HANDBOOK ON PUBLIC RESEARCH FUNDING

Title: Potentials and limitations of programme-based research funding for the transformation of research systems

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1. Introduction

The aim of this chapter is to analyze the opportunities and limitations of programme funding for the transformation of science systems. In recent years, various societal drivers have increased the pressure on the science system to legitimize the use of public funds. It is no longer sufficient to achieve goals intrinsic to research, such as contributing to the development of theory and methods or achieving knowledge gains. Furthermore, the contribution that research makes to solving problems matters, especially in the area of major societal challenges. This debate is strongly linked to keywords such as Sustainable Development Goals, Societal Impacts, the "New social contract of science", the mission and transformation orientation of research policy, the public value of research, next generation metrics as well as different policy frames that shape research and research funding (see also Ulnicane and Aleman Diaz in this handbook). All these keywords revolve around the questions of 1) what are legitimate expectations of science and its role in the innovation system, 2) how would internal structures and processes in the science sector need to change in order to meet external expectations, and 3) what can public research funding concretely offer to foster change. In our chapter, we focus on the question, what public programme funding, in particular, can realistically contribute to initiating, shaping, accompanying, or accelerating the change processes outlined above.

The chapter is structured as follows: In the following section two, we critically review the existing literature on transformative research and corresponding research funding approaches, using sustainability research as an example. The concept of (conflicting) policy frames (see also Ulnicane and Aleman Diaz in this handbook) offers a helpful lens through which these transformative changes can be described, namely the “republic of science” (Polanyi) versus "the societal function of research" (Bernal) (cited from Ulnicane, forthcoming). In the third section, we describe the role of research funding for enabling but also changing research processes, before we present the German funding framework to promote sustainability research (FONA) as an empirical illustration, in section 4. The chapter ends with a critical assessment of gaps and future research directions.

2. The science transformation debate

In recent years, the concept of mission orientation has become increasingly important in research and innovation policy and funding. Missions, which can be understood as a goal-oriented operationalization of the so-called "grand societal challenges," are characterized by their pronounced cross-cutting nature, cross-sectoral and interlocking interdependencies, broad time horizons, and high socio-economic and socio-cultural depths of intervention. It is emphasized that there can be no optimal shape of mission, but that each challenge requires a tailored form (Mazzucato 2018). Characteristics of impactful missions are considered to be appropriate granularity, ambitious and inspiring as well as at the same time realistic and measurable goals, as well as openness to different ways of solving problems (ibid.). Translating these elements into concrete research and innovation policy measures and governance presents numerous challenges. One of these is that the missions should not be seen as a continuation of conventional routines for setting research and innovation policy priorities and modifying or further developing existing funding programmes. Rather, due to the transformative nature of missions, it will be necessary to embed the design of research, technology and innovation policy (RTI policy) much more strongly than in the past in processes of social change and to relate it to these processes (Kuhlmann/Rip 2018). Much mission-oriented innovation policy focuses on sustainability,

and the Sustainable Development Goals (SDG) inspire research agendas (Mazzucato and Semiuk 2017; Kaldewey 2018). The environmental externalities generated by sustainability challenges (Rennings 2000) add an additional justification for publicly financed research for sustainability to the classic knowledge externality and market failure argument for knowledge production.

In parallel, a debate has been emerging which links an increased focus on societal challenges with fundamental changes in research processes. There are various interrelated strands of argument, which point towards fundamental changes in the research process. The increasing complexity of societal problems and challenges has led to a debate about the necessity of new forms of knowledge production (Nowotny et al. 2003, Etzkowitz & Leydesdorff 2000). This has been taken up by the debate about a transformative science in order to open up to society (Schneidewind et al. 2016; Scholz 2017; Shelley-Egan 2020; Grunwald 2020). These authors see a scientific paradigm shift evolving: The "classical", "normal", "mode 1" science is characterized by research questions defined primarily in an academic context, disciplinary orientation, quality control exclusively on the basis of criteria inherent to science, and knowledge production without considering the context of use. In contrast, the new "post-normal science", "Mode 2", is characterized by a much stronger need for interdisciplinarity, interaction between research system and society, and involves also stronger reflection processes (see Nowotny et al. 2003, Frederichs 1999, Gibbons et al. 1994, Weingart 1997).

