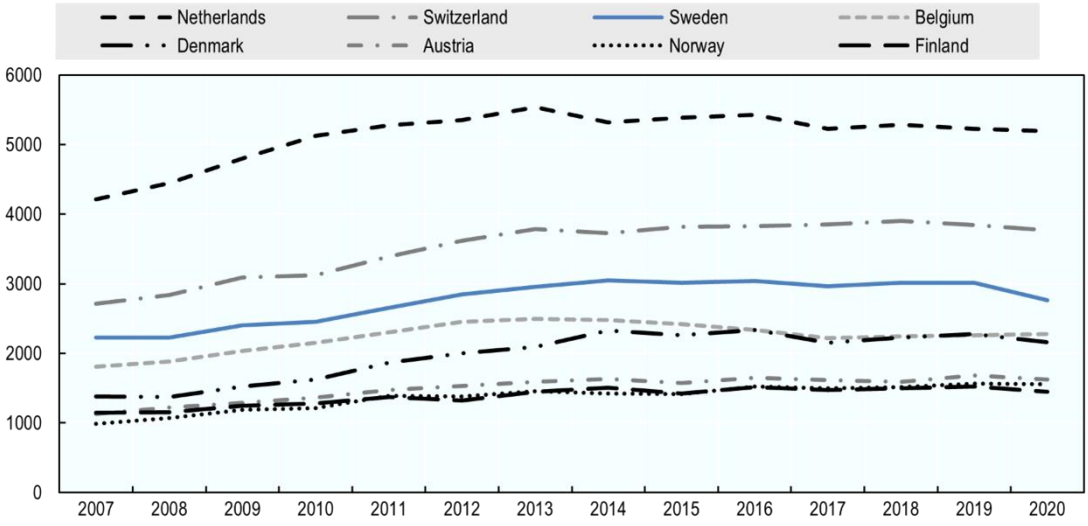
Figure 3. HERD and HERD financed by the government sector as a percentage of GDP

HERD: higher education expenditure on R&D; GUF: general university funds



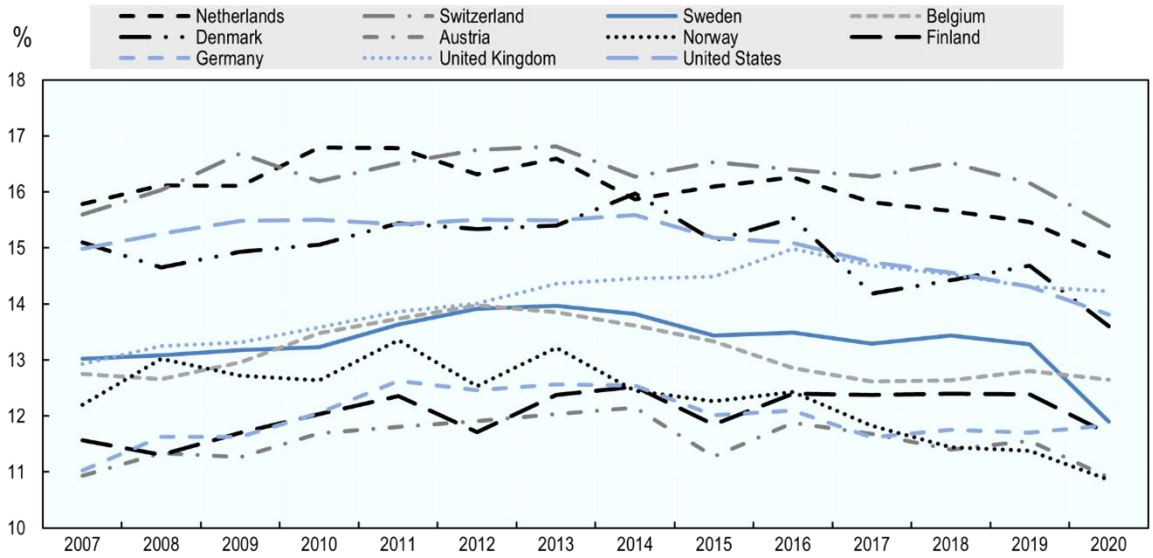
Note: the data of 2019
Source: OECD STI Scoreboard (last accessed on 23 February 2023)

Figure 4. Total number of 10% top-cited scientific publications, fractional counts



