EFFECTIVE OPERATION OF COMPETITIVE RESEARCH FUNDING SYSTEMS

POLICY PAPER

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Foreword

This report analyses existing competitive research funding mechanisms and their effectiveness, taking into account a variety of contextual factors. It is aimed both at the research funding community and policy-makers wishing to adapt competitive research funding strategies to different objectives. It includes a number of policy recommendations, which engage different actors and are derived from the analysis including identification of gaps in the available data and information.

The project that forms the basis for the current report was initiated by the OECD Global Science Forum (GSF) in 2016. It builds on a variety of work on research funding by the OECD Committee on Scientific and Technological Policy and focuses on the efficiency of funding allocation mechanisms relative to their objectives. The initial aims were to: 1. Develop a typology of competitive funding mechanisms and their component parts and compile existing evidence on their relative effectiveness; 2. Describe the prevalence of these mechanisms within participating countries, and consider whether contextual factors make different components of these mechanisms more or less appropriate; 3. Gather and synthesise available qualitative and quantitative evidence on impacts for different competitive systems. From the outset, it was clear that the diversity and complexity of existing funding schemes would not allow for a detailed classification, so the analyses were focused on processes in relation to the objectives of the various schemes.

The main elements of this project have been an extensive survey of individual funding schemes in different countries, complemented with targeted interviews. A workshop organised in October 2016 at the OECD provided initial input to identify the major issues and challenges faced by funders in a changing landscape. Findings from the survey and interviews, completed with contextual data on national research funding trends, were analysed to identify major challenges for competitive funding processes and to propose options to overcome them. Policy recommendations were developed to address some of the key unresolved challenges.

The project has been overseen by an international Expert Group whose members were nominated by GSF. This Group was chaired by Tateo Arimoto (Japan), Adam Jaffe (New Zealand) and Kei Koizumi (United States). Adam Jaffe and Kei Koizumi took the lead in drafting the final project report, with support from the OECD GSF Secretariat – Qian Dai, Frédéric Sgard and Carthage Smith.
# Table of contents

EFFECTIVE OPERATION OF COMPETITIVE RESEARCH FUNDING SYSTEMS  POLICY PAPER .............................................. 2
Foreword ........................................................................................................................................................................ 3
Abstract .......................................................................................................................................................................... 5
Executive summary ............................................................................................................................................................ 6

1. Introduction .................................................................................................................................................................. 9
   1.1. Rationale ............................................................................................................................................................. 9
   1.2. Background .......................................................................................................................................................... 10
   1.3. Methodology ......................................................................................................................................................... 10

2. General research funding context ............................................................................................................................... 12

3. Findings ...................................................................................................................................................................... 17
   3.1. Taxonomy and general objectives of competitive funding mechanisms ............................................................ 17
   3.2. Funding process ..................................................................................................................................................... 20
   3.3. Success rates .......................................................................................................................................................... 33
   3.4. Monitoring, impact, and measures of success .................................................................................................... 37
   3.5. Perceived challenges and responses ..................................................................................................................... 40

4. Analysis ...................................................................................................................................................................... 44
   4.1. Improving efficiency of competitive funding schemes ............................................................................................ 44
   4.2. Implications of success rates .................................................................................................................................. 45
   4.3. Encouraging transformative, risky, and multidisciplinary research ........................................................................ 47
   4.4. Matching competitive funding to strategic objectives ............................................................................................. 48
   4.5. Improving monitoring and evaluation ................................................................................................................... 49

5. Conclusions and recommendations ............................................................................................................................. 52

Endnotes ......................................................................................................................................................................... 54
References ......................................................................................................................................................................... 55

Appendix 1. Expert Group Members .............................................................................................................................. 59
Appendix 2. Survey questionnaire ....................................................................................................................................... 61
Appendix 3: Survey interviews .......................................................................................................................................... 67
Abstract

In OECD countries, much science funding is allocated via competitive mechanisms. Competitive funding schemes are widely favoured for being the optimal method for not only evaluating but also encouraging scientific excellence, in a process that is controlled by the community itself. Increasingly however, additional objectives, such as a demand for socio-economic value, are included in the process. The reliance of competitive systems on peer review brings up some concerns about the reliability and validity of evaluation processes in assuring the selection of the best proposals considering the breadth of objectives they are expected to fulfill. Competitive funding processes are also costly, both to awarding agencies and research performers.

This report analyses existing competitive research funding mechanisms and their effectiveness, taking into account a variety of contextual factors. It is aimed both at the research funding community and policy-makers wishing to adapt competitive research funding strategies to different objectives. It includes a number of policy recommendations, which engage different actors and are derived from the analysis including identification of gaps in the available data and information.

Key words: public research grants; competitive research funding; call for proposals; reviewing process
In OECD countries, much science funding is allocated via competitive mechanisms. Competitive funding schemes tend to have several common features: a call for proposals, a panel assessment, peer review, scoring, award of funding for a limited time, and follow-up. Awards may be for individuals, teams, research centres or institutions and can be of variable size and length. Competitive funding schemes are widely favoured in the science community for being the optimal method for not only evaluating but also encouraging scientific excellence, in a process that is controlled by the community itself.

There is widespread agreement that confidence in the integrity and reliability of the proposal evaluation process is crucial to acceptance and support of the system by the researcher community. And in general, that confidence is closely tied to a strong belief that peer review is the most – perhaps only – valid and reliable way to evaluate the merits of research proposals. The reliance of competitive systems on peer review, however, brings up some concerns about the reliability and validity of peer-review processes in assuring the quality of science. Competitive funding processes are also costly, both to awarding agencies and research performers. There are also opportunity costs to the research community in providing peer reviews.

The aim of this project was to analyse existing competitive research funding mechanisms and their effectiveness, considering contextual factors. This was achieved by collecting information via a questionnaire on 75 competitive funding programmes from 21 countries and conducting interviews with programme managers and reviewing panel members as well as collecting information and data from the literature, experts and data bases.

Despite its recognised importance, public research funding has been under budgetary pressure in recent years across the OECD. Growth of R&D systems in most countries has led governments and research funding bodies to seek increased efficiency in the use of funds; one of the responses has been to strengthen competitive funding in order to channel resources toward specific priorities and/or enhance excellence.

A broad taxonomy of competitive funding schemes can be described. In terms of size, this ranges from the competitively awarded research-funding grant to an individual investigator for a research project, to larger awards to teams of researchers in a center, cross-institutional teams, and sometimes entire institutions. Intersecting with the size of awards are the purposes for awards, ranging from blue sky or purely investigator-driven research to mission-led research with societal objectives in mind.

Competitive funding processes show similarities across the many programmes and nations surveyed. The goal of selecting among proposals for scientific excellence leads programmes to rely heavily on peer review by external researchers working in the same fields as applicants. Peer review, by giving the scientific community itself the leading role in allocating funds for scientific research, is widely trusted by the scientific community and therefore has legitimacy among researchers. Competition and competitiveness have become ubiquitous across the global science enterprise. There is evidence in the literature that scientific excellence is linked to competition among researchers but the literature also shows contradictory results between the degree of-competition and the overall productivity of national research systems. The underlying situation is complex but there is considerable concern that hyper-competitiveness and low rates of success in applications for competitive funding may be distorting research practice.
From the project’s review of the literature, the advantages of competitive funding are: a
tendency to increase the quality and relevance of research project proposals; a way to
ensure that research awards meet a minimum standard of quality; providing researchers an
opportunity to test their ideas among peers; and building trust in the community that awards
are made fairly. But there are also disadvantages: an increasing reliance on competitive
funding can result in shorter-term, lower-risk projects rather than longer-term, higher-risk
research, although the evidence for this is mixed; the resource and time burdens of applying
for and reviewing competitive grants; and the inability of researchers and institutions to do
long-term planning because of uncertain future funding.

The report focuses mainly on two features of the competitive funding process: the call for
proposals and the reviewing process. Within the sample of programmes that were surveyed,
the dominant frequency of calls for proposals was once a year, although there was a wide
range from every month to every three to five years. There have also been experiments with
no-deadline or rolling applications. The nature of the calls varied also: a one-step open call;
a one-step thematic call; a two-step open call in which pre-proposals are followed by a
second full-proposal call for successful first-step applicants; a two-step thematic call;
restricted-eligibility calls where applicants must meet certain criteria to apply; and co-
financing calls. For the review process, most programmes appear to employ a multi-
stage proposal evaluation process, which can include: initial screening, external review of
proposal documents, external review by a committee or panel, and interviews of applicants
by a panel. There was no common standard for how many reviewers must review a
proposal, although the most common minimum number is 3. Only a minority of funding
schemes has an appeals system, and that there are few mechanisms to gather feedback from
applicants or reviewers after the fact. A few nations are experimenting with novel review
processes.

One key facet of competitive funding schemes is the success rate, the ratio of awards funded
to applications submitted. Within the study sample, there was a wide variation in success
rates, with a clustering between 10 and 20%. There was no obvious relationship between
the size of a programme, the number of applications, or award size and the success rate.
There is increasing concern that low and declining success rates portend a crisis for the
research community. From the data collected, it was impossible to determine an ideal
success rate, although interviewees stated repeatedly that success rates below 10% are a
concern because below that threshold it is claimed that peer review is ill-equipped to make
meaningful funding decisions. There remains much more research that could be done on
success rates and the extent to which standard ways of allocating competitive funding
become increasingly inefficient as success rates drop.

The Expert Group found wide variation in nations’ monitoring of the peer-review process,
and also a wide variation in evaluation of impact/success measures. There are few
agreed-on criteria for scientific success in general, and therefore little concrete guidance on
how to evaluate success or impact as part of the peer-review process. The survey identified
some promising ad hoc approaches for evaluating impact but few systematic examples.
One barrier to evaluating impact is a lack of access by the science-policy research
community to detailed anonymized data on peer review that could allow for comparative
analyses of differing competitive allocation mechanisms in terms of impact.

This study identified four key issues that are recurrent across different competitive funding
systems and that, if addressed, could improve the operation of such systems:
• Accounting for the true costs of competitive funding schemes, including not only administrative costs for making awards but also evaluation costs and the time and effort spent by researchers to participate in the competitive funding process.
• Reducing burdens for applicants, reviewers and agencies by reducing the time, expense, and administrative burdens of application and review processes.
• Counteracting the widespread worry that peer review, especially as success rates decline, tends toward conservatism and away from potentially transformative, breakthrough, and interdisciplinary research.
• Refining competitive mechanisms and evaluation criteria to assess not only scientific quality and excellence but also societal objectives, such as economic competitiveness and human development.

To address these issues, the Expert Group offers four corresponding recommendations:

1. Interested countries are invited to initiate further analytical and comparative studies on the true costs and benefits of competitive funding schemes; this should incorporate not only the monetary costs of operating competitive funding mechanisms but also the volunteered time of reviewers, the costs of researchers and institutions in applying for and managing competitive awards, and opportunity costs for the entire research community.

2. Research funders are encouraged to develop experiments in competitive funding, especially in easing the administrative burden often linked to peer review and for increasing efficiency. Results should be evaluated carefully and shared with other OECD members, to facilitate collective learning.

3. Governments and research funders should promote experimental approaches that preserve competition while encouraging potentially transformative, breakthrough, and interdisciplinary research to counteract any conservative tendencies in peer review in an environment of declining success rates.

4. Governments are encouraged to further study how public research support can best contribute to broader societal challenges, looking at better identifying competitive proposals for potential impact and better evaluating the impacts funded proposals create.

In addition to address the lack of data on key features of competitive funding schemes, the report concludes with a call for governments and the OECD to take steps to improve the collection, analysis, reporting, and accessibility of data about competitive funding schemes to allow more-robust comparisons in the future.
1. Introduction

1.1. Rationale

Much public, non-governmental organisation (NGO), and indeed some private, science funding is distributed via competitive mechanisms. These competitive mechanisms have been originally adopted in the domain of research funding to allocate limited resources, as well as increasingly for the promotion of scientific excellence and efficiency. It has been argued that a shift from institutional core funding to project funding is occurring (e.g. Lepori et al 2007), although there is limited evidence of a widespread trend in this direction. Nevertheless, there is increasing debate regarding mechanisms for allocating resources to research as well as questions regarding their efficiency and effectiveness.

The use of competitive funding mechanisms reflects the use by Research Councils or Science Funding Agencies of allocation mechanisms that involve the participation of the research community itself. For the purpose of this report, we will talk about “competitive funding mechanisms” to describe the programmes or instruments of Funding Agencies, Research Councils, or Ministries that allocate resources for government-supported research based on formal contests or competitions, in which applicants apply for funding. The two main attributes of competitive funding mechanisms are the solicitation of proposals and the ranking or rating of the proposals.

Competitive mechanisms have a number of common features: a call for proposals, a panel assessment, peer review, scoring, award of funding for a limited time, and follow-up. Awards may be to individuals, projects, or centres and can be of variable size and length. Competitive allocation mechanisms are often favoured in the science community for being the optimal method for not only evaluating but also encouraging scientific excellence, in a process controlled by the community itself that therefore has the confidence of the research community.

A small but growing body of empirical research suggests that some stages of assessment and award processes are not efficient, or do not necessarily lead to more effective decisions, in addition to potentially contributing to a trend towards conservatism rather than breakthrough or high-risk research [Horrobin, 1990; Smith, 2006; Stephan et al., 2017]. The reliance of competitive systems on peer review brings up more general concerns about the robustness and validity of peer review processes in assuring the quality of science and the fairness in the selection (Chubin and Hackett, 1990; Wenners and Wold, 2001).

Competitive funding processes are also comparatively costly, both to awarding agencies and research performers (the latter in time spent preparing applications). There are also opportunity costs to the research community in providing peer reviews, even on a volunteer basis, as is often the case. Achieving the optimal balance of high-quality decision making and cost (given that resources expended on assessment or preparation of applications could be redirected to the conduct of research) is of critical importance in the design of research funding systems.

In response to these concerns, some funders have started to innovate and experiment with other allocation procedures such as lottery, individual expert judgment, or other alternative processes for awarding competitive funding. Recently, researchers have proposed utilising artificial intelligence technologies such as advanced data-analysis tools (such as Sheridan)\(^1\)
to replace or augment peer review. Others have proposed radically altering current peer review processes or experimenting with sandpits and other methods.\footnote{2}

1.2. Background

Many aspects of research funding have been investigated under the lead of the OECD Committee for Science and Technology Policy (CSTP) in recent years. The OECD Working Party on Science and Technology Indicators (NESTI) regularly collects national data from research performers about sources of funding and aggregates information from Government spending for R&D into its Main Science and Technology Indicators (MSTI), which are published in the regular OECD S&T Outlook and Scoreboard publications. These data collections are guided by the recommendations of the Frascati Manual (OECD 2015). Additionally, national research funding policies are also often investigated in Innovation Policy reviews being carried out under the CSTP and in recent CSTP work related to promoting research excellence (OECD, 2014). The new European Commission/OECD international survey on Science, Technology and Innovation Policies (STIP) which feeds into the OECD STI Outlook publication also collects a variety of information on funding practices. However, more in-depth qualitative and comparative analysis of research funding practices and efficiency had not been performed in recent years.

In 2016, the OECD Global Science Forum initiated an activity to analyse existing competitive research funding mechanisms and their effectiveness, considering whether contextual factors make different components of these mechanisms more or less appropriate. Contextual factors include specific policy goals, the characteristics of different national science systems, and the field or focus of the research funding.

1.3. Methodology

The activity was supervised by an Expert Group (see Appendix 1) whose members were nominated by national OECD GSF delegations and was co-chaired by Professor Adam Jaffe (Mottu University, New Zealand), Professor Tateo Arimoto (Japan Science and Technology Agency, Japan), and Mr. Kei Koizumi (Office of Science and Technology Policy and then American Association for the Advancement of Science, United States).