Closely related to increasing demands of science are expectations that science should cooperate more with societal actors and implement more inter- and transdisciplinarity as well as problem- and application-orientation (see e.g. Renn 2019; Müller-Christ 2017)[1]. A strengthened and improved relationship between science and society is also at the core of the concept of "Responsible Research and Innovation" (RRI) which aims to embed responsibility as a core value in research and innovation processes and cultures (European Commission 2014, Lindner et al. 2016, Bogner et al. 2015). Generally speaking, RRI intends to create a new and improved relationship between science and society. The EU Commission defines RRI as “a process where all societal actors (researchers, citizens, policy makers, businesses) work together during the whole R&I process in order to align R&I outcomes to the values, needs and expectations of European society” (von Schomberg 2013). RRI has also been defined as "... a transparent, interactive process in which societal actors and innovators become mutually responsive to each other with a view on the ethical acceptability, sustainability and societal desirability of the innovation process and its marketable products.“ (Call FP7-SiS-2012-1). Scholars like Stilgoe et al (2013) emphasize four integrated dimensions that characterize responsible research and innovation: anticipation, reflexivity, inclusion and responsiveness[2].

One of the most prominent examples of such a paradigm change is sustainability research. The emergence of the new field of sustainability research dates back to the turn of the century, as indicated by landmark publications such as Kates et al. (2001), and high level conferences such as the World Congress "Challenges of the Earth 2001" (Komiyama and Takeuchi 2006; Gochin and Zaman 2010). The elements connecting sustainability research to the paradigm shift outlined above are twofold: first it is the alignment of scientific research production to societal problems in order to contribute to societal transformation processes. Secondly, it is the way that research is conducted (Komiyama and Takeuchi 2006; Gallopin et al. 2001). Research for sustainability aims at providing solutions for existing societal (grand) challenges such as mitigation of and adaptation to climate change, or the protection of natural resources. Hence the usability and transferability of research results into non-academic settings is a core component of sustainability research. This implies changes in the research processes themselves: Sustainability science aims at transcending disciplinary boundaries by uniting different scientific disciplines around a problem (interdisciplinarity), and the results of Schoolman et al (2011) and Lam et al. (2014) indicate that it indeed is moving in this direction. There are several

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1 Potential unintended consequences of such a shift towards application and impact-orientation is discussed in Coburn et al (2022) in this handbook.

2 A further important strand of the debate in this context revolves around the creation of public value, see among others Bozeman (2022).

reasons for the importance of interdisciplinary principles for sustainability research: Sustainability research is about contributing to solving complex problems. Disciplinary boundaries, however, do not necessarily follow the structure of knowledge necessary for coming up with solutions. Cleveland and Kaufmann (1995) point towards the interdisciplinary nature of sustainability per se, linking natural, economic and social dimensions. According to Newell (2001), complexity is a key justification for an interdisciplinary approach. The different interwoven dimensions of sustainability increase the complexity of the problem. The plurality of values and norms involved furthermore increase complexity, and call for a holistic view associated with transdisciplinarity and Mode 2 type of research (Hadorn et al. 2006; Newig et al. 2019, Lang 2012). Furthermore, sustainability also includes an international perspective and especially takes into consideration implications of the research in countries of the global South. It involves stakeholders in those countries with regard to development issues (Kates 2011), but also with regard to being affected by global changes such as climate change (internationality). In sum, sustainability research adopts a systemic perspective of the research object and takes into consideration the different impacts that research can have beyond the scientific community. This is supported by a survey by Daedlow et al (2016) that underlines that sustainability research is seen to be increasingly more embedded, self-reflective and co-productive, and there is an acknowledged need for a more inter- and transdisciplinary focus, as well as problem- and application-orientation[3].

The nature of sustainability research has also led to calls for specially tailored research programmes. The rationale for this seems to be clear: sustainability research emphasizes the outcome of research for society, thus producing “public value”[4], and pushes for research processes which run counter to the traditional, disciplinary oriented research programme. Thus, within traditional research programmes, which put emphasis on academic outcomes only, sustainability-oriented research is disadvantaged in comparison with more traditional forms of research.

Increasingly, research programmes are put forward, which state impacts on sustainability as an explicit goal, such as the European Framework Programme (e.g. Horizon 2020, Horizon Europe), but also national programme for example the German Framework Programme for Sustainability Research (FONA), the Finnish Strategic Research Funding Instrument (SRFI) or the research funded by the Swedish FORMAS[5]. The following table shows the main characteristics of the mentioned funding programme:

3 Methodological reflections have led to a set of eight criteria, which sustainability research in general should follow (Feretti et al. 2016; Helming et al. 2016), and which have been adopted by the German non-university research organizations (Fraunhofer Gesellschaft; Leibniz-Gemeinschaft; Helmholtz-Gemeinschaft 2016).

4 A comprehensive analysis of the meaning of “public” in public research is delivered by Bozeman in this handbook.

5 Further funding programmes and strategies like the German High-Tech-Strategy (HTS), the Swedish Challenge Driven Innovation Programme (CDI), the Swiss National Research Programme (NRPs) or the Dutch long-term, interdisciplinary and transdisciplinary research along NWA routes by consortia (ORC) can be perceived as mission-orientated programmes but have a broader thematic scope and target groups than the three programmes shown in table 1.