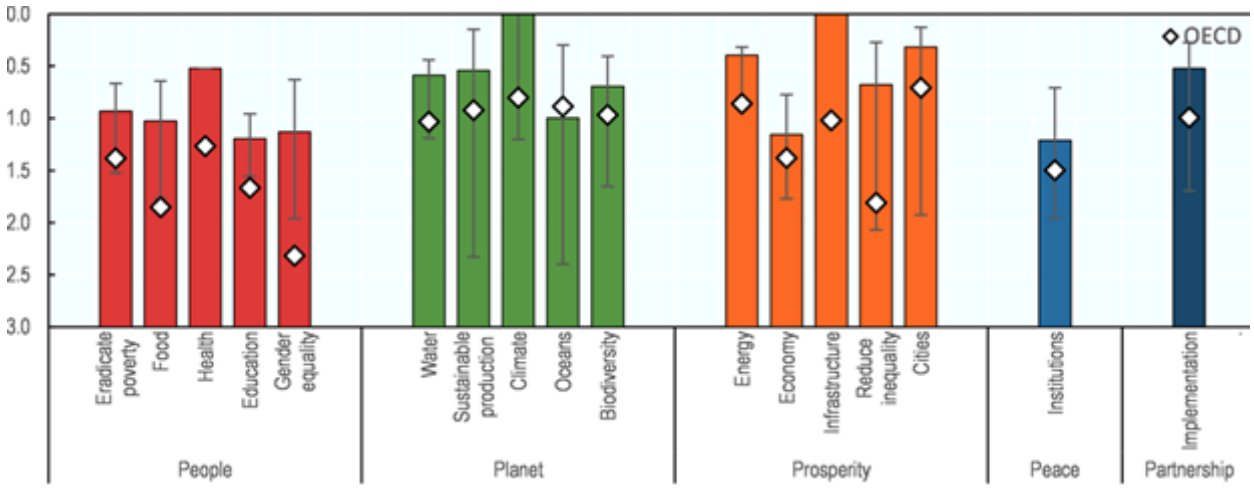
Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 6.2022, September 2022.

Figure 5. Proportion of 10% top-cited scientific publications to total scientific publications, fractional counts, %



Source: OECD calculations based on Scopus Custom Data, Elsevier, Version 6.2022, September 2022.
Note: the drop in most countries from 2019 coincides with the COVID-19 pandemic and should be interpreted cautiously.

Figure 6. Sweden's average distance to the SDG targets level



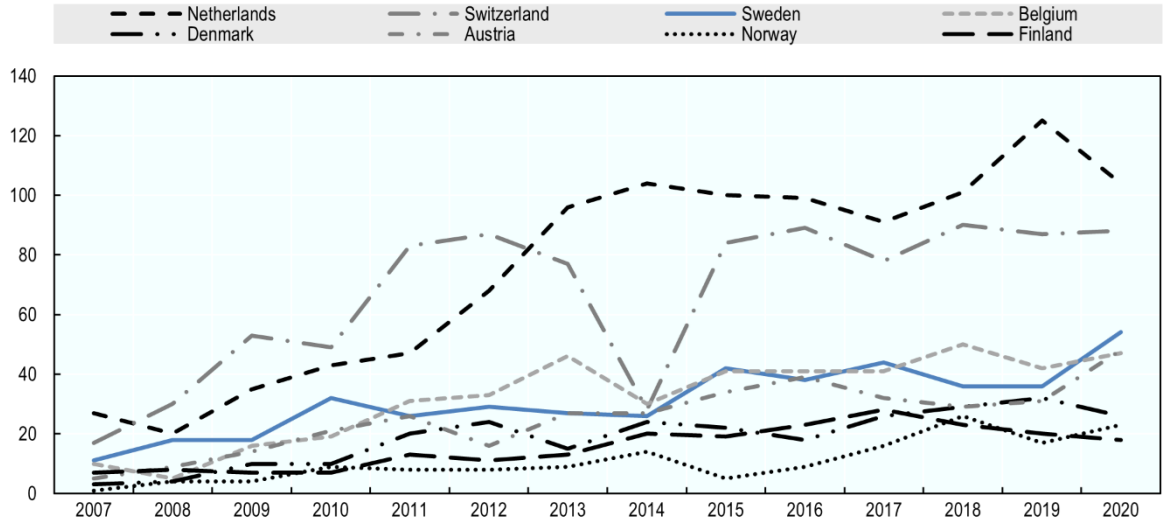
Note: It shows the average distance the country needs to travel to reach each SDG. Distances are measured in standardised units with 0 indicating that the level for 2030 has already been attained and 3 is the distance most OECD countries have already travelled. Bars show the average country performance against all targets under the relevant Goal for which data are available, and diamonds show the OECD average. Whiskers show uncertainties due to missing data, ranging from assuming that missing indicators are all 3 standardised distances from the 2030 target level to assuming that they are already at the target level.
Source: Measuring distance to the SDG targets – Sweden

Table 2. Higher education institutions' income from research grants in Sweden by funder, SEK million (current prices)

	SEK Million	%
Councils and government agencies	**10,393**	**47.6%**
The Research Council	5,110	23.4%
Formas	1,144	5.2%
Forte	589	2.7%
Vinnova	1,034	4.7%
Swedish Energy Agency	787	3.6%
Other government agencies	1,729	7.9%
EU	**2,162**	**9.9%**
Public research foundations	**1,307**	**6.0%**
SSF (Swedish Foundation for Strategic Research)	650	3.0%
Other public research foundations	657	3.0%
Foundations and other non-profit organisations (NPOs) in Sweden	**5,875**	**26.9%**
Wallenberg Foundations	1,969	9.0%
Other private foundations and NPOs	3,906	17.9%
Others	**2,106**	**9.6%**
Total	**21,843**	**100.0%**

Note: the data of 2021; Universities have other funds such as the direct government subsidies, SEK 21.6B, including the basic funding of higher education institutions, SEK 19.1B
Source: Universitet och högskolor Årsrapport 2022

Figure 7. Number of projects funded from the European Research Council (ERC) by country



Source: ERC (2023) datahub of ERC funded project, https://erc.europa.eu/project-statistics/project-database (accessed on 8, February 2023)