A preliminary review of existing literature on the operation of competitive research funding systems was first conducted by the GSF Secretariat, with input from the Expert Group. In addition, some generic national research funding information was collected by Expert Group members and extracted from existing OECD data sources and reviewed to provide contextual background.

After discussion within the Expert Group, a first questionnaire was sent to funders to solicit information on a broad range of funding schemes. A conscious decision was made at this stage not to limit the study to a particular type of scheme but rather to explore the variety of approaches that are being adopted across countries. Questions were articulated alongside seven elements:

- basic funding mechanism information (number of applications, success rate, programme size, etc.)
- purpose of the scheme (objectives, recipients, etc.)
- nature of the funding awards (grant duration and size, co-funding, etc.)
• request for proposal (RFP) process (proposal frequency, reviewing approach, evaluation criteria, etc.)
• proposal evaluation process (initial screening, reviewers’ tasks and designation, reviewing panel’s role and composition, etc.)
• studies or evaluation of the scheme
• monitoring and evaluation of the impact.

The responses, covering 75 funding schemes from 21 different countries, were compiled and analysed (see appendix 2 for framework questionnaire and funding schemes analysed).

To supplement this first questionnaire survey, a second survey was then conducted through interviews with over 30 representative funding-body project administrators and managers, expert panel members and grant recipients (interview framework and list of interviewees in appendix 3) to obtain further information on the following specific issues:

• What is the context/importance of the funding scheme in the national research system.
• How to match the priorities for the funding scheme with scientific excellence
• What is the target audience and success rate.
• Detailed peer review process.
• How was impact monitored and what element(s) were considered to establish whether the funding scheme was successful.
• Acceptability to the scientific community/Cost to the research community/efficiency.
• Perceived challenges in the system and proposed/implemented (innovative) solutions.

Further information was also sought regarding specific types of funding targeting young or senior researchers, breakthrough/innovative science and societal challenges (with interdisciplinary dimension).

The Expert Group held several meetings, and the preliminary results from the interviews were also discussed during an international workshop, which took place on 12 October 2016 in Paris at the OECD headquarters. There were 70 participants, including members of the Expert Group, invited experts, GSF and CSTP Delegates, and members of the OECD Secretariat. The Expert Group’s preliminary findings were also presented and discussed during an international conference on peer review for research funding held in Amsterdam (Netherlands) on 29-30 June 2017.
2. General research funding context

Despite its recognised importance, public research has been under budgetary pressure in recent years. Government spending for R & D in government budgets (Government budget appropriations or outlays for research and development, GBAORD) has in fact slightly decreased in real terms in many OECD countries between 2008 and 2016 (Figure 1).

**Figure 1. Government budget appropriations or outlays for research and development**

![Graph showing government budget appropriations or outlays for research and development](image)

*Source: Calculations based on OECD Research and Development Statistics - GBAORD Government budget appropriations or outlays for RD dataset. Data extracted from IPP.Stat on 1 June 2018.*

A large share of government R&D funding in most countries goes to research carried out in the public sector. The public research sector has seen public research expenditures largely flat in many OECD countries since a slow down after the economic crisis (Figure 2). This overall trend on average means a significant decline in research spending in a number of countries that has affected the resources available for public research, although countries such as the People’s Republic of China (hereafter “China”) or Korea have benefited from continuous growth of public research spending.

The rest of government R&D funding goes to businesses and other private firms either as direct funding or subsidies (tax concessions). Research funding to companies also declined over this period, from 9% of the total business enterprise R&D (BERD) expenditure in 2009 to 6% in 2014, from USD 58.6 billion (PPP) to USD 49.6 billion, although this reduction was significantly offset by an expansion in tax concessions (OECD, R&D Tax Incentive Indicators, [http://oe.cd/rdtax](http://oe.cd/rdtax) and Main Science and Technology Indicators,

Figure 2. R&D funded by higher education and government in selected economies

Index 2005=100


The growth of the R&D systems in most countries (production of PhDs and number of researchers) has put pressure on research funding which has led governments and research funding bodies to seek increased efficiency in the use of funds; one of the proposed solutions has been to strengthen competitive funding, in order to channel resources towards specific priorities and/or enhance excellence.

Competitive funding schemes are often cast in opposition to so-called institutional funding schemes. In this report, institutional, block, or non-competitive funding schemes refer to methods of allocating research funds that do not rely on selection in a competition among competing proposals for funding. One common institutional funding scheme is formula funding, in which research funding is distributed among institutions and then further among researchers according to a mathematical formula based on quantitative characteristics, such as number of researchers in an institution or historical patterns of funding. One variant of such formula funding is egalitarian formula funding in which all eligible institutions or researchers receive an equal amount of funding. Another variant is random funding in which funding is distributed randomly to certain researchers in an eligible pool. A more common non-competitive funding scheme is for programme managers or other funding-agency personnel to make funding allocations at the institution level or laboratory level, without resort to a competition pitting project ideas against one another. One variant is for political leaders to make allocation decisions through the political process.

Despite the movement toward competitive funding systems for research and despite a robust and longstanding OECD effort to aggregate national R&D funding indicators, there
is still a lack of robust comparable data on the ratio of competitive funding vs. institutional/block (non-competitive) funding for many OECD countries. The definitional issues are formidable and there is a lack of cross-country consensus on what are the key concepts for measurement as well as on their measurability.

Nevertheless, OECD has conducted some experimental data collection on modes of public R&D funding based on the GBAORD survey for the years 2008-13. The percentage of project funding (a proxy for competitive funding) as a share of domestic R&D was collated for a number of countries (Table 1), showing a large diversity of systems with no obvious trend over this time period.

Table 1. National public project funding of R&D as % of GBAORD allocated for domestic performers

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Source: OECD, 1st and 2nd experimental surveys on modes of R&D funding through GBAORD (2009, 2012/3).

Recently, EUROSTAT started to collect voluntary information on the share of project and institutional funding from European countries (Figure 3). Similar information was also collected in a more recent project on performance-based funding systems from the European Joint Research Centre (Jonkers and Zacharewicz, 2016). These data suggest that the relative importance of project funding is typically between 25 and 50% in the European countries analysed and has been relatively stable over recent years, with some noticeable exceptions. It was also noted that, although data collected during this latter study were usually similar or identical to EUROSTAT data, significant differences were nevertheless found for a number of countries, which underlines the methodological difficulty to assess precise levels of project (competitive) research funding at the national level. This was, for example, the case for France where discrepancy is about a factor of three, as EUROSTAT data (not shown) suggested that competitive funding represented less than 10% of research funding while more recent estimates suggest a French competitive research funding rate of at least 25%.
For this GSF project we have collected, mainly qualitative information on national funding systems, when available. The data collected in the first questionnaire included, among other information, country shares between “institutional and competitive funding” to establish some contextual information for the analysis. Those data confirmed that there is wide variation in competitive funding ratios among countries, leaving aside methodological issues of comparability across economies or each economy’s definition of competitive funding. Within the limited sample, the reported amount of competitive funding within total public research funding ranged from 20 to 80%. Second, the questionnaire also showed no clear evidence of a trend of increasing competitive funding within the 10 countries for which information was provided, despite the anecdotal evidence suggesting that competitive funding is gaining as a share of total research funding worldwide. Four nations, for example, reported a stable ratio of competitive funding vs. total funding over the past 10 years. Countries in Central/Eastern Europe have seen increases in competitive funding ratios related to overhauls of their research systems, but one Nordic European nation reported a declining ratio in recent years. Some countries also reported the introduction of competitive selection mechanisms in traditional institutional funding.

There are however no data at all for many countries, for example the United States. In fact, the United States has moved from attempting to collect data on competitive vs. institutional funding of research to halting that data collection in the early 2000s because of concerns about the definitions of these categories and whether they could be applied reliably throughout the U.S. government. Complicating matters was the recognition that competitive vs. institutional is not truly binary in the U.S. funding system: indeed, there were and continue to be degrees of competition on a continuum between pure competitive...
funding systems and pure formula-based funding systems with categories such as competitive review through systems other than peer review, programme-manager allocations, and performance-informed formula funding systems; in the end, the U.S. data collection effort collapsed under the weight of determining and then implementing this continuum of categories in an annual data collection. The U.S. experience is mirrored in the experiences of other nations, also suggesting that there is a continuum between project or ‘competitive’ and institutional or ‘non-competitive’ allocations of research funds across the OECD, for example in the United Kingdom where institution-based block research funding increasingly contains competitive elements (Dialogic and Empirica, 2014).

In other nations, we find that many research ministries or funding agencies use formula-based allocations, and although many nations use formulas derived from non-research indicators such as population, many use funding formulas that are at least partially based on quantitative research indicators such as research outputs, and some also mix peer review with quantitative research output data (Jonkers K. and Zacharewicz T., 2015). Other nations have introduced elements of competition into institutional funding by establishing (research) performance-based approaches to allocating institutional research funding (OECD, 2011) which have the effect of being a tool for promoting competition in research and increasing the impact of national research expenditures just as competitive project funding does.

In summary, in institutional vs. competitive funding data we are a long way from standardised classifications and ongoing internationally comparable data governed by the Frascati Manual that are now the norm for other aspects of national R&D funding systems, and comparing funding ratios between countries should be avoided. But within nations that have implemented data collection on competitive vs. non-competitive funding mechanisms, competitive funding is a key feature of R&D funding and there is also a general trend toward introducing competitive elements even in block funding or other traditionally non-competitive funding mechanisms despite concerns, described in the remainder of the report, over some aspects of competitive funding including cost.
3. Findings

3.1. Taxonomy and general objectives of competitive funding mechanisms

The sample of 75 funding schemes analysed in this study is not statistically representative of all competitive funding mechanisms and so the quantitative analysis should be considered accordingly. However, cross-checking with recent data from the OECD Science, Technology and Innovation Policy database and feedback from experts gives some confidence that the sample is broadly representative of the variety of competitive funding schemes that are in operation.

Not surprisingly, since the primary stated value of competitive funding mechanisms is to select for scientific excellence, the questionnaire found that ensuring scientific excellence was the overwhelming goal for competitive research programmes.

But there was wide variation in the stated purpose of competitive research programmes (Figure 4). Although supporting interdisciplinary research, supporting “blue-sky” and investigator-initiated research, and promoting frontier knowledge were the top 3 purposes of the programmes as stated by managers of the programmes, all of which lend themselves to some mechanism for identifying scientific excellence, there are other purposes for competitive research programmes where the value of competition may be less obvious. These include: promoting international collaboration; responding to societal challenges (of many kinds); economic competitiveness; and capacity building (infrastructure, human resources). The wide range of responses demonstrates that competitive funding has been adapted to respond to multiple purposes beyond evaluating scientific excellence.

Some funding schemes explicitly try to meet multiple purposes simultaneously. The U.S. National Science Foundation (NSF), for example, evaluates its proposals based on two equal criteria, Intellectual Merit (roughly equivalent to scientific excellence) and Broader Impacts, though there are lingering questions as to whether the criteria are weighed equally in practice. New Zealand’s Endeavour programme also weighs Excellence and Impact as equally important aims.

Figure 4. Purposes of research funding schemes analysed in the questionnaire survey (more than one answer possible)
It is not simple to classify competitive funding schemes in a taxonomy, and no such authoritative taxonomy exists, but a basic classification can be derived from the sample in the current project (Figure 5).

**Figure 5. General taxonomy of research funding schemes analysed, with some typical examples**

A significant proportion of competitive funding is awarded to individual principle investigators. Increasingly, many of these ‘individual’ awards actually support teams of researchers including technicians, students, postdocs, and investigators. There are sub-categories of individual awards, including early-career awards, training awards, special mechanisms for senior/elite researchers, and an emerging category of ‘people’ awards that fund not individual research projects but individuals themselves who are free to use a single award to investigate a research topic or multiple research topics of their choosing.

Overlapping those categories are individual awards specifically targeted to societal challenges (including economic competitiveness) or predetermined research questions as opposed to investigator-initiated topics. Within the samples analysed, the majority of research awards are delivered for between 3 to 5 years (Figure 6), with reports of increasing grant durations in more recent funding schemes, but there is a wide variation from 1 year to ‘long term’ (until a research output is produced), longer durations (7 years +) often linked to funding directed to consortia or centres with lower application numbers. There are however some research projects that do not fit on this taxonomical model, for example research awards with the aim of building research capacity or specifically for fostering international science cooperation, that are neither investigator-initiated topics nor targeted to societal challenges.
Other related mechanisms explicitly support teams of researchers working on a collaborative project, often in a centre (or Centre of Excellence, or other such organisation within a single institution). Not surprisingly, Centre awards tend to be for longer time periods than for individual projects. There are also funding mechanisms to support cross-institutional teams, especially industry-academia collaborations/consortia. And there are funding mechanisms geared to small firms, firms, or other specific organisation types within the general research community.

There are also competitive funding research mechanisms that are not project based. In addition to the ‘people’ awards described above, there are mechanisms that support research infrastructure, specifically support international cooperation and/or researcher mobility, and support institutions rather than projects.

Another aspect of the taxonomy of funding mechanisms is whether an award requires co-funding. In the questionnaire, roughly half of the programmes do not require explicit co-funding, while half do. The co-funding percentage was found to vary greatly, from 5% to as high as 60%. This can comprise cash and/or in-kind contributions but excludes waived overhead costs, unrecovered overhead costs, and other forms of implicit co-funding.

Complementary information coming from the OECD STIP database indicates that about two thirds of recent research funding initiatives in OECD countries required some sort of collaboration (most often with other academic partners) (Figure 7).
Finally, an important element to take into account which could not be properly assessed in this study is the importance of overheads and their definition (what they actually include) which can vary greatly between systems.

### 3.2. Funding process

The competitive funding process shows similarities across the many programmes and nations surveyed. The goal of selecting among proposals for scientific excellence leads programmes to rely heavily on peer review by external (not employed by the funding agency) researchers working in the same fields as the applicants. In this report, peer review refers to a process by which experts assess the quality and/or the relevance of a proposal, usually according to predefined criteria (van den Besselaar, 2010).

There are many reasons why peer review is the standard and preferred (by the scientific community, and increasingly by policymakers) mechanism for allocating research funding competitively. Perhaps most importantly, as suggested by the use of the term ‘peer’, peer review gives the scientific community itself the leading role in selecting proposals for scientific research rather than having allocations made by a process not under the control of the community. Support for peer review is not only about control, however; the longstanding argument that scientists’ proposals are best evaluated for scientific merit/excellence/quality by their scientific peers is a powerful, widely accepted one although, surprisingly for such a core tenet of the scientific community, there is little empirical data to support the argument. In fact, the notion that external peer review is the best way to select for scientific excellence is unproven, either on efficiency or effectiveness grounds. The argument, however, dates back to foundational documents such as the British Haldane principle in the early 20th century, stating that decisions about what to spend research funds on should be made by researchers rather than politicians, or for the United Kingdom *Science, the Endless Frontier*, which in the immediate aftermath of World War II sought successfully to have scientists in control of the allocation of a substantial portion of United States government research funds (Bush, 1945). The argument was won
rhetorically and politically, not empirically, and became a core principle for the United States government research funding system before empirical data on its efficiency and effectiveness could be collected. Since then, there has been a burgeoning literature on peer review but no definitive studies showing that it is indeed the best method for selecting among proposals for scientific excellence or other criteria. However, there are promising approaches appearing in the literature for how to test the effectiveness of peer review using network analyses, statistical oversight, and other techniques taking advantage of burgeoning data created as part of the scientific process (Gush et al., 2017 and Li, 2017).