Table 1. Overview on strategic research funding programmemes[6]

	FONA (DE)[7]	SRFI (FI)[8]	FORMAS (SE)[9]
Start date	Since 2005	Since 2015	Since 2000
Budget	ca. 370 million euros per year (total expenses 2005-2018 = 5 billion €)	56 million euros granted funding per year	170 million euros (1.8 billion Swedish kronor) per year
Funding instruments	**Project** funding (single, cooperation junior research groups) & **structural** funding (infrastructures, others like the IPCC secretariat)	Provides funding to long-term multidisciplinary **research** that seeks solutions to the challenges facing Finnish society.	Targeted calls (national research programme , 2/3 of the budget) and researcher initiated calls (1/3 of the budget) for research projects
Interdisciplnariy	Required as a so-called system characteristic	Multidisciplinary research consortia are required	Stimulates activities aiming at cross-sectoral and interdisciplinary approaches
Transdisciplinarity	Required as a so-called system characteristic in several specific programme lines	Emphasis on active interaction and engagement with users and beneficiaries of research	Strengthening collaborations between those performing the research, those funding the research and stakeholders in society
Prioritised research problems	Clear focus on promoting research for sustainability and sustainable developments	General focus on research that addresses the grand challenges, whereas sustainability-related topics are at the core, especially in the current programmes	Sustainable development, with a particular emphasis on environment, agricultural sciences and spatial planning
User oriented outputs	Science and technology transfer is again a so-called system characteristic and an important selection criteria for the collaborative projects	See above, transdiciplinarity, SFRI requires active collaboration between those who produce research knowledge and those who use it	Particular emphasis is given to science communication and strengthening collaboration between researchers, research funders and societal actors.

All three programmes have in common that the research they fund shall contribute to solving urgent societal challenges and that inter-, multi-, and / or transdisciplinary research is required. The three programmes pursue overarching strategic goals and are endowed with substantial funds. The funded research should also be clearly oriented towards the needs of future users, i.e. there is a clear requirement to produce useful results outside the realm of science. However, the programmes also show several differences. In addition to obvious ones such as the start date of the programme and the available budgets, the three examples differ in terms of the content priorities they pursue. While FONA and FORMAS clearly focus on sustainability, SFRI is slightly broader in content and generally prioritizes the major challenges, with sustainability also playing a central role. Additionally, FORMAS places a special emphasis on science communication and policy analysis. FONA, on the other hand, shows the broadest policy mix, since it not only supports collaborative projects between science,

6 The rows follow the four characteristics for societal targeted research developed by Ramos-Vielba et al. (2022) but added information on the start date and average budget as well.

7 See Bührer et al. 2020a

8 https://www.aka.fi/en/research-funding/funding-opportunities-at-a-glance/funding-for-strategic-research/

9 https://www.formas.se/en/

business and, in some cases, also other actors from civil society or municipalities, but also large-scale infrastructures, service activities and junior research groups.

3. Main challenges in transforming research through public funding

Since the 1990s, a reorientation in the relationship between the state and science has taken place in numerous (Western) European countries, which can be summarized by the catchword New Public Management (NPM). In essence, this means that the state reduces its (operational) control over public research institutions and grants them more autonomy in their decisions, but in return expects performance to increase (Ferlie et al 1996). In the course of these changes in governance between scientific institutions and the state, various mechanisms were introduced, like global budgeting, performance-oriented resource allocation and goal agreements. The introduction of New Public Management also led to an increasing relevance of competition and performance-oriented funding, either as part of institutional funding or through an increasing importance of competitive third-party funds (Hicks 2012, Geuna 2001, Jongbloed and Vossensteyn 2001, Jongbloed and Lepori 2015)[10].

Research institutions, like all other organizations, need a range of resources to carry out their missions. In addition to infrastructure and human resources, these are primarily financial resources. In essence, the funding modalities of research performing organizations can be traced back to two basic pillars: 1) **institutional funding** and 2) **project funding**[11]. It is worth noting, however, that institutional funding is as well (increasingly) based on performance criteria or at least dependent on different criteria that serve the organizations' strategic goals. Thus the traditional distinction between competitive and institutional funding does not sufficiently reflect the current funding systems (Larrue et al. 2018)[12]. However, current practices of assessing the performance of research still almost exclusively rely on criteria inherent to science, and here in particular on peer-reviewed publications in high-ranked journals and subsequent citations. This happens despite a growing trend to question this approach, known under headings like the "metric tide", i.e. the increasingly critical voices from academia on the question of how excellence is measured (Wilsdon et al 2015, Hicks et al. 2015, DORA (Declaration on Research Assessment 2012).