The widespread acceptance of peer review within the scientific community, then, is substantially a matter of faith and confidence. There is a strong belief in the scientific community that it works well for the selection of scientific excellence and there is trust in the process, trust that is notably lacking for alternatives such as lotteries (NWO International peer-review conference, 2017). And despite the irony of a scientific community acting on values such as faith and trust, it remains true that social acceptance of peer review by the community is important for the continued legitimacy and operation of peer review systems, not least because of the volunteer efforts that are necessary for its operation. It is surprising indeed that the scientific community continues to trust the peer-review system even though there is growing evidence (Li and Agha, 2015) that the process can sometimes be biased, subjective, conservative, and unable to make fine distinctions between proposals. The confidence of the scientific community in peer review is so strong that some interviewees reported that their nations have expanded competitive funding and the use of peer review in the hope that the legitimacy of the peer review process would give their funding agencies greater trust and legitimacy.

Although this report describes an emerging set of good practices for peer review, even after several decades there is an absence of agreed, defined standards on the core principles (European Commission, 2015).

Competition and competitiveness have become ubiquitous in the global science community not only at the project level or in allocation systems but in the discourse about nations’ scientific enterprises and individual scientists’ work. The European Commission, for example, has stated that funding through open calls for proposals that are evaluated by peer review incentivizes researchers and their research institutions to be internationally competitive (European Commission, 2012). The Japanese government has made international competitiveness in research a key objective for some of its research funding schemes (see Box 1). There is clear evidence in the academic literature that excellence in science is linked to competition between researchers (Franzoni et al., 2011) and that scientists who are evaluated through competitive international benchmarks produce higher research quality. Some macro-analyses show a link between more-competitive funding environments for universities and the productivity of a national research system (Auranen and Nieminen, 2010), but these analyses have been methodologically questioned (Sandstrom and Van den Besselaar 2018). Additionally, there are also other studies that show no relationship between competitive funding schemes and a nation’s scientific performance (Dialogic and Empirica, 2014), and studies showing that the introduction of performance-based funding schemes has little effect on nations’ scientific excellence (Jonkers and Zacharewicz, 2015). The broad conclusion is that, while increased competition in research funding allocations is associated with higher performance, the underlying situation is complex and is subject to other incentives and to contextual factors (Georghiou, 2013), leaving unanswered the question of what the most effective ways to improve research performance are.
Box 1. Japan’s World Premier International Research Centre Initiative (WPI)

In the last few decades, the Japanese government has established a variety of funding mechanisms to strengthen the nation’s research innovation capacity. There are programmes aiming for industry-academia collaborative research, interdisciplinary research, and university reform. One of them, the “World Premier International Research Centre Initiative (WPI)” was launched in FY2007 by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), motivated by intensifying global competition for the best and the brightest researchers.

The objective of the WPI programme is to establish globally open and appealing research centres to attract talent from all over the world. The centres advance leading-edge research, create and expand new interdisciplinary domains, and help to reform research institutions (universities or national institutes). This programme differs in nature from traditional competitive funding programmes intended mainly for research support. The programme offers JPY 5-13 billion per year per centre for 10 years, in principle. At the same time, it requires each centre to secure resources (competitive funds, donations, in-kind contributions from affiliated institutions, etc.) equivalent to, or more than, the amount of WPI support. A centre’s host institution must clearly define the centre’s role within the institution’s mid-to-long-term strategy, and provide the centre with comprehensive support accordingly.

The selection process for the WPI programme consists of three stages of external peer review: first screening is a mail review of a proposal outline; the second screening is a mail review by a panel of full proposals; and the third screening is a panel review of in-person hearings (in English). In this process, only applicants who pass the first screening submit full proposals, and only a subset of applicants in the second screening are invited to a hearing. Thus, the time and energy of both reviewers and applicants are saved.

For awarded centres, an elaborate follow-up system exists. The programme committee, the programme director (PD), and the programme officers (POs) conduct site visits to assess progress on all aspects of the project’s implementation and advise on necessary corrective measures. Such site visits, held for two days every year, are deemed important for the success of each centre as well as the WPI Programme.

Ten years after the programme’s start, the WPI programme has produced high-quality research results in several fields. Production of global top 1% papers by the initial five WPI centres has been calibrated to be higher than the world’s top universities. The WPI programme is also highly rated by industry and other stakeholders. On the other hand, difficulties have also arisen. Complex challenges include continuously training and retaining researchers and making the best use of infrastructure after the end of the official support period. Reflecting on these strengths and challenges, not only the WPI programme but also other Japanese centre of excellence programmes are expected to evolve in the future.

One intended or unintended by-product of the push to competition is broad movement, as perceived by agency programme managers, toward a ‘project mentality’ or a “projectification” (Serrano-Velarde 2018; Torka 2018). This is characterised by thinking about research in terms of discrete, fundable projects, accompanied by the development of skills in articulating the aims of research and packaging the results of research in measurable units such as publications. Whether a project mentality is a good or bad thing...
is not clear, but certainly a competitive funding system requires science to be divided into projects that can be articulated in proposals and evaluated competitively.

There are many advantages of competitive project funding compared to other allocation methods. From the analysis for this project and from the literature, the advantages of competition are: a tendency to increase the quality and relevance (to research agency objectives) of research project proposals; a way to ensure that research proposals are viable or meet a minimum standard of quality; providing researchers an opportunity to test their ideas among peers; building trust in the research community that allocations are transparent and accountable; support from the research community as an equitable way of distributing funds (fairness); and a viable alternative to relying solely on internal funds (Kubler, 2013; Schmidt et al., 2006). Competitive funding can also promote institutional diversity, in that new researchers and institutions can emerge more easily through competition than through block funding freezing in place existing institutional capacities, although this effect may not hold true across nations: Japan and the United States, for example, have found that researchers from small institutions encounter difficulty in receiving funding, perhaps because of reviewer bias against smaller institutions. The United Kingdom has set up a dual competitive support system, under which the Research Councils provide grants for specific projects and programmes, while the UK Higher Education Funding Council provides block grant funding to support the research infrastructure and enable institutions to undertake research of their choosing. This later funding is also competitive and determined by a periodic assessment exercise whereby expert panels review academic outputs and impact beyond academia. Finally, despite researcher complaints about the burden of writing and submitting proposals, there is widespread agreement in the research community that the process is worthwhile. This applies both to proposal preparation (organizing research ideas clearly, the discipline of clarifying and explaining research ideas) and review (receiving peer feedback on ideas that can help to improve the research project) (International Peer-Review Conference, 2017).

There are also disadvantages of competitive project funding compared to other allocation methods that emerge from this project’s work and from the literature. The most-commonly stated disadvantage is that increasing reliance on competitive funding can result in an emphasis on short-term, low-risk projects rather than longer-term, higher-risk fundamental research (OECD, 2011). The premise is that block or institutional funding allows researchers to work with a funding guarantee over the long term to perform high-risk, long-term research without fear of losing funding. Conversely, competitive funding tends to favour shorter-term, less-risky research proposals. The evidence in the literature is mixed; it is not clear that stable institutional funding does indeed result in more longer-term or high-risk research than competitive funding, nor is it clear that peer reviewers necessarily favour low-risk research in their evaluations, especially when potentially transformative or high-risk or breakthrough research is explicitly emphasized in review criteria. Recent modelling of the cost of competitive funding mechanisms (e.g. Gross and Bergstrom, 2018), in comparison with other options, also found that the effort researchers expend in writing proposals may be comparable to the total scientific value of the additional funding, especially when only a small percentage of proposals are funded: the resource and time burdens of applying for competitive grants, i.e. the high transaction costs therefore constitute an issue. Other disadvantages include: the risk of researcher careers being interrupted or ended if competitive applications are unsuccessful; the inability of researchers and institutions alike to do long-term planning at both the individual (career) and institutional level because of uncertain future funding; disincentives for collaboration in a competitive system; increased bureaucracy and administration; and the increasing
likelihood that winning competitive funding becomes a goal in itself rather than scientific breakthroughs or other scientific outcomes (Young, 2015). In addition, one potential problem of peer review is the existence of different forms of bias (for a review see: Lee et al., 2013).

At the institutional level, research institutions balance institutional and competitive funding. Institutions, such as universities, face challenges in maintaining long-term stable investments in research personnel, instrumentation, and infrastructure solely through discrete, limited-term awards and therefore have to generate some level of institutional or core funding. At the opposite extreme, few institutions are interested solely in institutional funding because of the advantages that are associated with competition. In practice, most universities and public research organisations in OECD countries attempt to strike a balance between the stability and efficiency of core or institutional funding and the excellence and higher impact expected from competitive funding. Yet there is no agreement on an optimum balance either at the institutional or national level.

There are alternatives to traditional peer review that are still competitive. In addition to the allocation of institutional funding based on STI indicators, project funding can also be competitively awarded without an external peer review process. Some funding agencies, such as the U.S. Defense Advanced Research Projects Agency or DARPA, rely on a strong scientific programme manager to decide which applications to fund in a research portfolio, a mode that can be summarised as one-person internal review by a scientific peer. Some funding agencies rely on internal review by programme managers who may or may not be scientific peers of the applicants but who select from applications using scientific and other criteria. Some programmes have experimented with altering the composition of ‘peer’ review panels by inviting non-scientists to participate: the U.S. Department of Defence, for example, awards some of its medical research grants by panels that mix scientists with non-scientists such as patients or patient group representatives; other programmes with an industry mission include industry representatives on panels, while yet other government programmes include representatives from other government agencies who are ‘customers’ for the research in their panels. There are also numerous experiments underway to select applications for funding through competitive means but without using external peers; some of these experiments are described in this report.

One possible experiment is a lottery. Some research suggests the value of modified lotteries (e.g., Fang and Casadevall 2016). Lotteries, because of their low transaction costs, are appealing to funding agencies although there are considerable concerns over whether this mechanism can select for excellence or whether implementing lotteries is politically acceptable (Barnett 2016). There may be opportunities to experiment with a lottery for select programmes, especially for allocating funding to the ‘middle group’ of applicants, those that are neither clearly excellent nor clearly poor on the premise that peer review already has difficulties in distinguishing between proposals falling in this middle category. In other contexts, choosing winners by lottery is perceived as appropriate to break ties; many participants recognise that the difficulty of distinguishing proposals is often so great that they are, effectively tied. For example, a lottery system after having passed some form of performance control has been utilised by the Volkswagen Stiftung. (https://www.volkswagenstiftung.de/en/funding/our-funding-portfolio-at-a-glance/experiment) in the funding initiative “Experiment.”

There are other potential experiments, but few are being tried at scale. One alternative selection mechanism is the ‘sandpit’: already used to some degree in the United Kingdom, sandpits are interactive workshops over multiple days involving a large number of
participants: the programme director, a team of expert mentors, and a number of independent multidisciplinary stakeholders. There is a mix of potential research performers and of participants not eligible to receive funding; at the end of the process, one result is agreement on research projects that are eligible for funding, a result that comes about after ideas are developed, winnowed down, and validated. The main driver for sandpits is to push boundaries and promote transformative research but they incur high overheads to reach a funding decision and so their applicability is probably limited. The actual peer review component is quite conventional – the novelty is in how it is implemented. Other ideas that have emerged, but have not been tested on a broad scale, include oral pitches, various voting schemes, and ‘self-funding science’ (distribution of funding via credits by researchers within a community). Other types of allocation mechanisms have been suggested, for example, by Bollen et al. 2014, 2017.

One facet of the application and review process that this project tried to explore is the duration of the process. We found a wide variation in the time between a call for proposals and the research award, with a clustering between six to 12 months. Competitions for large awards such as centres can take longer, while awards involving industrial firms tend to be reviewed faster. Programme managers were satisfied to mildly dissatisfied in the time to award, with several taking steps in recent years to reduce it. Such steps include: informing rejected applicants as early as possible in the process, especially for multi-stage review; instituting small efficiencies wherever possible in review; and using on-line tools to speed the reviewer selection process. But in general, both agencies and applicants appear to accept the need for a careful peer-review process even if it takes time. Some programmes set goals for time between application and award; in one Danish example, this goal was 100 days.

The following sections describe analysis with respect to the two key features of the competitive funding process: the call for proposals, and the reviewing process.

3.2.1. Call for proposals and eligibility criteria

The dominant frequency of calls for proposals in the sample for this study was once a year, although there was a wide range from every month to every three to five years (Figure 8). Recently, there have been experiments (such as in the U.S. National Science Foundation) in having no deadlines, or a rolling call in which applicants can submit a proposal at any time. One surprising result of the NSF pilots is a drop of nearly half in the number of applications (see Hand, 2016). The United Kingdom and Australia have already moved beyond experimentation and have established no-deadline rolling applications for some programmes (see Box 2). For the overwhelming majority of calls for proposals with deadlines, the questionnaire found the open time period for calls to cluster between one and three months, although there are outliers of less than one month to as long as nine months. The Group found some examples of programmes shortening call periods to deliberately reduce the number of proposals and thereby improve success rates.
Box 2. Australian Research Council continuous submission of applications

The Australian Research Council (ARC) administers a number of competitive research funding schemes supporting research ranging from basic to applied research. One of the schemes that has been in place since 2001 is the Linkage Projects scheme. The ARC has awarded over AUD 1.6 billion to date through the Linkage Projects scheme to stimulate research-industry linkages.

The Linkage Projects scheme aims to create research-industry connections that can endure beyond the duration of ARC funding. Like any other working collaboration, these linkages build lasting associations and professional relationships, which expand the scope of national research activity.

A significant change to the operation of Linkage Projects occurred in July 2016 with a shift from an annual cycle to a continuous submission cycle for applications. The continuous application process was implemented as an outcome of the Australian Government’s National Innovation and Science Agenda, in order to allow more-rapid assessment between proposal submission and outcome announcement. Proposals can be submitted at any time. Following detailed peer review, proposals are considered by an external selection advisory committee as they are submitted, rather than having to wait for a scheduled annual selection meeting. This change allows for more nimble and responsive funding in response to industry timeframes.

From 1 July 2016 to 5 February 2018, 139 new collaborative research projects were awarded under the ARC’s Linkage Projects scheme. These projects represented AUD 55.7 million in ARC funding to support new collaborative research with over 270 partner organisations.

During the establishment of the continuous process, the ARC put in place mechanisms to ensure that only excellent research was funded, and the efficient use of the selection advisory committee’s time.

An evaluation of the implementation of the changes to the Linkage Projects scheme is planned for 2019.
There are different types of calls (Jacob, 2010). Some examples are: a one-step open call with broad eligibility for investigator-initiated research projects; a one-step call for thematic areas (more-limited topics); a two-step open call in which pre-proposals or brief proposals are followed by a second step of full proposals for successful applicants of the first step; a two-step thematic call; restricted eligibility calls, where applicants must meet specific criteria to apply (an international partner, a business performer or partner, a certain career stage); and calls where applicants must demonstrate co-financing of a certain percentage of funding coming from another source (either self or an external source). There are interesting French and Dutch examples, among others, of segmenting proposals by career stage into separate competitions; the Netherlands Veni (0-3 years after PhD), Vidi (3-8 years), and Vici (8-15) competitions ensure that only applicants at similar career stages are in competition for funding, eliminating one of the potential pitfalls of peer review: the chance that early-career researchers without extensive track records will not be reviewed as favourably as established researchers (see Box 3).

**Box 3. Veni Vidi Vici in the Netherlands**

In 2000, the NWO (Netherlands Organisation for Scientific Research) joined forces with the Royal Netherlands Academy of Arts and Sciences (KNAW) and Dutch universities to establish the Innovational Research Incentives Scheme. The programme includes three types of grants: Veni, Vidi, and Vici.

The aim of the Scheme is to promote innovation in academic research and to provide encouragement for individual postdoctoral researchers at various stages of their careers. Providing creative opportunities for adventurous, talented, pioneering researchers to do research of their own choice and to encourage them to make a permanent career of academic research are therefore key aims of the Scheme. Researchers at foreign institutions are eligible for the Scheme provided they carry out their research at a Dutch institution recognised by NOW in the Netherlands.

The Scheme targets postdoctoral researchers in three distinct stages of their careers with three separate schemes:

**Veni**

Veni applicants must have obtained their doctorate within the last three years. The focus in this respect is on innovative and curiosity-driven research. The candidates are at the start of their academic careers but have already demonstrated a striking talent for doing scientific research. It is essential that researchers should have the ability to formulate and conduct a line of scientific research independently.

**Vidi**

Researchers who want to submit a Vidi application can do this from three years and up to a maximum of eight years after having been awarded their PhD. The Vidi target group consists of excellent researchers with a striking and original talent as well as a considerable fascination for doing challenging and pioneering research. The candidates should have carried out several years of postdoctoral research after their PhD and have demonstrated the ability to independently generate innovative ideas.

**Vici**

Vici applicants must have obtained their doctorate within the last fifteen years.
The Vici scheme is aimed at the excellent senior researcher who has successfully demonstrated the ability to develop his/her own innovative line of research and the ability to act as a coach for young researchers.

**Selection procedure**

Applicants can apply in the four science domains of NWO: sciences, social sciences and humanities, applied and engineering sciences, and health research. There is another track for cross-domain applications. The available budget is divided over the three schemes and the 5 domains.

Applications are reviewed by external peers, mostly from abroad. The applicant has the opportunity to rebut peer comments. An independent assessment committee meets and discusses the application, peer review comments, and rebuttal. The assessment committee selects the best-ranked proposals for an interview.

Since the start of the Scheme, NWO has made awards to about 3000 talented researchers. The Innovational Research Incentives Scheme grant has given these researchers an opportunity to develop their career in a way that would otherwise have been impossible for many of them.

Calls for proposals are adapted to the strategic objectives of the funding instrument and may be directed to selected categories of applicants (for instance consortia-only). Selection based on the applicants’ age or career stage (time from PhD) often forms a subset of larger calls rather than the object of specific calls (but this latter formula also exists).

Grant size varies greatly between funding schemes but, in the sample analysed, traditional mechanisms funding projects led by a principal investigator (PI) were found to usually provide grants of about EUR 3-500k size (total) while funding for institutional projects are more in the range of EUR 1-3M+.

In the study sample, the calls for proposals were overwhelmingly oriented to the funding country, not surprisingly. For national funding schemes, applicants must either be domestic nationals or residents or foreign nationals who commit to performing the research in the funding country. There are a small number of proposals that are open only to domestic nationals. Of course, there are also funding schemes in the European Union that are explicitly open to nationals of any member or associated nation.

### 3.2.2. Reviewing process

The Expert Group found predictable variation in the nationality of peer reviewers. Larger nations such as the United States and Japan rely almost exclusively on domestic researchers as reviewers, while smaller nations rely heavily on foreign reviewers. Small nations’ reliance on foreign reviewers, despite the extra cost, is often necessary to assemble a pool of researchers qualified to offer a scientific opinion on a proposal topic with small disciplinary research communities. Interviewees from Denmark, in particular, expressed strongly that foreign reviewers are indispensable for a small nation such as Denmark to review proposals for excellence because only by looking to foreign communities can enough ‘peers’ be found. In addition, in small nations with overlapping relationships and collaborations there is a challenge in finding qualified peer reviewers who do not have conflicts of interest with the applicants. However, relying on non-national reviewers may be hampered by language barriers when English is not commonly used within the scientific community and by the administration of the funding body.
Although most funding schemes have review processes that are well described in programme materials, usually available on public websites, the actual workings of review processes are often opaque. Some funding schemes use scoring, but we could find no instances of scoring rubrics based on quantitative data; rather, scoring tends to be numerical scores associated with qualitative assessments such as “fair” or “excellent”. And although the criteria used to evaluate applications tend to be described, they are almost entirely qualitative, with few criteria that can be evaluated independently. Selection criteria also vary according to the strategic objectives of the funding scheme: while scientific excellence (often interpreted as both the scientific quality of the proposal itself and the quality of the scientists as judged by their track record) remains a primary criteria, other elements may also be taken into account (see Figure 9). These are often more challenging for scientific peers to assess. In other words, peer reviews are seldom replicable: because of the large role played by individual qualitative expert judgment, the chance that two reviewers would offer identical evaluations beyond a summary assessment of “recommend for funding” or “excellent” for the same application is essentially random. Only in competitions for large laboratory awards or centres did this study find a strong role for indicators in review processes. In fact, a few interviewees stated that in the peer review process, they used indicators ‘as little as possible’ in favour of qualitative assessment.

**Figure 9. Selection criteria for project grants for public research**

![Figure 9](image_url)


From the sample of questionnaires and interviews, it is difficult to draw definitive conclusions, but most programmes appear to employ a multi-stage proposal evaluation process, although there are many programmes that only have one stage (most often panel/committee). These stages can include: initial screening, external review of proposal documents, review by a committee or panel, and (more rarely) interviews of applicants by an external review panel. The research literature indicates that one-stage review tends to be used by smaller research programmes, while larger programmes tend to use two-stage processes (Kubler, 2013). Faced with large numbers of applicants, there however seems to be a growing trend for pre-selection procedures (beyond just an administrative process to ensure the conformity of the applications to the call). This is sometimes (but not always) linked to a two-step procedure whereby an initial shorter application (or sometimes a letter...
or a CV) is requested and assessed internally before more-detailed proposals are invited for submission to undergo the full peer-reviewed evaluation process. In some countries, programme managers play a proactive role in soliciting or discouraging proposals. This can be an important part of application management but is rarely a fully open and accepted process. While these mechanisms are justified as a way to streamline procedures and reduce the workload of (unsuccesful) applicants, this pre-selection procedure is usually carried out internally within the funding organisation with little transparency on the evaluation criteria.

In a recent United States National Science Foundation (NSF) example, the NSF’s 2016 merit-review report found consistency across years in NSF’s merit-review processes (National Science Foundation, 2017). NSF has long relied on a mix of reviewing approaches: in 2016, of the 95% of NSF proposals that were reviewed externally, 67% of proposals were reviewed by a panel (committee of experts) only, 27% were reviewed ad hoc (document review by experts) plus a panel, and 5% ad hoc (document) review only. (NSF does not use interviews in its peer reviews.) In addition, 5% of all NSF proposals were reviewed internally, that is by NSF staff and not by external peer reviewers.

This study found no common standard for how many reviewers must review a proposal, although the most common minimum number is three in a clustered range from 2 to 5. Conversely, individual reviewers receive very different numbers of proposals to review, from 3 to more than 20. Although there was a wide variation, agencies strived to keep a certain percentage of reviewers from year to year to help preserve continuity and coherence, while at the same time recruiting new reviewers in order to refresh panel expertise. Many programmes such as those run by United States NIH and some German and United Kingdom programmes have standing committees or study sections of a stable group of peer reviewers who review multiple successive competitions in a research programme, providing some continuity of reviews over time.

Several methods are used to recruit reviewers: open calls, reviewers of previous competitions (with some specified turnover), nominations from agency staff or from the external community, peer review colleges, recommendations from a panel chair who is selected by the funding agency programme manager, suggestions from the applicants, and searches of databases such as Scopus or Google Scholar or Elsevier tools, etc. There appears to be very little research on good practices for recruiting reviewers, nor any strategic insights into how funding agencies might recruit reviewers to help solve, for example, agencies’ reported difficulty in finding certain types of reviewers such as reviewers from industrial firms or reviewers (and panels) able to review interdisciplinary projects. In the study sample, there were few experiments for reducing recruitment burden or encouraging more researchers to serve as reviewers. One intriguing experiment from the United States National Science Foundation required applicants to an NSF programme to review up to seven other applications for the same programme, a twist on a common tactic of having applicants commit to reviewing future applications as in the case of the Australian Research Council. In that experiment, not only were reviewers recruited with less effort than the standard NSF search for reviewers, but each proposal received more reviews than the standard (Science, 2014).

No obvious differences were found in recruiting document reviewers and panel reviewers. Indeed, in many cases reviewers participate in both tasks and sometimes in a third interview stage. Although review panels usually synthesize their reviews into numerical rankings, the results of their reviews are most often qualitative recommendations (fund/not fund or excellent/fair).
Only a minority of the funding schemes that were analysed had an appeals system for appealing the outcome of a peer-review process, and even when one existed, it was often an administrative procedure rather than a new review of the proposal. We found this to be a source of broad dissatisfaction among researchers, who argued that a trustworthy system should allow applicants to respond to or rebut peer reviews, either verbally or in a written rebuttal (International peer-review conference, 2017). Clearly, however, establishing an appeals system beyond the finality of peer review as currently constructed would require new administrative structures and possibly additional rounds of peer review or additional panels, all adding to time to award and cost. The Group found a few schemes that allow for a second review of the proposal either by the same reviewing panel or by a different group.

There appear to be few systemised efforts to gather feedback from applicants, successful or unsuccessful, or reviewers. The limited feedback that agency programme managers receive appears to be informal through conversations and communications outside the review process, although some funding bodies, such as the Research Councils UK, gather feedback periodically through user satisfaction surveys (see Box 4). Although there are opportunities for successful applicants to provide feedback on the review process as part of annual reports or final reports, the Group did not find any research programmes that took advantage of this opportunity; instead, these reports focused on the research project itself and its outputs and impacts rather than the process by which they were selected for funding.

**Box 4. Peer Review at Work in the UK Research Councils**

The peer review process is the cornerstone of the work of the UK Research Councils (RCUK) in allocating public funds. The Haldane principle proposes that decisions on how to spend research funds are best taken independently of Government by those who have the expertise and experience, for example through peer review. In the United Kingdom, upholding this principle is considered to be a vital part of ensuring academic independence and excellence.

There are a number of variations in the peer review process, reflective of the variety of funding mechanisms and types of research, but the process typically involves two stages. Proposals are considered by external referees (usually by correspondence) and then by a separate expert Panel or Board (usually at a meeting). This Panel will have a role in assessing or moderating the proposals and agreeing a rank ordered list for funding. In between these two stages the Principal Investigator is provided with the anonymous peer review comments and given the opportunity to provide a written response to these, which is presented to the Panel alongside the reviewer comments. To increase transparency, feedback is provided to research organisations about the assessment of proposals that the organisations have submitted.

RCUK draws peer reviewers from a wide pool nationally and internationally for academic and research user reviews. Some of the Research Councils have peer review colleges of between 1 000-4 000 members, broadly reflecting their research communities in relative size and in terms of their spread of knowledge and expertise. Members are appointed for a fixed period, may be invited or nominated onto the college (including self-nomination) and are assessed on their experience relative to the requirements of the college. Peer Review college membership is also reviewed periodically to address any imbalances and to ensure coverage for new and emerging areas. Councils that do not use colleges, use their own knowledge together with reviewer matching software to select relevant experts from their communities. In certain funding calls, the investigator may also suggest referees who are experts in the research field or...
who they believe may be able to provide an expert view on the value and benefits to research users of the research proposal.

There is a “Pathways to Impact” section within the application for investigators to think about what can be done to help ensure that their research makes a difference to wider society and the United Kingdom’s economy. Through Pathways to Impact RCUK encourages investigators to explore, from the outset and throughout the life of their project and beyond, who could potentially benefit from their research and what they can do to help make this happen.

RCUK provide the United Kingdom peer review community guidance on completing reviews and field regular user satisfaction surveys. RCUK has also introduced a programme for peer reviewers and decision makers to raise awareness and reduce the impact of unconscious bias as part of a commitment to addressing equality and diversity.

Feedback from the academic community is that the work involved in preparing proposals (e.g. background research, discussions and experiments) and the feedback from peer review help investigators to both generate and improve their ideas.

In its investigations of competitive funding schemes, the Expert Group searched for innovative processes and found that although nations are experimenting with reform of competitive funding systems, truly innovative schemes are few and far between. Some examples follow. In the United States, the National Science Foundation has been experimenting with no-deadline or always-open calls for proposals, and reductions in required elements for proposals (to reduce burden for applicants); the United Kingdom and Australia have adopted these approaches for some programmes. The Australian Research Council has introduced a Career Interruption Policy that extends the period of eligibility for early- and mid-career fellows with an interrupted academic career. One Danish programme has also experimented with reducing required elements in proposals. The Natural Science Foundation of China has established a pilot micro-grant programme to support preliminary research on new ideas and to support exploratory research on emerging fields that may not rate highly in standard peer-review approaches. Some programmes are experimenting with interviews of applicants incorporating a “pitch” by the applicant. Evaluation of a pilot for United Kingdom social sciences research, under the auspices of the Economic and Social Research Council, found that the ‘pitch’ second stage was successful in identifying transformative approaches without sacrificing quality. The National Institutes of Health has instituted “bridge” awards in which applications that have narrowly missed the cut-off for funding in the peer-review process are re-evaluated by agency staff for one-year “bridge” awards to allow researchers to continue their research and re-apply for a standard research award the following year; the number of NIH programmes adopting ‘bridge’ awards has increased steadily in recent years (see Box 5). The latter scheme is intriguing because it is a change from the usual binary funding/no-funding result of peer review. The option of giving a smaller, shorter award to keep a researcher funded until the next competition round helps to ameliorate the all-or-nothing nature of funding competitions that can be disruptive for researchers as they plan their research and their careers.

These experiments suggest that OECD countries have numerous options for how to adjust their competitive funding systems. However, the evaluation of the efficiency and effectiveness of these various options appears to be missing in many cases.
Box 5. U.S. National Institutes of Health “Bridge” Awards

One alternative to the binary “yes/no” or “go/no-go” decisions for competitive funding mechanism is the so-called ‘bridge’ award, a smaller, more-limited award given to applicants for a competitive funding scheme who fall just short of a successful peer-review score.

In the United States, several component institutes of the National Institutes of Health (NIH) make R56 awards, formally known as a High Priority, Short-Term Project Award but universally known as bridge grants or bridge awards. These awards provide one, sometimes two, years of funding to researchers and are given to applicants for competitive NIH awards (such as the standard, competitively-awarded R01 research grant which average four years in duration) who fall just outside the cut-off limit of peer review scores for the full NIH award.

Interestingly, investigators never apply directly for a bridge award but instead receive them as a third outcome between receiving a standard NIH research grant and a rejection. The bridge award is typically for a year, with a maximum of two years, and allows the investigator to continue research and to revise a R01 proposal for resubmitting the next year in the standard competition. Most, though not all, bridge awards are for R01 renewal applications, an NIH-funded investigator ending one R01 award project and applying for another R01. Thus, the mechanism is intended to be a ‘bridge’ between one R01 award and another future R01 award. If the investigator is successful in the future R01 competition, then the future R01 award is offset (reduced by one year and the cost of the bridge award).

After a peer-review panel (in NIH, external reviewers organised in “study sections”) grades and ranks applicants for a R01 or other competition, NIH programme managers determine a cut-off score known in NIH as a payline based on available funds. This process results in R01 awards going to the most highly-rated proposals, but also a list of proposals that rank highly but just below the payline score. NIH sends these proposals to programme managers, who make ranked recommendations on which of these proposals should receive bridge awards. Therefore, there is no additional peer review for bridge awards; the peer review is for the original R01 competition.

The bridge award gives NIH programme managers a tool to manage applications from year to year. For example, if a programme is unusually competitive one year, NIH can shift applicants from the current year’s competition to next year’s competition and allocate them bridge funding to sustain their research until then.