For the other strand of public research funding, project-based and in particular applied research funding, the following observation can be made: Between 1970 and mid-2000, the share of **project funding** steadily increased in the overall public research allocation (Lepori & Jongbloed 2018, Lepori et al. 2007, Larrue et al. 2018)[13]. In European countries, it constituted the second main channel of public funding for research funding (Lepori et al. 2007). However, there are significant differences between countries as regards the overall importance and share of performance-oriented funding (Jongbloed and Leopori 2015). The share of project funding varies highly, depending on the countries and can

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10 It should be noted, however, that it is rather contested whether the introduction of NPM leads to an improved performance (Auranen and Nieminen 2010, Jongbloed and Vossensteyn 2016, Jongbloed and Lepori 2015, Schubert 2009).

11 There are numerous – and more sophisticated - approaches to illustrate differences in the funding modalities of the public research sector, see for example Lepori 2007, Auranen and Nieminen 2010, Jongbloed 2010, Lepori 2011), but this simplified understanding seems to be purposeful for this chapter.

12 Larrue et al. (2018) therefore propose a new conceptual framework to classify research funding instruments that take the policy context into account and thus acknowledge the increasing relevance of the policy frame that emphasizes the social function of research

13 A high proportion of third-party funding can have advantages and disadvantages, for example increased transparency and accountability, increased relevance to the research agency objectives, promotion of institutional diversity, better research outputs as well as research community profits on the one hand but also emphasis on short-term, low-risk research; negative career effects; disincentives for collaboration, bureaucracy, bias through peer review process, lack of long-term planning for staff / infrastructure as disadvantages (OECD 2018). Further criticism was articulated by several scholars, emphasized the risk of the “Matthew principle”, i.e. awarding only those who were already strong in the past (Viner (2004), by favoring a certain kind of short-term oriented mainstream research (Laudel 2006) and by weakening the strategic possibilities of the RPOs (Bleiklie et al 2001).

go from 5% to 92%; the majority of European countries seems to have levelled in the past years between 25% and 50% of project funding (OECD 2018; Jonkers und Zacharewicz 2016). Since mid-2000 however the share of research funding channelled through projects is not any more increasing (Larrue et al. 2018).

For project funding, often also labelled as competitive funding, it has always been clear that certain objectives are linked to it. Thus, competitive project funding is by nature targeted to specific predefined objectives. While these objectives were in the past primarily linked to promoting scientific excellence (pushing knowledge frontiers further), qualifying junior researchers or strengthening the research system, the past years have seen a fanning out of goals to which research programmes should contribute (see also Reale et al. 2022 in this handbook). As shown in a survey of 75 competitive funding schemes conducted in 2018, research programmes have not any more a sole focus on scientific excellence, but are asked to provide results that go beyond the research system and generate profit to non-scientific stakeholders. Approximately one third of the analysed funding schemes state as objectives "Responding to societal challenges" and / or "economic competitiveness"[14] (OECD 2018).

After the move towards performance based funding, we see a second wave of changes towards funding for societal goals gearing up, so far visible only in project based funding. Clearly it is easier to redirect rather short-lived specific research projects towards new goals than to change existing institutions. Indeed we assume that under the conditions of New Public Management, i.e., a high degree of autonomy of research performing organizations with regard to their internal structures, processes and incentive systems, it is comparatively difficult for externally set incentives to have a sufficient impact on the organization. This is especially true when there are conflicting goals: As mentioned above, internal performance systems are still largely geared towards conventional bibliometric indicators and take only limited account of the special features of transdisciplinary or interdisciplinary research (Wilsdon et al. 2015, Geuna and Piolatto 2016).

The premise of our following reflections is that the higher the importance of institutional funding for the organization and the more strongly science-inherent performance-based funding elements are applied there, the more difficult it will be to induce institutional change towards a greater alignment of science with societal needs. This applies in particular to sustainability research, which is characterized by its strong transfer orientation as well as transdisciplinarity and interdisciplinarity. These are all important features for achieving the translation work called for in the sustainability debate, also known as "boundary work" (Cash et al 2003). There is a further aspect: careers in the science system are still often disciplinary and based on conventional scientific criteria. More recent requirements such as the exchange with society, the “third mission”, an extended impact orientation and interdisciplinarity are hardly defined as selection criteria for, as an example, the appointment to a professorship position. This is a further hindrance towards a transformative change of research systems (see Jaeger-Erben et al. 2018, Haider et al. 2018, Zucker 2012, Ruppert-Winkel et al. 2015, Pfirman & Martin 2017, Rhoten & Parker 2004). However, as Laudel points out in this handbook, no convincing theory yet exists about how to link the macro-level of the research funding landscape with the individual strategies at the micro-level of individual researchers.

The difficulty of initiating transformational changes within institutions support a strategy starting with programme based funding. Indeed the survey results mentioned above indicate that programme based funding increasingly addresses societal goals explicitly. However, we also argue that focusing on a societal research topic is not sufficient for the transformation of the science system - it has to be accompanied by changes in the research process as well. Thus, we see the following questions arising:

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14 The particular role of programme managers at funding agencies and thus the grant making process in fostering change is analyzed by Arnott 2021. The author describes “these actors as potentially de factor makers of research policy” (page 8), thus underlying the important influence of programme funding in promoting new types of research.

- Do we see indications that the change towards focusing research on societal challenges in project based research funding is also accompanied by a change in the research process?
- How effective can research funding programmes that address societal challenges be in changing the research system as such? Are, for example, particular boundary organizations (Clark et al. 2003) necessary or can the required change also be implemented in the existing research performing organizations?
- How are potential shifts in research processes fostered by programme-based funding perceived by the research performing organizations given the existing incentive framework they are subject to?

Tackling these questions will be an important part of research on transforming future research systems.

4. Empirical illustration – The German framework programme for sustainability research FONA

In the following, we examine the German framework programme for sustainability (FONA), of the German Federal Ministry for Education and Research (BMBF), established in 2005, as an empirical example of how public funding can – or cannot – promote a shift in research towards more sustainability. FONA has disbursed 5 billion euros as of 2018. This example provides a suitable illustration of the possibilities, but also the limitations, of programme-based public research funding to transform a science system, for the following reasons: 1) The selected funding instrument has a comparatively long history (whereas such a long-lasting and comprehensive programme approach is not yet known from other countries). This allows us to study long-term change. 2) Substantial funding is available. 3) The funding instrument is ambitious and aims to contribute to fundamental change in science, business and society. 4) With the focus on sustainability research, a type of research is promoted that genuinely deals with system transformations. 5) The FONA programme has been thoroughly evaluated, whereas other programmes have not. The Swedish FORMAS, for example, just launched a survey exploring whether FORMAS fulfils its missions and goals[15] and the Finnish Strategic Research Funding Instrument (SRFI) announced the availability of evaluation results for summer 2021, the respective report being only available in Finnish[16].

For a better understanding of what follows, it is worth mentioning that research funding in Germany is divided between the Federal government and the Federal states. The latter are primarily responsible for the basic funding of the Higher Education Institutions, whereas the Federal government mainly supports non-university research, research infrastructures and programme-oriented research. Due to this shared responsibility, the hurdles to reaching a common understanding of the policy frames to be pursued and the research funding priorities derived from them are particularly high (keyword: no dominant actor) (Hinze 2015). If we look at Federal spending on research and development by funding type, the amount for project funding and departmental research was between 6.3 and 7.6 billion euros, and for institutional funding between 5.3 and 8 billion euros between 2010 and 2018[17]. By way of comparison, FONA accounted for just under six billion euros in the period 2005-2018. The Federal government's spending on research and development by funding area in 2019 also shows the great importance of the thematic area of climate, environment and sustainability, which ranks fourth in terms of spending (ibid.). If we compare the FONA expenditures with the funding volume available to the German research foundation (DFG), the central funding body for basic research in Germany, almost

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15 https://formas.se/en/start-page/archive/news/news/2021-07-22-focus-survey-on-formas.html, retrieved at 10th January 2022.

16 https://www.aka.fi/globalassets/3-stn/1-strateginen-tutkimus/tiedon-kayttajalle/tietoaineistot/yhteiskunnallisen-vaikuttavuuden-arviointi---strategisen-tutkimuksen-ohjelmat-2016-2019.pdf

17 https://www.bundesbericht-forschung-innovation.de/de/Abbildungen-und-Tabellen-1713.html

three times as much funding is available for the period 2005-2018[18] (14 billion euros), but this is distributed across all disciplines.