The bridge award is also a way of managing success rates. NIH programme managers could give all of their programme’s funding as R01 awards. But reserving some funds for bridge awards has the effect of reducing the success rate for the standard awards yet providing some form of funding to a greater number of researchers. In addition, it allows proposals to become more competitive, in theory resulting in better science; investigators use the bridge award funding to do research and improve their proposals to be more competitive in the next competitive round.

3.3. Success rates

The questionnaire and subsequent research found wide variation in success rates (including some programmes with a reported success rate of 100% and others of below 10%), with clustering of success rates between 10 and 20% (Figure 8). The Expert Group found no obvious relationships between the size of a programme, the number of applications, or
award size and the success rate. It should be noted that there are some relationships between the type of programme and success rate: centres of excellence, mission-oriented research in priority fields, and innovation and industry-oriented programmes tend to have higher success rates than individual general-purpose research awards, with the lowest success rates for investigator-initiated, general-topic, open-call research awards.

Programmes with initial screening or multi-stage application processes tend to have higher success rates for the final selection stage, which is not a surprising finding considering that the purpose and effect of pre-screening or initial screening is to reduce the number of proposals that have to be reviewed in the final selection stage. Applying initial screening or multiple stages that can reduce the number of applications that must be peer reviewed is a worthwhile strategy for nations to consider.

Several screening strategies are used by nations, including: administrative screening (agency staff triaging incomplete applications or checking administrative eligibility criteria); pre-proposals (requiring applicants to submit a shorter, simplified proposal or letter of intent or a CV for initial screening that is either peer reviewed or reviewed internally, and allowing only successful applicants in this round to submit full proposals); preliminary internal review (agency staff review applications and send only a subset to external review); and multi-stage review (usually a document review followed by a committee review and sometimes followed by an interview stage, with the number of reviewed applications shrinking at each stage). These strategies appear to work well in different contexts and are worth consideration by national funding agencies. Many have the added benefit of reducing burden by eliminating the need to write full proposals for applicants who do not make it to the final round.

One strategy to avoid oversubscription and to reduce non-relevant applications that has been used by the Severo Ochoa Centres of Excellence programme in Spain is to require applicants to submit a bibliometric self-assessment (see Box 6).
Box 6. Using bibliometric self-assessment to avoid oversubscription: The “Severo Ochoa Centers of Excellence” programme in Spain

The “Severo Ochoa” Centers of Excellence programme was launched in 2011 with the aim of funding and accrediting research centers in Spain. In 2014, a new variation for smaller research units (the Maria de Maeztu Units of Excellence programme) was launched. There is an annual call for applications. The core annual funding allocated under this mechanism is EUR 1 million per year, but there are also additional streams of funding through other public funding instruments, such as PhD fellowships, post-doctoral contracts, etc.

To be funded, public research centers and units, in any domain of research, have to demonstrate scientific leadership and impact at a global level, as well as active collaboration in their social and business environment. They should be organisational structures with highly strategic research programmes in the frontiers of knowledge and they should be among the best in the world in their respective scientific areas.

To be eligible, applicants for a center grant are required to present at least 10 researchers (6 in the case of R&D Units) plus the scientific director as guarantors of the excellence of the applicant center or unit. Those “guarantors”, or principal investigators, are required to present bibliometric evidence of their performance, including the “normalised impact factor” of their recent works.

These requirements serve to reduce the number of applicants and the average success rate has been 30% over three years of competitions.

The evaluation and selection process is carried out by an independent international committee of prestigious scientists, organised into three main domains. In most cases, the chairs of these Panels are Nobel Prize winners, and the focus of the evaluation and the criteria for assessment is the substantive scientific contribution of the Center or Unit, recent performance and expected results and impacts.

One issue with initial or multi-stage screening is that although the number of proposals that have to be peer reviewed may be reduced, the number of disappointed applicants (researchers who are not funded) is not reduced. Measures to increase success rates, in general, do nothing to change the competitive environment for researchers, who are obliged to submit increasing numbers of applications to different funding competitions. Addressing the symptoms, researchers caution, will not remove the causes which are linked to the competitive environment (International Peer-Review Conference, 2017).

Other strategies to increase success rates focus on taking applicants out of the applicant pool. Some nations are experimenting with longer research grants (greater than 5 years) and prohibiting these recipients from applying to other programmes until the original research grant is complete. This approach has the benefit of allowing these researchers more time between applications.

There are other strategies to raise success rates that are more controversial. One is to reduce the number of applicants by barring unsuccessful applicants (or applicants with scores below a certain threshold) from applying to a future round of a funding programme (referred to in some nations as “quarantine”). Related is a “time out” system in which applicants, successful or unsuccessful, cannot re-enter a competition for a certain amount of time. Another is to limit the number of research awards from an agency that a single
investigator can hold simultaneously. Some programmes apply limits to the number of applications that a single institution can submit to a competition, which can have the effect of creating an intra-institution competition before the main competition. Another is to impose limits on current awardees reapplying to a funding programme with a new project, or limits on renewals of ongoing projects that have not been completed in the time period of the initial award. Other strategies can include institutional limits on number of applications for a specific competition, or require applicants to have a funded grant portfolio of a certain size in order to be able to apply, or not allowing previously unsuccessful proposals to be resubmitted regardless of time, unless invited to do so. And there are also financial strategies, such as increasing the co-funding required by institutions to reduce the number of applications any institution will submit.

The success rate problem is not only on the numerator side but also on the denominator side. The research workforce in most OECD countries tends to grow faster than research resources because of the traditional academic model whereby one researcher advises and mentors several students, many of whom go on to pursue independent research careers (for more on this topic, see Stephan, 2012). Thus, if left unchecked, the number of researchers applying for funding tends to grow. This is compounded by the fact that the salaries of many researchers, including PIs, are dependent on competitive project funding. One method of improving success rates is therefore to limit the population growth of researchers. Not surprisingly, this idea is not very popular in the scientific community.

And of course, one method of increasing the success rate is to increase the funding available for a competition. However, in a time of fiscal austerity across the OECD, this method has obvious limits.

There are other practices undertaken for policy reasons that may also have the effect of raising the success rate. Many funding programmes restrict the pool of eligible applicants according to defined criteria: career stage (time from PhD); nationality; performer type (small business, academic institution, or a subset of academic institutions); geography (competitions limited to certain jurisdictions that are historically disadvantaged in competing for research funding); and collaboration (limiting applications only to cross-sector or cross-national research collaborations). While the adoption of such measures primarily to raise success rates may not be appropriate, aligning eligibility with policy objectives makes sense.

As an aside, the majority of programmes surveyed do not have an explicit process for renewal of awards or reapplication (a rejected project applying for funding in a new call), although policies regarding renewal and reapplication can affect success rates.

From the data, it is impossible to determine an ideal success rate. Interviewees stated repeatedly that success rates below 10% were a concern because below that threshold it is claimed that peer review is ill-equipped to make meaningful funding decisions and therefore the selection process becomes a ‘lottery,’’ delegitimising the process in the eyes of the scientific community. In other words, low success rates erode the trust in the peer-review process that is key to the scientific community’s support for it. In addition, the cumulative burden of peer review per award increases as the success rate decreases, thereby reducing the efficiency of the selection process. Interviewees suggested that success rates between 25 and 33% were optimal. These assertions are based on personal experiences and involve professional judgment as to the “right” ratio of applications and reviews to funded projects, but this study could not identify data to support these assertions.
There remains much more research that could be done on success rates. One promising research area is determining what percentage of “good” or “worthy” proposals should be funded in an “optimal” situation. Several funding agencies, including NIH and NSF, make informal assessments on how success rates compare to the percentage of applications that peer review panels deem “good” or worthy of funding, usually to argue for more funding to fund more of the worthy proposals deeper in the application pool. In the interviews, the Expert Group found that programme managers generally agree that most competitions result in three categories of applications: “good” proposals that should be funded, “average” proposals that could be funded if funds are available, and “bad” proposals that should not be funded. For them and for the scientific community, one issue that is eroding trust in the peer-review process is a growing sense that many “good” proposals are not being funded in heavily subscribed competitions with very low success rates. In the EU, it is interesting to note that several countries such as France or Spain have mechanisms to fund highly rated ERC applications that failed to get ERC funding (as success rates for ERC grants are below 10%).

3.4. Monitoring, impact, and measures of success

This study found wide variation in funding agencies’ monitoring of the peer-review process, and also a wide variation in evaluation of impact/success measures of research funded competitively. One problem encountered was that it was difficult to separate programme monitoring from impact evaluation, or in other words, it is difficult to distinguish between programme efficiency and programme effectiveness.

There are few agreed-on criteria for scientific success in general, and therefore little concrete guidance on how to evaluate success or impact after competitive awards have been made. The most common metrics used to evaluate the scientific excellence (impact) of funded proposals are: bibliometric indicators (publications, citations, impact factor), prizes, qualitative assessments of impacts either self-reported or externally reported, the ability to attract additional funding, and qualitative assessments of interdisciplinarity, breakthrough discoveries, or innovative outcomes. There are however, questions regarding the actual value of journal impact factor and metrics such as the H-index for assessing the quality of publications or the contribution of individual researchers.

Outcomes related to policy priorities were variously evaluated but only in a minority of the programmes in this study. Approaches included: qualitative assessments of whether the research helped to meet programme objectives; qualitative or quantitative assessments of interdisciplinarity; disciplinary balance; regional balance; and overall changes in national research structure. Although innovation/technology transfer would appear to be the easiest category of impact to evaluate quantitatively, direct impact indicators of economic/innovation impact were rarely used; instead, programmes used qualitative assessments of success stories and self-reported economic impacts. Collecting and then synthesising these various qualitative evaluations often required more expert panels, that is to say additional peer review.

Nevertheless, there are some promising approaches for evaluating impact beyond traditional bibliometric outputs. The Science Foundation of Ireland, for example, has developed an impact framework based on impact categories that are derived from an applicant’s original impact statement (see Box 7). There is an ex ante evaluation of impact based on the impact statement and evaluation guidelines. Annual and mid-term reviews of awarded grants are carried out against this impact statement.
Box 7. Science Foundation Ireland Research Impact Evaluations

As Ireland’s scientific infrastructure and capacity matures, there is a strong focus on demonstrating the economic and societal benefits of publicly-funded scientific research to society. Science Foundation Ireland (SFI) published a strategy document, Agenda 2020, in 2013, which set out a vision in which Ireland, by 2020, would be the best country in the world for both scientific research excellence and impact. In line with other international funding agencies, SFI defined impact as “the demonstrable contribution that excellent research makes to society and the economy.”

SFI had always asked applicants for competitive funding to articulate the value of their research to Ireland but, following the publication of its strategy, expanded and refined this aspect of research evaluation. To this end, SFI began using experts in the translation, commercialisation, and development of scientific research to evaluate research impact as an integral part of post-award review processes. Towards supporting impact assessment, many of SFI’s awards, are subject to a mid-term programme progress review. International experts in the relevant disciplines, including those with expertise in relevant areas of industry, commercialisation, and translation, evaluate the progress being made against the original Impact Statement as submitted in the funded proposal. There is specific guidance provided to direct the reviewers to “score” with reference to indicators of impact, as defined by SFI, and not simply to “rate” award outputs, some of which may have little relevance to impact. Furthermore, all Research Centre awards are asked to provide targets for specific outputs in direct support of delivering Impact. These are examined internally by SFI staff, and are used to report progress to the SFI Executive and Board, and SFI’s parent department (Department of Business, Enterprise and Innovation). Additionally, as part of annual reporting guidelines, all current SFI awardees are provided with a list of 11 Impact “declarations” or statements. They are required to select the statements which best reflect the impact(s) arising from their award; they must provide details justifying the statements selected and metrics in support of their selected impact(s). The Impact statements help SFI to quantify the types of impacts arising from awards made under various SFI Programmes. They provide SFI with impact case studies for public dissemination and are particularly important for scenarios where impacts arising from specific programmatic activities are required by the parent department as justification for investments made.

The Group found few attempts by agencies to evaluate the efficiency or effectiveness of their competitive selection processes although many possibilities exist. In part, this is because agencies are understandably reluctant to share detailed data containing personally sensitive or business confidential information on award applications, peer-review scores and reviews, and awards. But researchers who have persevered in collecting and analysing detailed anonymized data have made intriguing findings: one study of NIH awards and their peer-review scores found no correlation between the percentile ranking in peer review of an application and its eventual citation impact (Fang et al., 2016). Another study of the New Zealand Marsden programme found no systematic evidence that the programme’s peer-review selection process predicted the subsequent success of the research project. At the very least, such research provides some empirical foundation for the notion, already discussed, that peer review is ill-equipped to make fine distinctions between research applications.

When evaluations of competitive funding mechanisms do take place, they are often retrospective qualitative assessments by external panels. One example is an international 2011 evaluation of the Natural Science Foundation of China’s funding and management performance by a team led by the National Center for Science and Technology Evaluation
The European Research Council and U.S. funding agencies also conduct periodic external retrospective evaluations of competitive funding mechanisms; we found that there is no standard methodology for such evaluations nor a standardised set of data used in such evaluations, only a range of inputs (bibliometric indicators, questionnaires, interviews, citations data, award project reports) that are most commonly used to inform an external panel’s review.

Box 8. International Evaluation of National Natural Science Foundation of China’s Funding and Management Performance

Since 2005, the government of China (GOC) has increasingly focused attention on the performance of scientific research supported by public funds and explicitly required an evaluation of the National Natural Science Foundation of China’s (NSFC) performance. NSFC plays an important role in basic research under China’s National Innovation System (NIS), and its influence is well recognized among China’s scientific community.

An international evaluation of NSFC was implemented from June 2010 to April 2011. Its objectives were to: (1) provide an independent assessment of the overall performance of NSFC’s funding and management during the past 25 years, with a truly global perspective; (2) present key findings, lessons learned and recommendations to improve the NSFC’s funding and management performance as well as to achieve excellence in management; (3) and develop a set of forward-looking guiding ideas, based on a truly global perspective, supporting the Ministry of Finance (MOF) and NSFC to redefine NSFC’s strategic role within the NIS of China.

The Evaluation covered four dimensions: (1) NSFC’s strategic positioning, (2) funding performance, (3) management performance, and (4) impact on China’s S&T system. The National Center for Science and Technology Evaluation (NCSTE) was responsible for designing and implementing the Evaluation, and preparing synthesis evidence for evaluation. An International Evaluation Committee (IEC) – in practice a mixed Chinese/international panel – was established to assess this evidence and draw conclusions and recommendations.

The evaluation provided a number of recommendations around five dimensions: strategic positioning of NSFC, funding performance, international connections, funding instruments, and management and administration. The evaluation report was widely circulated within NSFC and published online. The majority of the recommendations were adopted by the NSFC and the Ministry of Finance. For example, as recommended, the budget for NSFC doubled between 2010 and 2015; NSFC has implemented performance evaluations of the General Programme, the Young Scientist Fund in 2015, and the Fund for Less Developed Regions in 2016; the duration of the General Programme project, the most important funding instrument of NSFC, increased from three years to four years; and the General Programme grant size increased from RMB 600 000 to 800 000.

Clearly, greater access by the science-policy research community to detailed anonymised data on peer review could allow for comparative analyses of differing competitive allocation systems (peer review vs. programme manager review, panel review vs. panel + interview, peer review with bibliometric or other indicators vs. purely qualitative peer review, etc.). There are also opportunities for counterfactual studies, for example, to assess impacts of funded proposals in a competition vs. unfunded proposals that were later funded by other funding sources. Such comparative research could provide an empirical basis for determining the advantages and disadvantages of different modes of competitive research funding, or the most appropriate mode to use in particular contexts. There have already been notable studies in which such data have been used to study the degree to which
factors such as gender, race/ethnicity, or age affect peer reviewers’ judgments, and more such studies would help to identify barriers to effective peer review (Ginther et al., 2011). But detailed studies on the advantages and disadvantages of different competitive funding mechanisms are lacking in the literature, and could be useful opportunities for future research provided data and funding are available.

In particular, there is a continuing need to investigate the impact of race/ethnicity, gender, age, and other factors of both the reviewers and the applicants on peer review outcomes. There is a welcome movement toward ensuring gender balance and diversity both on review panels and in funding awards. And training programmes for peer reviewers (such as those operated by the Research Councils UK) to raise awareness of and potentially reduce the impact of implicit bias in peer review are growing in number. While there is an emerging body of literature suggesting that diversity in both reviewers and applicants is important in ensuring fair outcomes, the impact of biases on peer-review decisions is not well understood, and therefore policy measures to correct for biases are not well developed.

The need to screen for bias and to understand the role of bias in competitive funding mechanisms will only grow more pronounced if in-person processes, such as interviews and ‘pitches’, become more prevalent in selection mechanisms.

3.5. Perceived challenges and responses

Costs of competitive funding schemes

Although studies have shown that a competition in a funding system may bring significant benefit to the quality of the research produced (Li and Agha, 2015), the true operating costs of competitive funding schemes are not accounted for. This real cost not only includes the funders’ administrative resources required to manage and distribute grants and monitor their use, but also those required for the whole evaluation process and, perhaps the most critical element of all, the time and effort spent by researchers to respond to grant proposals and, for the grantees, to meet post-award requirements.

This project highlighted the lack of data on operating costs of competitive funding systems. Where reported, operating costs appear to be under 5% of the total programme cost. But the questionnaire yielded no data at all for many programmes, and no details as to how each programme calculates operating cost. Just as an example, the study found considerable variation in how operating costs are attributed: some programmes include operating costs within the programme budget, others have operating costs supported out of a central agency-wide fund, and many others do not attempt to calculate operating costs separately. Interviewees repeatedly said that operating costs were difficult if not impossible to calculate with any precision.

The evaluation process itself is most often based on peer review. Peer review relies heavily on the volunteered time and effort of external reviewers, most commonly employed at academic institutions. Although a small sample of competitive programmes pay external reviewers through honoraria, peer review relies predominantly on external reviewers volunteering their time and being compensated only for travel and other expenses associated with their service on panels. Even if they are not direct costs, the time and effort of external reviewers are a cost to the entire research system, both in terms of their salaries and in terms of the opportunity cost of the research and other activities that they could be doing if they were not serving as external reviewers. Accounting of the uncompensated costs of peer review remains approximate, but anecdotally, these costs are considerable,
especially as success rates decline and therefore more external reviews are required per research funding award.

The effort devoted by researchers to comply with competitive funding requirements is even more difficult to assess and includes the proposal preparation itself, usually some pre-award administration efforts and, for the awardees, some sort of post-award administration and report preparation. Time spent for these various tasks is variable between researchers and funding schemes, but a 2012 publication (Schneider et al., 2012) reporting on a study carried out in the United States indicated that an average of 42% of the time spent by principal investigators supported by active federal grants was related to meeting funding requirements. Even considering that a significant time is devoted anyway to administrative duties by researchers using other forms of funding, the 15% time allocated to proposal preparation reported in this study indicates that competitive funding does involve significant effort and resource allocation by researchers.

Assessing the full cost of competitive funding mechanisms is complex, particularly as the criteria taken into account for the cost associated with researcher’s proposal preparation/submission and reporting may vary. In a 2006 report of the UK Research Councils, the total cost of the system was evaluated to about 13% of the Research Councils’ budget spent in higher education and research. Although based on estimates, this gives a rough value of the cost of peer-reviewed funded research. This value was subdivided into about 75% linked to researchers’ proposal preparation, 20% related to the evaluation process and about 5% associated with internal Research Council activities. The relative cost of competitive funding is affected by the success rate of a given funding mechanism, as the costs associated with proposal preparation and evaluation increase relative to the funding awarded as success rates fall (the 2006 United Kingdom estimate is to be analysed in a context of about 30% success rate). The real cost per amount awarded can vary significantly as a function of the complexity of the proposal requirements, the size of the grant allocated and the complexity of the evaluation and management process.

Debate around the cost of competitive funding mechanisms and their real added value continue in the absence of conclusive evidence. In a 2009 publication, Richard Gordon and Bryan Poulin suggested that the cost of the Canadian NSERC science grant peer review system exceeded the cost of giving a baseline grant to every qualified researcher. They advocated a mixed portfolio of high, medium and low-risk funding through 40% baseline funding, 50% peer-review competition and 10% industry collaboration. In a more recent (2017) paper, Krist Vaesen and Joel Katzav calculated that an egalitarian distribution of funding would not lead to an unacceptable dilution of resources and would allow research teams to both maintain current PhD and postdoc employment level and have at their disposal budgets for travel and equipment. Therefore, although the added value of competitive funding mechanisms in helping foster the best research not only through the selection process itself, but also via “soft” benefits to the researchers (facilitating collaborations, etc.) is still widely accepted, whether this process is always cost-effective (particularly when success rates are very low) is debatable and should be further studied.

Sustaining peer review

At least in the academic research community, there is an ethos of service that encourages researchers to participate in peer review as a form of service to the broader community. Some research funders have begun to bolster that ethos through soft or hard requirements for applicants and/or awardees to ‘give back’ by serving as future reviewers as a condition of the award. However, there are other challenges in recruiting reviewers, especially from industry, where the culture of uncompensated service to the community through
participation in peer review is not as ingrained. Even within the academic research community, there are challenges in recruiting peer reviewers in countries where peer review is not well established as a tradition and where paid external consultancies are the norm rather than volunteer service. On top of these challenges, there appears to be growing fatigue among researchers at being asked to serve on numerous competitive-funding peer-review panels in addition to other peer review efforts such as journal manuscript review, evaluation teams, and prize/award selections.

Some of this fatigue could be counteracted by measures to make peer review less burdensome and more rewarding for reviewers. Examples from the literature and from the 2017 Amsterdam international peer review conference include: greater standardization of review criteria and questions; clearly defined guidelines and expectations for reviewers on how to review; better training in peer review (including ideas about including peer-review training as part of PhD or postdoc programmes, and paying reviewers for participating in peer review training); paying reviewers for their service through honoraria or other compensation, in addition to the customary reimbursement for travel expenses; and ex-post feedback for reviewers. Incentive payments to reviewers is a mechanism that has been adopted by some funders, although it may not always be effective: The United Kingdom EPSRC 2013 Review of Peer Review report found that payments did not help secure reviews and recommended that the allocated budget for reviewers (GBP 1 million) should instead be reinvested into the science. Another idea that has emerged recently is to create online platforms for reviewers to share their experiences with peer review. In terms of rewards, it was also suggested, in Amsterdam, to increase the recognition of the reviewers within their own institution, by making this task more formally linked to their official duties (alongside research and teaching) and therefore better acknowledged by employers. Anecdotal evidence on peer-review costs would benefit from being backed up by data and indicators on the true operating costs of competitive funding, the financial and time burdens of competitive funding on reviewers and their institutions, the burden of competitive funding on applicants and on funding agencies, and similar indicators on other forms of peer review. A potential response is for OECD countries to undertake concerted efforts to better document the true operating costs of competitive funding schemes in general and research funding schemes more broadly, including efforts to document opportunity costs and non-monetary costs.

Preserving transformative, risky, and multidisciplinary research

Another challenge that emerged from this project is the lack of data to investigate the concern that peer review, especially as success rates decline, tends toward conservatism. If unchecked, there are worries that competitive systems disadvantage risky, potentially transformative, and transdisciplinary research proposals in favour of applied, incremental, or disciplinary proposals. Evidence is lacking and despite the need for some empirical basis for identifying the riskiness, the transformativeness, or degree of interdisciplinarity of research projects or proposals, robust indicators do not exist (Koizumi, 2011). Without data to evaluate conservative vs. transformative research, it is nearly impossible to document, for example, whether incremental projects were funded instead of transformative projects in any given competition.

In this qualitative area, one strategy is to explicitly call on reviewers to consider an application’s riskiness, potential for transformative insights, transdisciplinarity or novelty, on the premise that reviewers can identify these qualities in an application. Doing so may require a de-emphasis on other review criteria, such as the likelihood of an applicant producing a “successful” outcome (as defined by publishable findings or a research article).
or an applicant’s prior track record. Alternatively, it may require setting aside a certain proportion of a programme’s funding for proposals that are judged as truly risky or transformative. Or, on the assumption that transformative ideas tend to elicit widely differing reactions from reviewers compared to incremental ideas, programmes may adopt scoring rubrics that give added weight to a proposal with a greater variation in reviewers’ scores than a proposal with a similar average score but with less variation in individual scores. But at this time, there is little guidance for research funding agencies on how to counteract the perceived tendency to conservatism in competitive funding schemes.

The European Research Council has commissioned periodic reviews of its peer-reviewed competitive funding schemes to answer the question of whether ERC funding has supported projects of high scientific value and whether it is funding high-risk, high-reward research (or potentially transformative research). While it is encouraging that recent reviews have found the answer to be yes on both counts, the lack of a counterfactual or similar evaluation of other alternatives means that it remains unclear whether other funding mechanisms would have achieved equally excellent or transformative research (ERC, 2016).

Matching competitive funding to strategic objectives

A challenge for a subset of competitive funding schemes with strategic objectives is how to adapt evaluation criteria, the reviewers, and the composition of panels to assess both scientific excellence and the other objectives of a particular scheme. Such objectives vary from raising economic competitiveness or technology transfer to improving health. This is further complicated by the need to accommodate and review properly the proposals from the many different disciplines that may respond to a strategic call. There little guidance on how to ensure that a panel can competently assess all the criteria for a research funding call designed around a strategic objective.
4. Analysis

4.1. Improving efficiency of competitive funding schemes

There is widespread recognition that operation of competitive funding systems consumes significant resources, on the part of the managing agency, research proponents, and external reviewers. Further, as research communities have expanded and success rates have declined in many countries (see next subsection), these costs have increased without a corresponding increase in funded research, leading to concerns about the overall proportionality of costs to research expenditure.

There appears to be widespread agreement that confidence in the integrity and reliability of the proposal evaluation process is crucial to acceptance and support of the system by the researcher community. And in general that confidence is closely tied to a strong belief that peer review is the most – perhaps only – valid and reliable way to evaluate the merits of research proposals. Presumably for this reason, most systems around the world have maintained peer review as the core of their process.

Historically many competitive systems had funding that was adequate to support most of the meritorious proposals that were received. Under such conditions, the task of the peer review process is to determine which of the proposals are worthy of funding and which are not. In systems that receive many more funding-worthy proposals than can be funded, peer review must take on a fundamentally more difficult task: it must identify within the set of funding-worthy proposals which are the best. Indeed, most competitive systems ultimately use peer reviews in some way as a basis to rank proposals from most promising to least, and fund proposals from the top of the ranking down, either in strict order or perhaps with some discretion but still based on the merit ranking.

There are of course, different ways of soliciting, tabulating and utilising peer review evaluations. Some systems use numerical scores that are combined in various ways; others use solely qualitative evaluations, and some use a mix of scores and qualitative evaluations. Most programmes solicit reviews from a relatively large group of expert reviewers, and then combine these reviews in some way to yield an overall ranking. Such combinations can be purely formulaic, or ranking can be undertaken by agency staff. Most systems, however, use some kind of panel or committee that considers the information gathered from prior peer review and then uses its own judgment and discussion to produce a ranking.

There is a general understanding that individual peer reviews are inherently idiosyncratic, subject to both random variation and potentially systematic biases across reviewers. A variety of techniques are used to try to mitigate the effects of such variation, including requiring a minimum number of reviews (often three), using median rather than mean scores, and excluding particularly high or low scores. There is a widespread belief by participants in the systems that discussion of reviews by panel members mitigates the effect of idiosyncratic reviews, although there is no systematic evidence supporting this belief.

The recognition that in many systems only a small proportion of the very best proposals can be funded has led to various mechanisms to reduce the resources invested in distinguishing poor proposals from mediocre ones, neither of which have any chance of being funded. Such mechanisms typically involve an initial screening, requiring less time and resources than typical peer review, to identify a subset of proposals that will be advanced to full review. For a given number of proposals received, such screening clearly
reduced costs, because full peer review is undertaken only for a portion of all proposals. The risk, of course, is that some number of meritorious proposals will be rejected at the first stage, since it is by definition a more cursory review.

In some systems this economising on agency and peer review resources is extended to economising on proposal effort, by requiring a less detailed pre-proposal or letter of intent at the pre-screening stage, with full proposals prepared only by those applicants who are selected to advance to the second stage. It is possible, of course, that conducting the initial screening based on a less detailed proposal increases the chances that meritorious proposals will fail to advance. Further, reducing the initial proposal burden in this way can be expected to increase the number of initial proposals received. Even though these proposals do not receive full review, their review does require some effort, so this effect offsets to some degree the benefits of the two-stage process. Thus the choices involved in implementing and designing a two-stage process are complex; to our knowledge there has been no systematic effort to quantify or even characterize the tradeoffs involved.

Another experiment some systems have tried as a way to deal with large proposal volumes is to allow submission at any time, rather than having fixed deadlines. This smooths out the receipt and processing of applications over the year. It is generally popular with researchers, as it increases their flexibility. How such timetables are synchronised with review processes will depend on the nature of such processes.

All programmes struggle to some degree with securing high-quality referee reports. Some systems have invested significant effort in constructing, testing, and refining specific guidelines for assessors, and believe that such guidelines improve the quality of evaluation reports, particularly with respect to minimizing the problem of some reviewers being consistently too “soft” or too “hard”. But it will always be a challenge and these systems depend fundamentally on volunteer referees undertaking reviews as part of their general social obligation to the science system. (A few systems do offer small honoraria for referee reports, but no one pays amounts that really cover the value of the needed time, and there is no consensus that paying produces better reports.)

The sense of social obligation that underlies refereeing is naturally weaker when reports are sought from international experts. This is a particular problem for small countries in which qualified domestic experts are few in number and often encumbered by conflicts of interest. An obvious solution, if practical difficulties could be overcome, would be for countries to form associations in which refereeing obligations and reports are pooled. Experts could be made to understand that their refereeing for another country was explicitly in exchange for experts in that country reviewing proposals from their own. It is not clear, however, what context or mechanism could be used to organise this kind of co-operative solution but the outsourcing peer-review service provided by the European Science Foundation provides an interesting example.

4.2. Implications of success rates

As already noted, a number of systems around the world have experienced significant declines in the fraction of proposals funded (“success rates”). Despite wide discussion of this phenomenon, we are not aware of any systematic tabulation of the trend in success rates around the world. Several experts interviewed during our study have expressed alarm about possibly dire consequences for the science system of a prolonged period of low success rates. This raises wider science policy issues, but this report focuss on the implications for the operation of the selection mechanisms themselves.
As mentioned, lower success rates translate almost automatically into higher operational costs per research grant awarded, because those costs are largely a function of the number of proposals processed rather than the number of grants made. In addition, many participants in the programmes we reviewed expressed concern that success rates in the range of 10% and below risk undermining the overall confidence of participants in the system, because at this level so many worthy proposals have to be rejected that participants come to view the funding decisions as essentially random.

An emerging issue is the interaction between low success rates and feedback to applicants. Many participants in the competitive process (reviewers, programme managers, and applicants) view feedback on the strengths and weaknesses of a proposal as important, even if it was unsuccessful. But when success rates are very low, it is inevitable that numerous unsuccessful applicants will receive feedback that make it very hard to see why they were not funded, or which will highlight the fragility of the evaluations as, for example, when a proposal is criticised for an element that in a previous (also unsuccessful year) was complimented.