Within Germany, the debate about sustainability science was preceded by a debate about environmental research from a systemic perspective (see for example Daschkeit and Schröder 1998), on which FONA could draw. Two important additional aspects played a key role for dedicating FONA to sustainability research. First, the framework research concept of the German BMBF called for directing the traditional environmental research programme of the BMBF much more strongly towards innovation and impact. Second, Germany had introduced a sustainability strategy in 2002, which further drove environmental research towards sustainability research. Thus, FONA's main goals are twofold: a) promote research for sustainability and strengthening research for sustainability in Germany and thus (implicitly) also induce a change in the research process towards more inter- and transdisciplinarity; b) produce research results that are relevant to society and that contribute to solving societal challenges. With the FONA framework, the BMBF focused on a type of research that was not only oriented towards pure knowledge generation or the generation of innovations as such, but that was explicitly oriented towards global challenges and included the perspectives of diverse societal stakeholders. FONA funded research projects should be interdisciplinary, transdisciplinary and take up a systemic perspective. Research outputs should not only fulfil scientific excellence criteria but also be useful for non-scientific stakeholders. In short, FONA intends to promote changes which fit into a larger transformation perspective of the German science system. Its policy mix of instruments therefore not only focuses on funding collaborative projects, but also funds junior research groups, infrastructure and international networks and other research coordinating activities[19]. FONA thus also fulfils the four criteria for research funding oriented toward societal goals identified by Ramos-Vielba et al. 2022 (see Table 1 and section 2).

The main results of a programme evaluation conducted between 2018 and 2020 (Bührer et al. 2020a, Bührer et al. 2000b) were that FONA has been successful with regard to initiating first steps towards changes within the German science system by explicitly strengthening interdisciplinary and transdisciplinary research approaches, by enriching the research landscape through funding the emergence of new departments and by integrating new elements into the training schemes for young researchers.

For universities and non-university research institutions, FONA is first and foremost a relevant source of third-party funding which, due to the relatively long project durations, has a positive significance for the thematic development as well as the training and career prospects of young scientists. In several interviews, the funding was described as indispensable for the thematic orientation of the chair or institute, which made this type of research possible in the first place in terms of content and structure, especially at smaller chairs. FONA results are also used in teaching and make it possible to write theses that are relevant to practice, sometimes in cooperation with practitioners. In particular, the junior research groups offer young scientists the opportunity to establish their own networks early in their careers, which are not limited to their specialist communities.

It was also emphasized in the interviews that FONA has increased the legitimacy of sustainability research in the research institutions. At the beginning of FONA, scientists conducting sustainability research would often have been seen as loners in a niche and not taken very seriously. The third-party funding associated with FONA, but also the continuity of the programme, would have changed this thoroughly. Strategy development in universities and non-university research does not follow individual federal programmes, but is integrated into institute-specific or cross-institutional strategies (e.g. research areas of the Helmholtz Association of German Research Centers (HGF), performance

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18 https://www.datenportal.bmbf.de/portal/de/Tabelle-1.1.7.html

19 The majority of (over 70%) financed research projects or project related research groups (e.g. junior research groups), approx. 20% of funding financed research infrastructure. A third of the FONA funding went to universities while non-university research organizations received approx. 44% of funding.

and target agreements of universities). Projects from the FONA programme often form a central element of third-party funding here - in individual research areas or disciplines. In the HGF, these have a predominantly complementary function to the internal programme oriented funding; for university research, third-party funding per se is of greater importance. On the one hand, this is because it enables research on a larger scale, and on the other hand, because third-party funding, along with publications, continues to be the central currency for reputational gains. These reputational gains also allow the topic of sustainability research to gain broader recognition compared to traditional research areas.

For scientific institutions, strategic effects often arise only downstream, since FONA is integrated into existing institute and university funding as a component of externally funded research. At the HGF, overarching strategy issues are developed within the framework of the internal overall strategy (programme oriented research) and at the level of the research areas, explicitly incorporating concepts such as the Grand Challenges. Thus, objectives can partly overlap with topics, focal points and programmes of FONA, but a medium- and long-term orientation can only be based on budgetary funds and not on third-party funds to be acquired in the future. For universities as a whole, strategic effects of FONA participation can be seen primarily in the strengthening of interdisciplinary cooperation within the university and beyond institutional boundaries. At the same time, funded departments and participating staff units gain opportunities to give the topic of sustainability greater visibility and relevance in the perception of university management, administration, other departments and teaching.

For universities, FONA also stands alongside other funding as an important source of third-party funding. As the acquisition of third-party funding is becoming increasingly important for both the quality and the scope of research at universities, the programme fits into university strategies. As a renowned source of third-party funding, FONA can strengthen the relevance of sustainability-oriented chairs and research groups at the respective universities. Staff units benefit from additional funding and projects that increase the visibility and relevance of the topic of sustainability among university management. In some cases, research is also embedded in a larger context of activities, which includes, for example, the preparation of sustainability reports. The longer project durations compared to other funding programmes make it possible to build up more constant networks within and outside the universities. These durations were also perceived as positive for the training of young researchers. Overall, there has been a considerable number of new research groups and chairs established at the university level. Non-university research institutions also considerably expanded their activities in the field of sustainability science, even to the extent of new institutes being founded that focus on sustainability research. The evaluation showed that these new organizational structures heavily relied on FONA funding. Thus, FONA has provided impetus for changes towards sustainability, in particular in making sustainability research an established scientific topic both within universities and non-university research organizations.