It is important to keep in mind that the success rate is a complex function of the overall amount of funding available, the size of grants, and the decisions of researchers regarding applications. On some level, potential applicants are balancing the burden to them of the application process against the possibility of funding success. All else being equal, a low success rate is itself a disincentive to application (though this disincentive may be offset as the low success rate itself amplifies the prestige conferred by success). Given that success rates are generally pretty well understood by applicants, the persistence of low success rates signals a willingness or a need by applicants that is not likely to change on the basis of incremental changes to how funding systems are managed. If funding were increased modestly, the expected increase in success rates might be partially or wholly offset by an increase in the number of applications induced by the higher expectations around success. Over a long period of time it is possible that the larger forces governing the science system will adjust so that the balance between funding and perceived need will return to historical levels, but for the foreseeable future low success rates are not likely to go away.

A second important aspect of the situation is that the perception of stakeholders that funding decisions have a large component of randomness is, in fact, reality. Evaluation of proposal quality is an inherently difficult subjective task. While the true slope of the underlying quality curve as one moves from the best proposal to the 10th or 20th percentile will vary somewhat across contexts, in most of these systems there is a group of good proposals that are fundamentally indistinguishable. The difference between the proposal that is rated top and the proposal that is rated at the 10th percentile or 20th percentile is as likely to be due to imprecision in the ranking system as it is to be due to true superiority of the underlying proposal. This is a difficult truth to face because we all want to believe in the inherent reliability of the selection system, but perhaps it is healthy to face up to this truth (Gush et al., 2017).

If low success rates are likely to persist in some systems, and if participants come to accept that selections made among a small fraction of proposals are inherently somewhat arbitrary, it may be time to rethink the significant resources that are devoted to carefully ranking among the set of potentially fundable proposals. While care would have to be given to issues of transparency and external confidence, it is possible that less intensive allocation mechanisms could produce results that would be objectively as valid as the current processes but at lower cost.
Another consequence of low success rates is the likelihood that some truly promising research will fail to achieve funding. While this problem can never really be solved, some systems have tried to mitigate its worst consequences with changes in funding strategies. Panels may be given increased flexibility to modify proposed budgets so as to accommodate funding for more proposals from a fixed budget. A portion of available funds may be set aside for 'bridge funding' that is insufficient to really advance a research project but can be used to keep a given research line open until greater funding can be identified. One interesting approach that is aimed at both the problem of low success rates and perceived inability to generate truly transformative ideas is a separate application track explicitly limited to relatively small amounts of short-term funding, used to initiate a larger number of “smart ideas” with the expectation that many will fail. This is for example the idea behind the New Zealand “smart ideas” grant programme.

4.3. Encouraging transformative, risky, and multidisciplinary research

This project was launched with an intention to develop a “typology” of competitive funding schemes, with the explicit goal of trying to identify best or at least good practices for different types of scheme. It quickly became clear, however, that the concept of such a typology is problematic, because of the heterogeneity and complexity of relevant funding programmes around the world. To fit the observed programmes into a detailed typology would require either specification of so many types as to be unhelpful, or else grouping within given “types” of schemes that differ in important ways. So a more generic and progressive organisation was proposed (Figure 5, chapter 3.1)

Some general observations about different types of schemes are nonetheless possible. In particular, many systems around the world now seek to accomplish with their research funding particular policy goals in addition to research success per se. Indeed, the trend seems to be towards more programmes stating such multiple goals, and these goals being given more serious attention within programmes that have nominally stated such multiple goals for some time.

These broader goals fall into two broad categories. One category is the fostering of certain attributes or conditions within the research system itself, including:

- advancing the careers of early-stage researchers
- more generally building long-term research capacity
- fostering international collaboration
- fostering interdisciplinary research
- fostering “breakthrough” or “transformative” research.

Development of mechanisms for interdisciplinary and breakthrough/transformative research seem to be particular challenges. In particular, the challenge seems to be how to create and then maintain processes that recognise interdisciplinary or transformative research in the face of strong disciplinary and conservative tendencies in the existing system. Funders have experimented with special panels constructed for their expertise in interdisciplinary research, and also with review by multiple panels from different disciplines, who are required to coordinate their evaluations.

With respect to encouraging transformative research, the challenge is the difficulty of identifying ex ante which proposed research will ultimately have transformative impacts. In addition to specifically identifying such potential as a criterion that reviewers should
look for, systems have experimented with various methods designed to protect such proposals from the possibly adverse effects of “highly transformative” being seen by some reviewers as risky or unlikely to succeed. This can include combining multiple referee scores in ways that are perceived to assist risky proposals (e.g. discarding each proposal’s lowest scores). Some systems allow each panel member one “gold” vote, which allows them to protect a proposal they think is highly promising regardless of negative views of other panel members. A few agencies are experimenting with a “go/no-go” system that allows full funding for a risky project only after an initial trial period (typically one year).

The challenge of fostering transformative work is believed by some to be connected with the so-called “Matthew effect”, namely that the strongest predictor of success in the proposal process is previous grant success. It is believed by some that this self-reinforcing tendency causes researchers to play it safe in terms of research ideas, and makes it difficult for new innovative ideas to break into the system. Some funders operating from this perspective have considered undertaking project reviews without use of CVs or other identifying information, or at least separating evaluation of the promise of the proposed research from any evaluation of the capability of the proposers. (Such approaches are also sometimes advocated as a response to other perceived biases in peer review, such as gender.) There is no real evidence, however, that outsiders or less-experienced researchers are particularly likely to generate the most transformative ideas; the Matthew effect is likely due, at least in part to the reality that some researchers are innately creative and therefore repeatedly come up with brilliant new ideas (Bol et al., 2018). To whatever extent this is true, efforts to reduce the likelihood of funding those who were previously most successful may also potentially reduce the flow of transformative research.

4.4. Matching competitive funding to strategic objectives

The other category of objectives relate to the broader impacts of research, including:

- fostering commercial innovation
- fostering international competitiveness
- building the evidence base for public policy formulation
- improving the environment
- improving the well-being of citizens, particularly the disadvantaged
- supporting other specific policy objectives of countries.

From first principles, it is not obvious that competitive funding mechanisms are the ideal way to pursue these objectives, in general or with respect to any specific objective. For example, early-stage researchers are, by definition, inexperienced at research and difficult to assess in terms of likely success so a competitive grant process is inherently ill-suited to their support. More generally, the peer-review based evaluation that is at the heart of virtually all competitive research grant selection mechanisms may not be well-suited to evaluating likely success with respect to complex objectives.

Despite these difficulties, most programmes that have taken on these additional objectives use processes adapted from the traditional evaluation model. Some use relatively narrowly crafted CFPs (call for proposals), for which proposals must directly address specific policy goals in order to qualify. Many programmes retain a more bottom-up approach, allowing proposers wide latitude to formulate proposal ideas, but then evaluate the potential benefit or impact of the proposals with respect to policy goals in parallel with their evaluation for
scientific merit. In some cases, a formulaic combination of scientific merit and broader benefits is used, e.g. with a 50% weight placed on both scientific merit and other benefits. Several systems have implemented specific procedures for bringing evaluation of likely social and economic impacts into the decision process. Project proponents are asked to describe not just the research outcomes they are pursuing, but specifically how these outcomes, if achieved, would contribute to specific social or economic objectives, and the implementation pathways that would be used to maximize the likelihood that the impacts are realized. Proposals with such additional information are then evaluated using referees specifically chosen for their expertise on impact mechanisms (both scientists with significant implementation experience, and non-scientists from the commercial and public policy sectors). These referees can be used remotely through written reports, or convened as an “impact panel”. Referees can be given specific guidelines for impact evaluation, defining the nature of the impacts that are valued, and instructed to evaluate the robustness of the implementation plans or mechanisms laid out in the proposals.

It appears that the political and policy environment will continue to increase the importance of these broader goals for research investment in OECD countries. The United Nations' Sustainable Development Goals as well as various social challenges such as global environmental problems, security concerns, energy issues and economic prosperity are a good examples of where scientific research is expected to contribute to finding solutions. For this reason, it would be very valuable to understand better how public research support, including competitive grant systems, can best contribute to these objectives. As there are a multiplicity of approaches being tried or used across the OECD member countries, ongoing study of the performance of these different approaches could shed light on such questions as:

- How suitable are competitive grant systems for fostering specific policy objectives?
- What kind of people are most capable of judging the likely benefit of research proposals with respect to particular policy objectives?
- Can these likely benefits be effectively evaluated within the same structures used to evaluate scientific merit, or are different structures needed?
- Does “tuning” research grant systems to maximize their success in achieving broader policy objectives generate tradeoffs in terms of the scientific success of funded projects, and if so how can such tradeoffs be managed?
- How can research funding agencies best achieve buy-in from the researcher community to the broadening of the evaluation process to include these objectives?
- How can the private and public sectors benefit from lessons learned in each sector to maximize research impacts?

4.5. Improving monitoring and evaluation

Most funders engage in monitoring and evaluation to some extent. Frequently such monitoring is focused on specific aspect of the operations of different schemes. For example, there have been numerous studies of the gender balance of both applicants and funded proposals. Many programmes find that female scientists are under-represented in the applicant population, but most find that the success rates do not depend on gender after controlling for other characteristics such as publication record. However, self-censorship
of female or minority scientists (relative reluctance to submit proposals), which might operate at the system level, has not been investigated adequately.

There are two levels at which to consider the issue of more comprehensive and systematic monitoring and evaluation of funding programmes. At one level, we can ask: to what extent is the funding mechanism, over time, achieving the policy objectives at which it is aimed? This is an important question, and one that science agencies around the world are increasingly being asked. It is also a very difficult question, in part because of the increasing range of objectives that funding programmes are taking on. While more and more programmes are tabulating bibliometric indicators of research success of their grantees, the extent of impact on objectives such as commercial innovation, societal benefit, quality of policy advice or well-being of disadvantaged populations will depend on a long and complex causal change, with many compounding factors. How to undertake such evaluation meaningfully is a challenge that funders are just beginning to think about.

There are major challenges to this level of evaluation, including:

- ambiguity surrounding what social and economic impacts are the objectives of funding
- long and uncertain time lags between research investment and impact
- complex chains of causality in which research investment interacts with other social and economic variables (impact pathways)
- difficulty in identifying the counter-factual world against which to compare observed outcomes to determine the impact of the research investment.

These problems can never be entirely solved but some level of inference is still possible. Some programmes are explicitly identifying the impacts that they hope to achieve and therefore will monitor. Intermediate outcomes such as investment by the private sector, and proxies for impacts such as citation of research reports in policy documents can be used to indicate possible impact along the pathway to ultimate impact. Qualitative assessment shortly after research completion can provide expert views as to whether significant benefits are likely to be realised eventually. Improved tracking of unfunded as well as funded researchers, and clever exploitation of policy changes to identify natural experiments can help to establish counterfactual comparisons.

Much of this analysis can be developed and implemented by outside researchers, if funding agencies maintain and make available basic information on their funding decisions, including who applied and who was funded and the subject of the research. If these foundational data are collected and maintained, then creative researchers can use publicly available data, webscraping, qualitative assessments and other tools to connect indicators of impact to the underlying funded and unfunded activities in an emergent “Science of Science” field (Fortunato et al., 2018).

Another level at which to think about monitoring and evaluation is inherently somewhat simpler. This kind of evaluation is focused on the operational level, trying to understand how changes in the mechanics of the selection process affect the selection outcomes. It is easier because it does not necessarily require measuring ultimate impacts. If, for example, one could determine that using two reviewers per proposal produces grant decisions that are not significantly different than those that are produced when three reviewers are used, then resources can be saved. We will still not know whether the projects we are funding are achieving our long-term objectives, but if we are funding the same projects while consuming fewer resources we are operating more efficiently.
Evaluation along this second dimension inherently involves comparing different ways of doing things. For any one funding system, making comparisons of this kind is inherently difficult. It is both politically and operationally challenging to set up comparable but distinct processes and then compare the results. Occasionally, changes in practice over time may offer possible comparisons, but the occurrence of such changes is likely to be too infrequent to be truly useful. An additional challenge is that drawing conclusions about the consequences of different approaches requires sample sizes large enough to undertake reasonable statistical inference. Many systems do not make enough funding decisions each year for comparisons across different possible approaches to yield statistically meaningful answers, even if possible comparisons across different approaches are presented.

Pooling data across multiple different funding systems offers a potential solution to the problems of both lack of comparative approaches and small sample sizes. In principle, combining data on the funding decisions of the dozens of distinct funding systems in the OECD member countries would allow some useful comparisons to be made, and some statistically valid conclusions to be drawn. There would be considerable challenges at both the conceptual and operational level in lining up different systems for comparison, and standardizing data on system operations so that they would be consistent. A fully consistent globally comparable database is not likely to be feasible. But a significant effort to begin pulling together such data, and working through the steps necessary to make them comparable, would itself increase mutual understanding of how these systems work in different contexts. Even partial data compilation would allow significantly greater understanding than now exists about the consequences of mechanism choices.

It is notable that as this report was coming to completion, the Wellcome Trust in the United Kingdom announced a new initiative for “research on research”. Improving the efficiency and effectiveness of research funding allocation mechanisms is a specific area of focus for this initiative and efforts are being made to bring funding agencies together to discuss what data they have and can share with academic researchers. It will be interesting to see the outcomes of this exciting initiative, which hopefully will inspire other research funders to develop similar schemes.
5. Conclusions and recommendations

The project found a great deal of interest among nations in utilising competitive funding to build research capacity, to select research projects with the greatest potential to achieve scientific excellence and other societal objectives, and to involve the research community in the process of selecting funded research projects. It is hoped that the findings presented in this report will aid nations and OECD bodies in continuing to better understand and refine competitive funding schemes to maximise scientific excellence and other impacts. From the report’s findings, the Expert Group offers some recommendations for further study and action to extend this project’s findings.

1. Interested countries are invited to initiate further analytical and comparative studies on the true costs and benefits of competitive funding schemes. Although there are some studies on specific aspects of competitive funding mechanisms, many of which are discussed in this report, there is little research or analysis documenting the total costs for the research system of competitive funding mechanisms. This includes not only the monetary costs of operating competitive funding mechanisms (for which there are data) but also the volunteered time of reviewers, the costs of researchers and institutions in applying for and managing competitive awards, and opportunity costs for the entire research community. At the same time, further study on the benefits of competitive funding mechanisms and explicit comparisons between different funding mechanisms could also contribute to the findings presented in the report. There are claims in the literature for the benefits of competitive funding, as described in the report, but there remain opportunities to better document some of them, especially the knowledge gains to researchers of preparing competitive applications and participating in peer review and differential benefits/costs for different schemes.

2. Research funders are encouraged to develop experiments in competitive funding, especially in easing the administrative burden often linked to peer review and for increasing efficiency. Low success rates put a strain on competitive funding by increasing the workload of reviewers per successful proposal and increasing researchers’ administrative burdens; nations are encouraged to experiment with multi-stage reviews, pre-proposals, reducing paperwork requirements for applications and awards, and alternative competitive funding schemes. In addition to further experiments with some of the mechanisms discussed in the report, there is a need for experimentation with as-yet untried funding mechanisms, taking advantage of the emergent field of “Science of Science” to improve data collection and evaluation and new measurement modes for experiments. There is an opportunity to encourage experimentation with new techniques and technologies such as the use of artificial intelligence and machine learning technologies with the aim of improving efficiency in existing funding schemes. Results should be evaluated carefully and shared with other OECD members, to facilitate collective learning.