Additionally, interdisciplinary collaboration[20] was very high in FONA projects. In 75% of the projects surveyed, more than two disciplines worked together. In about a quarter of the projects, engineering and natural scientists worked together with humanities, social and cultural scientists. The cooperation in the interdisciplinary consortia was rated very positively by the project leaders interviewed. Obstacles such as communication and organizational problems within the project team were present, but not dominant. However, further findings indicated that the joint formulation and processing of research questions still has a clear potential for expansion. Additionally, especially in the case of interdisciplinary collaborations between natural and engineering sciences and social scientists, the focus was still strongly on disciplinary scientific exploitation. Following the distinction between multi- and interdisciplinarity as defined by Goshin and Zaman (2010), one explanation of this evidence might be that perhaps many projects remained in a multidisciplinary stage of collaboration and were not moving

20 Interdisciplinary collaborative projects are defined as those that bring together people from different scientific disciplines around a research question, according to the definition of van den Besselaar and Heimericks, who see interdisciplinarity as a deviation from the normal state of a discipline by using new theories, concepts and methods to answer a research question (van den Besselaar und Heimeriks 2001).

towards a more intensive interdisciplinarity. A second explanation might be that many journals still reflect a disciplinary pattern. Researchers from FONA might react by publishing their results in a distinctly disciplinary manner in order to adapt to that pressure. A third reason might be that an academic career quite often requires publishing predominantly in journals which are highly ranked in disciplinary journal lists. Clearly the disciplinary structure of academia was particularly inhibiting for young researchers who strive for a scientific qualification (doctorate) or establishment in the science system (post-doctoral thesis / professorial chair). A classic disciplinary profile is still assumed for this. The additional qualifications that result from interdisciplinary cooperation are still not (sufficiently) valued for a career in the German research system, especially the appointment to a professorship.

The strong involvement of practice partners in projects has proved the transdisciplinary character of FONA[21] . The evaluation found that about 40% of the funded FONA projects had been transdisciplinary cooperation in the narrower sense[22] i.e. cooperation that include societal stakeholders and public administration in addition to science and/or business. With the FONA funding transdisciplinary research could be funded in its infancy and it is to the BMBF's credit to have been one of the first to fund this type of research in Germany. However, it also became clear that not all of the three phases of transdisciplinary research we referred to above (see Lang et al. 2012) were equally taken up.

Summing up the evidence, the following conclusions for FONA emerge:

- We see clear indications that the change towards focusing research on sustainability in FONA is also accompanied by a change in the research process towards inter- and transdisciplinarity.
- At the same time, the existing traditional excellence criteria set was also successful: the scientists funded by FONA meet the classical requirements for publication output (measured as the number of publications and citations). This can be interpreted in such a way that FONA was able to increase the acceptance of sustainability science not only because of welcome additional research funding, but also because it is committed to and partially fulfilled the existing criteria for success (in publications). In this respect, sustainability science is incorporated into the established science system as an incremental innovation. This suggests that any future funding strategy must take into account that research that addresses grand challenges in particular must be excellent in its own right and fulfill the traditional criteria for scientific excellence, too.

The potential shifts in research processes fostered by project-based funding were perceived by the research performing organizations according to the existing incentive framework they are subject to: sustainability research had been able to acquire substantial research funds and come up with peer reviewed publications. Thus, it is a growing niche, which has gained some acceptance within the dominant science regime. However, it has not been able to transform the science system as such. Thus, there is still the need to foster additional structural change within the research system. This need is also addressed by FONA. With the FONA-funded initiative "Sustainability in Science" (SISI)[23], an exchange platform has been created to foster the dialogue on sustainability with and between researchers, administrative staff in research organizations, students and stakeholders outside re-

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21 The BMBF has opted for a definition of transdisciplinary research that is especially used in the German -speaking sustainability research community. It builds on the following three characteristics: a) research on socially relevant topics; b) use of paradigms that are cross-disciplinary, c) the inclusion of non-scientific actors (participatory research) (Pohl 2010)

22 As R&I activities can also be performed in companies, the FONA evaluation decided to exclude collaboration between scientific and industry actors in the analysis of transdisciplinary activities.

23 https://www.fona.de/de/ueber-fona/nachhaltigkeit-in-der-wissenschaft-sisi.php

search and development projects that aim at a sustainable transformation of research organizations[24]. Finally, this is also one of the central characteristics of FONA in comparison with other European research programmes, which also aim to strengthen inter- and transdisciplinary sustainability research, but only offer project funding and no funding instruments that support additional structural change.