3. Governments and research funders are encouraged to experiment with approaches to competitive funding that preserve competition while still encouraging potentially transformative, breakthrough, and/or multidisciplinary approaches to guard against potential conservatism of research. Here, experimentation is less robust than with the other challenges, so OECD members as well as philanthropic institutions and non-governmental organisation are encouraged to share good practices on creating and maintaining processes that recognise interdisciplinarity or transformative research in the face of strong disciplinary and conservative tendencies.
4. Governments are encouraged to further study how public research support, including competitive grant systems, can best contribute to broader objectives than scientific excellence. As there are a multiplicity of funding and evaluation approaches being tried or used across the OECD member countries for numerous societal objectives, ongoing study of the performance of these different approaches could shed useful light on how OECD members can better identify competitive proposals for potential impact and better evaluate the impacts funded proposals create. As with the other recommendations, OECD members are further encouraged to share their evaluations through the GSF and CSTP.

In addition, governments are encouraged to take steps to improve the collection, analysis, reporting, and accessibility of data about competitive funding to allow more robust comparisons in the future. The absence of an agreed conceptual framework and lack of reliable, standardised, data inhibits robust analysis and cross-national learning. Improving our information and data on success rates, evaluation metrics, and the other key issues discussed in this report is a necessary step in improving funding systems. There is a potential ongoing role for OECD in facilitating co-operation in this regard.
Endnotes

3. Modes of public funding of R&D: interim results from the second round of data collection based on GBAORD.
7. NWO International peer review conference.
References


## Appendix 1. Expert Group Members

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<tr>
<th>Country</th>
<th>Name</th>
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| Argentina        | María Guillermina D’Onofrio | National Directorate of Programmes and Projects
<pre><code>              | Minister of Science, Technology and Productive Innovation                     |
</code></pre>
<p>| Australia        | Kylie Emery                 | Australian Research Council                                                   |
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| Czech Republic   | Jana Bystřická              | Ministry of Education, Youth and Sports                                       |
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| European Union   | Neville Reeve               | Horizon 2020 policy Unit, DG Research                                         |
| Finland          | Tuomas Katajarinne          | Academy of Finland                                                            |
| France           | Pascal Maigné               | Ministry for Research and Higher Education                                    |
| Anne Guichard               | Ministry for Research and Higher Education                                    |
| Hungary          | Endre Spaller               | National Research, Development And Innovation Office                          |
| Japan (co-lead)  | Tateo Arimoto (co-chair)    | National Graduate Institute for Policy Studies (GRIPS)                        |
| Yasushi Sato                | Japan Science and Technology Agency (JST)                                     |
| Keiko Matsuo                | Japan Science and Technology Agency (JST)                                     |</p>
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<td>Korea</td>
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<td>Adam Jaffe (co-chair)</td>
<td>Motu Economic and Public Policy institute</td>
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<tr>
<td>(co-lead)</td>
<td>Richard Walley</td>
<td>People, Science and Enterprise Policy</td>
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<td>Centre for Social Studies, University of Coimbra and FCT</td>
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<td>Luis Sanz Menendez</td>
<td>CSIC Institute of Public Goods and Policies, Ministry of Economy, Industry and Competitiveness</td>
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<td>Mats Johnsson</td>
<td>Ministry of Education and Research</td>
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<td>Maisie England</td>
<td>Research Councils UK</td>
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<td>US (co-lead)</td>
<td>Kei Koizumi</td>
<td>Office of Science and Technology Policy, then AAAS</td>
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<td>OECD</td>
<td>Frédéric Sgard</td>
<td>GSF Secretariat</td>
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<td></td>
<td>Taro Matsubara</td>
<td>GSF Secretariat</td>
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<td></td>
<td>Carthage Smith</td>
<td>GSF Secretariat</td>
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</table>
Appendix 2. Survey questionnaire

Request for Information

The focus of the inquiry is publicly (direct) funding programmes for the support of scientific research that operate through some kind of request-for-proposal mechanism, under which proposals are evaluated relative to stated criteria, and the proposals that best meet the criteria receive funding. The goal of the activity is to characterise how these programmes are structured and operated in different countries, to synthesise existing evidence on the relative performance of different structures in the context of particular policy objectives, and to gather and synthesise available qualitative and quantitative evidence on impacts for different competitive systems.

There is a large diversity of research funding mechanisms, which broadly fall under the following categories:

1. institutional block funding to research performing entities (includes block grants for teaching and research as this is often not split out);
2. competitive funding for centres of excellence (Institutional competitive funding)
3. competitive funding for individuals or groups (competitive project-based funding)
4. fellowships/scholarships
5. other (such as funding for collaborations/consortia.

The purpose of this questionnaire is to collect basic information on the existence and structure of relevant funding schemes that fall under categories 2 and 3 in the participating countries, as well as on the existence of any evaluation studies that may have been carried out with respect to these programmes. This information will be synthesised to provide a preliminary baseline of information that we will use to structure more in-depth information collection.

There are certainly multiple funding schemes under your purview that fit this description. Please provide information on what you consider as representative/informative mechanisms (one copy of the questionnaire for each of these, except for question 1 on generic research funding information).

If there are other schemes that are no longer running, but which operated sufficiently recently that relevant information can be provided, please complete one copy of the questionnaire for each of these as well.

The questionnaire is designed to gather as much information as possible, recognizing that countries and systems differ widely. Please respond as feasible. Feel free to skip questions that are not appropriate for your system.

1. Generic research funding Information

   This is to provide some general background information on the national research funding context.

   What is a (approximate) percentage of funding coming from competitive/granting system vs institutional/block funding in your country (if some project funding is not distributed
through competitive mechanisms, please distinguish); what is the evolution over the last 10 years.

What are the main sources of research funding (for both institutional and competitive funding, i.e. research councils or agencies, ministries, EU funds, foundations, etc.) and their respective share for your country; what is the evolution over the last 10 years.

2. Basic Mechanism Information

*Please provide information on a typical/recent research funding scheme from your country/organisation*

Name of scheme:

- Approximate annual total of research funding granted (in local currency):
- Approximate annual number of proposals received:
- Approximate annual number of grants funded / % of success
- Approximate annual cost for operating and administering the programme:
- Period of time that this scheme has operated in approximately its current form:

3. Purpose of the Programme

*Please check all that apply to the scheme:*

- funds individual researchers or laboratories/teams
- Can fund non-national researchers/labs
- funds “blue sky” or investigator-driven research
- funds research devoted to particular mission(s) such as:
  - economic development
  - environment
  - health
  - energy
  - agriculture/forestry/fisheries
  - other:
- has particular mechanism for funding young researchers
- funds research projects proposed by universities and independent research institutes
- funds research projects proposed by firms
- other key features not covered above:

4. Nature of funding awards made

Duration of grant funding commitments made:

Is there an explicit process for renewal or reapplication that is different from new applications:

Range of funding awards (per grant) made:
Is co-funding (i.e. funding from different sources requirement) a consideration in the programme; and if so is there a mandatory co-funding formula?

5. Request for Proposal (RFP) process

Frequency with which proposals are solicited:

Time duration between publication of RFP and deadline for submission:

If the programme targets or has different review approaches for different types of submitters (such as young/new investigators; individuals versus teams; multidisciplinary teams; or multi-institutional teams), please describe:

Stated criteria against which proposals are evaluated:

If there are multiple criteria with explicit numerical weights given to different criteria, describe the weighting scheme:

If funding is open to non-national researchers/labs, are there specific conditions? What is the language of the request for proposal?

6. Proposal evaluation Process

If there is a website that describes the evaluation process, please provide the URL:

Please indicate which of the following evaluation mechanisms are used:

- Initial screening so that not all proposals receive full evaluation?
  - if used, what fraction of proposals are thereby eliminated

- External referees or reviewers?
  - if used, approximately how many referee requests are made for each proposal (including rejected requests/referees which are not available/willing)
  - If used, how are reviewers recruited (from a general pool of previous reviewers/reviewers suggested by the research community or stakeholders, from a specific pool of experts which has agreed in advance to review proposals for the specific call?)
  - approximately how many reports are received for each proposal
  - is there a minimum number of reviews required
  - are referee reports shared with the proposal submitters?
  - are proposal submitters given an opportunity to respond to referee reports?

- Review panels or committees?
  - if used, what is the nature of their decisions (e.g. specific funding decisions; numerical ranking of proposals; qualitative recommendations)?

7. Studies or evaluations of the grant process

Have any formal or informal studies or evaluations been undertaken to evaluate how well the grant review process works?

If so, please provide a copy of any reports from such studies.

If such reports are not available, please summarize the main findings of such studies.
8. Studies or evaluation of the impact of the funding scheme

Have any formal or informal studies or evaluations been undertaken to evaluate the impact of the funding scheme/initiative?

- What is the impact of the funding scheme on research excellence (publication rate/impact factor, international collaborations)?
- What is the impact of the funding scheme on scientists careers (average age of recipients and evolution, percentage of permanent vs fixed-term contract and evolution, etc.)?
- What is the impact of the funding scheme on innovation/technology transfer (patent, spin-off, staff mobility with industry, etc.)?
- Other types of impact

9. Other relevant information

If there is any other information you would like to provide at this stage, please do so here
<table>
<thead>
<tr>
<th>Country</th>
<th>Funding scheme</th>
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<tbody>
<tr>
<td>Argentina</td>
<td>Scientific and Technological Research Projects (Proyectos de Investigación Científica y Tecnológica - PICT-) of the Fund for Scientific and Technological Research (FONCYT)</td>
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<td>Odysseus</td>
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<td>Inter-Excellence</td>
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<td>Centers of Excellence</td>
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<td>Denmark</td>
<td>DFF–Research Project 2</td>
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<td>Estonia</td>
<td>Post-doctoral research programme</td>
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<td>Agence Nationale de la Recherche, Annual generic call</td>
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<td>EQUIPEX</td>
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<td>Creation of Innovation Centers for Advanced Interdisciplinary Research Areas Program</td>
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<td>Portugal</td>
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Appendix 3: Survey interviews

The objective of this survey is to gather information in order to identify major issues and existing successful practices related to the processes of competitive research funding.

Interviews have to be flexible to appreciate the variations between different countries and organisations.

Questions are designed for the two categories of stakeholders: administrators/managers of funding bodies, and panel chairs/experts involved in proposal evaluation.

Questions will have to be adapted/précised for each interviewee.

1. Brief presentation of the funding body (if not already provided by the questionnaire):
   - objectives/structure/funding provided
   - types of funding schemes

2. Brief presentation of the general funding mechanism with added information on specific mechanisms (if available and not already provided by the questionnaire)
   - objectives/funding provided
   - general infos on the call for proposals
   - general infos on reviewing process
   - general infos on impact (scientific output, socio-economic impact, structuring impact…)

3. Generic issues
   a. Context/importance of the mechanism in the research system
      - How unique/important is the funding mechanism in the national context?
      - How old is the mechanism?
      - What has been the evolution of the funding provided through the scheme over the years? (total amount of funding available)
   b. Matching priorities to scientific excellence
      - How is the funding scheme integrated into the broader national research priorities?
      - If the scheme has objectives beside scientific excellence, what is the approximate weight of the various objectives vs scientific excellence?
   c. Target audience / Success rates
      - What is the expected target audience for the call(s) – is it known (approx. number, proportion of the target scientific community)?
      - Is the success rate as expected/appropriate for the call(s)?
      - Was anything done to affect the success rate (i.e. broaden/restrict the call(s) for a bigger/smaller audience, adapt the objectives)?
Peer review process

- How are reviewers recruited? Do you encounter difficulties to recruit appropriate experts? What solutions have you implemented?
- What are the most important criteria used to assess the proposal? Are there explicit/written criteria and/or marks set in the “call” to assess the proposals? Do you use specific indicators/metrics (bibliometrics etc.) in the reviewing process? Is it satisfactory? What solutions have you implemented to improve the process (to select the “best” proposals according to priority criteria)?
- How many steps are included in the reviewing process? Is the system appropriate to select the best proposals or too conservative? Was there any changes implemented to improve the selection?

Impact monitoring and measures of success (tacit and explicit)

- Is the impact of research funded through this scheme evaluated? Based on what criteria?” (strategic objectives of the scheme, more general objectives in the scientific system…)
- “How do you evaluate the success of an award?”

Acceptability to the scientific community / Cost to the research community/ Efficiency

- What is the feedback of the funding mechanisms from the user side? Is there a mechanism to receive user feedback on the decision? On the process?
- How complex/time consuming is the funding mechanism for the users? Have simplifications been implemented?
- How long is the process from calls to decision and to receiving fund? Is it satisfactory? How can need for quality in the process and the need for rapid response be improved?

Open questions

- What does not work/what did not match expectations?
- What are the perceived problems in the system?
- What is impeding the effectiveness of the funding mechanism?
- What are the barriers in achieving targeted objectives
- What has been tried, what worked?

4. Issues related to specific types of funding programmes

a. Targeted support for young (or senior) researchers

- What is the objective of the funding scheme
- How is the review process adapted to the targeted audience (specific criteria, metrics…)?
- What are the challenges of such a scheme? How were they addressed?
- How successful is the funding scheme? How is it evaluated?
b. Breakthrough science/innovative funding schemes

- What is the objective of the funding scheme
- How is the review process adapted to the objective (specific criteria, specific reviewers, metrics…)?
- What are the challenges of such a scheme? How were they addressed?
- How successful is the funding scheme? How is it evaluated?

c. Societal challenges and inter-disciplinarity

- What is the objective of the funding scheme
- How is the review process adapted to the objective (specific criteria, specific reviewers, metrics…)?
- What are the challenges of such a scheme? How were they addressed?
- How successful is the funding scheme? How is it evaluated?

List of experts interviewed

Funders:

- Deborah Jackson (United States); NSF Engineering Research Centers scheme
- Bob Finkelstein and David Owens (United States); NIH Bridge funding program (R56 award)
- Ravi Basavappa (United States); NIH Pioneer Award Program
- Yves Leconte (France); ANR LabEx scheme
- Kylie Emery and Stephen Buckman (Australia); ARC national competitive grants, discovery grants, linkage grants, career grants
- Prue Williams (New Zealand); Ministry of Business, Innovation & Employment Smart Ideas and Research programmes grants
- Juliet Gerrard (New Zealand); Marsden Fund scheme
- Kathryn McPherson (New Zealand); Health Research Council
- Mirjam Rigterink (Netherlands); NWO Veni Vidi Vici scheme
- Björn Halleröd (Sweden); Research Infrastructure Council scheme
- Gunnar Öquist (Sweden); Swedish Research Council scheme
- Göran Marklund (Sweden); Vinnova innovation scheme
- Ellen-Kristina Kock Rasmussen (Denmark); Danish National Research Foundation Centers of excellence and Niels Bohr Professorships schemes
- Søren Haselmann (Denmark); Innovation Fund Denmark Grand Solution scheme
- Mads de Wolff (Denmark); Danish Council for Independent Research DFF International Postdoctoral Grant, Starting Grand and Project 1&2 schemes
Yuko Shimabayashi (Japan); JST agency Strategic Innovation Promotion (SIP) programme

Masashi Hara (Japan); JST Core Research for Evolutional Science and Technology (CREST) programme

Kazuko Shimizu, Sachi Yabuno and Mika Ikeda (Japan); JSPS World Premier International Research Center Initiative (WPI)

Marta Lazarowicz (Poland); Foundation for Polish Science programmes

Marcin Liana (Poland); National Science Centre programmes

Carlos Cassanello & Jorge Blackhall (Argentina); Fund for Scientific and Technological Research (FONCYT)

Jean-Pierre Bourguignon (European Union); European Research Council programmes

Tiina Petäinen (Finland); Strategic Research Funding programme from the Academy of Finland

Pamela Moss (Canada); Natural Sciences and Engineering Research Council (NSERC) Strategic Partnerships Grants

Torsten Fischer, (Germany), DFG Individual grant programme

Panel members/chairs:

Maria Otegui (Argentina), FONCYT

Héctor Targovnik (Argentina), FONCYT