5. Critical assessment of gaps and future research direction

In view of the prevailing paradigm of science, according to which research is most efficient when conducted primarily according to rules developed by science itself(following the policy frame of the “Republic of Science”), it is unrealistic to assume that programme or project funding, as extensive and attractive as it may be, can bring about change within a few years. Our case study from Germany has also shown that even a long-term and ambitious funding programme can at best provide an impetus in the direction of a system change.

In particular, the evaluation of FONA has identified an area of tension between sustainability research as a symbol for new modes of doing research, which demands impact-orientation, inter- and transdisciplinarity, and the conditions for establishing young scientists in the science system. This is where the influence of programme-based research funding to transform research systems reaches its limits. On the other hand, with an explicit strategic orientation and ambitious objectives to stimulate transformation, even programmes can trigger a debate on another level, in our example the emphasis on "sustainability in science" with strong implications for the design of research processes in research performing organizations outside the higher education sector. Insofar as FONA establishes a niche within the science system, and this changes the political economy and the levels of discourse: society's claim on science, which is not shared by all scientific stakeholders, becomes a claim by society together with parts of the science sector.

Furthermore, a Swedish study on the quality and impact of research in political science in Sweden has recently shown that there is a strong link between high scientific quality and impact (Swedish Research Council 2021). Further evidence of that kind is needed to build bridges between the different policy frames and to demonstrate that there is more convergence than contradiction between the “Republic of Science” and the societal function of research. However, there is a lack of systematic empirical studies that investigate on an empirical level whether, and to what extent, trade-offs occur between traditional scientific output and more effectiveness-oriented, inter- and transdisciplinary research. Thus, further research is needed to answer questions like: What are the building blocks for adapting science-inherent strategies and processes to allow more openness for sustainable and responsible research? How can the coupling of excellence and relevance be empirically investigated (control group comparisons in the direction of scientific and societal impacts)?

Project funding should continue these activities and also expand them in a targeted manner to include aspects of reflection on the effects of one's own research and on the establishment of a quality standard for good interdisciplinary and transdisciplinary research. The application of a framework for reflection, as developed in the FONA-funded LENA project (cf. Helming et al. 2016; Ferretti et al. 2016; Fraunhofer-Gesellschaft et al. 2016), could also lead to greater attention being paid to the effectiveness of one's own research already during the research process, and the achievement of impact not being projected solely onto a transfer phase that takes place after the actual research.

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24 In particular three projects are explicitly directed towards a structural change within the science system and aim at involving different actors of the German research landscape: 1) LeNa (Sustainability Management in non-university research organizations); 2) “Hoch-N (Sustainability at Universities), a network of eleven German universities exploring the topic of sustainability management and reporting for university; 3) "LeNa Shape" aims at exploring whether societal responsible research changes research processes with regards to its quality and impacts and effects on researchers and raises the question what the need for a transformation of research means for the definitions of the quality of research

The criteria used to assess the quality of research are of particular importance to solve the tension between disciplinary and interdisciplinary research, as described at the beginning. If interdisciplinarity and transdisciplinarity were regarded as important components of high-quality research, this would also have an impact on career opportunities and evaluation criteria in science. This argument is in line with the ongoing discussions on research quality, as mentioned above. But even if the question of the "impact of science" and its measurability is meanwhile very high on the agenda, further research is needed on how evaluation research and practice could contribute to overcome the hindrances towards transformative change within the research system by strengthening, for example, the perspective on the social outcomes of research.

However, some lessons learned can be derived from FONA's overall programme design to become effective towards sustainability: 1) the embedding of funding in an overarching strategic framework that is compatible with existing policy strategies, 2) the long-term orientation combined with substantial funds, 3) the policy mix with its variety of funding instruments, 4) the involvement of various actors from the quadruple helix in the programme design but also the implementation of the research.

6. Conclusions

Even a huge research programme in terms of funding projects remains only a part of research policy. Transformation cannot be expected from individual project-based programmes, but they change the conditions for further policies. Further steps will be taken to enlarge the specific mode of research processes towards other public research instruments such as institutional funding.

Here, the funding bodies would have to communicate their expectations even more clearly and transparently. Above all, they also have to make sufficient funds available to support the respective processes of change. Bottom-up buy-in supports the acceptance of change, as well as top-management commitment. Furthermore, participation and inclusion of the scientific staff raises awareness for the benefits associated with transformation, gains more acceptance and increases the motivation to join, while decreasing resistance.

An adaptation of the science system on all levels is needed, which involves a shift in mind set and also in the practices of individual researchers, the commitment of the research performing organizations including an altered orientation towards the impact of science, the need to overcome the still existing disincentives to interdisciplinary and transdisciplinary work and finally a new "Leitbild" for excellent research, which accounts for the need to direct research towards global challenges without compromising academic rigour.

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