OECD Global Science Forum

Draft summary of the GSF Virtual workshop on “Effective Policies to foster High-Risk/High-Reward Research”

22 April 2020, via ZOOM.

This document is an Annex to the summary record of the GSF 42nd meeting DSTI/STP/GSF/M(2020)1, held on 23-24 April 2020. It provides a short summary report of the GSF virtual Workshop on “Effective Policies to foster High-Risk/High-Reward Research” which took place on 22 April 2020.

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High-risk, high-reward (HRHR) research is defined as research that (1) strives to understand or support solutions to ambitious scientific, technological, or societal challenges; (2) strives to cross scientific, technological, or societal paradigms in a revolutionary way; (3) involves a high degree of novelty; and (4) carries a high risk of not realising its full ambition as well as the potential for transformational impact on a scientific, technological, or societal challenge.

The objective of this international workshop was to discuss key challenges for promoting HRHR research and to identify potential policy actions based on case studies.

This workshop was also the opportunity to discuss some of the challenges for Covid-19 research funding, such as how to determine priority topics, how to encourage new ideas and how to set up a fast-track selection of proposals without sacrificing quality.

Session 1: Introductory presentation (session chair: Frédéric Sgard, GSF secretariat)

**Keynote presentation: High-Risk/High-Reward Research: history, challenges and a look forward**

*Jim Kurose, Professor at University of Massachusetts, USA, former Assistant Director of the National Science Foundation (NSF)*

Professor Kurose’s presentation was centred on the evolution of HRHR research in the USA, and particularly at the National Science Foundation (NSF). HRHR, which is characterised by challenging existing paradigms and bold innovation, is complementary to the more traditional evolutionary research process that consists in a persistent, step-wise

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¹ The workshop, which took place prior to the 42GSF meeting was attended by ~100 people including: the HRHR Expert Group members; invited speakers and GSF Delegates.
work built on the discoveries and advances of others. He identified two categories of high reward: pure science breakthroughs and breakthroughs fuelling the economic engine and society.

In the United States, a number of important policy reports were published in the 2000’s that highlighted the need to support HRHR research, such as ARISE: Advancing Research In Science and Engineering: Investing in Early-Career Scientists and High-Risk, High-Reward Research (AAAS, January, 20092) and the report from the House Committee on Science and Technology: Investing in High-Risk, High-Reward Research (October, 20093. Federal research agencies such as the National Institutes of Health (NIH) and the NSF have set up a number of dedicated research funding programme to encourage HRHR research over the years. Supporting schemes for Research Centres (as with the Interdisciplinary centre-scale programs) are also important because they provide support for a timeline of 5 to 10 years for interdisciplinary research teams.

The need to take into account HRHR in research funding was further strengthened at NSF by introducing a new evaluation criterion in the merit review for all proposals, which request evaluators to assess “To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?” The goal was to counter the traditional averaging of panel process, and to be on the lookout for high-variance evaluations. The science expertise of (NSF) program managers is critical; they need to have the knowledge and training to work with reviewers to identify HRHR research proposals and advocate supporting them.

Measuring the impact of HRHR programmes is a challenge, as time to impact can be very lengthy, particularly in basic research, and traditional metrics are poorly adapted to this challenge.

Because even HRHR research builds on the work of others and does not happen in isolation, it is important for research agencies to have a portfolio approach, rather than manage projects on individual basis. Similarly, managing convergence (the convergence of disciplines in new spaces) is equally important: many High-Reward and “grand” challenges project are situated at the boundaries of disciplines, while research process and evaluation still largely works in silos.

Finally, Professor Kurose underlined the need for high-level support: HRHR research requires long-term commitments, results are by definition not guaranteed and reward may occur only after a long period of time. HRHR research especially requires support from government officials and potentially from the OECD to provide top-level cover for program managers and researchers to keep pursuing HRHR research.

During the discussion, the need to train panellists in review, including in the review criteria, and to have the proper disciplinary expertise mix to be able to evaluate proposals was highlighted. NSF program directors select panels, based on NSF policies and procedures.

Risk-mitigation was also underlined: at NSF-supported centres, a risk mitigation plan is set up with active, collaborative management between the centre and NSF staff. This is an ongoing process to minimise failures. However, real “failure” is rare as most well selected projects produce new knowledge, even though this may not correspond to what was originally planned. Furthermore, as indicated in the presentation, it is important to have a portfolio vision rather than to judge success based on individual projects.

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2 https://www.amacad.org/publication/arise-advancing-research-science-and-engineering
3 https://www.govinfo.gov/content/pkg/CHRG-111hhrg52484/pdf/CHRG-111hhrg52484.pdf
Session 2: Funding mechanisms and evaluation processes (session chair: Jessica Robin, co-chair GSF expert group on HRHR)

Speaker presentations:

- **From traditional funding schemes toward more out of the box research**
  *Marc Zbinden, Head of Division, Interdisciplinary and Internations Co-operation (InterCo) at the Swiss National Science Foundation (SFSN)*

- **Developing specific funding schemes for HRHR**
  *Lisa Higgins, Head of Challenge Research in Science Foundation Ireland (SFI)*

- **Let us experiment with how to identify and support innovative research!**
  *Thomas Sinkjær, Head of Talent Programmes at The Lundbeck Foundation*

- **HRHR programmes on societal challenges**
  *Jens Oddershede, former chair (2014-2020) of the Danish Council for Research and Innovation Policy*

Funding for HRHR at the Swiss National Science Foundation (SFSN) was initiated through the 2009 SINERGIA scheme, which was focused on promoting interdisciplinary and collaborative projects that propose breakthrough research. Although this mechanism proved to be successful and brought a HRHR culture in SFNS and in review panels, fulfilling the three main conditions (collaborative, interdisciplinary and breakthrough research) was challenging. And this scheme aims to support fairly ambitious projects that required contingency planning. A complementary funding scheme was thus set up in 2019, SPARK, that funds the rapid testing or development of new scientific approaches, methods, theories, standards, innovation, etc. Projects must show unconventional thinking and the focus is on promising ideas of high originality, with minimal reliance on preliminary data. It includes a double-blind evaluation with no panel discussions to minimize bias and herd effects.

Early feedback shows that blind evaluation is a challenge, incremental proposals still do come in, and a common definition of ‘unconventional’ is needed. A final rating is difficult in cases where there are discordant reviews (high variance). Nevertheless, early findings are promising with a large group of early-career and first-time applicants. However, some gender bias was seen in the proposals, with far more male than female applicants, suggesting that men are more willing to oversell their proposals than women, a factor which will need to be corrected.

In Ireland, the Science Foundation Ireland (SFI) also initiated various funding schemes to support HRHR. The Future Innovator Prize is a funding scheme that aims at supporting the development of high risk, novel and potentially disruptive technologies. The process is very much team-focused, and each team has a societal impact champion, which can come from a different background than the investigator and help linking the project to economic or societal needs, as the objective is to drive toward impact 3-5 years after conclusion of the project.

Awards are given after a panel-based review, and there are panel interviews and extensive dialogue between teams and program managers at subsequent stages. Clear guidance is offered to reviewers, with many criteria that touch on aspects of HRHR research. The stage-gate funding process allows for small, initial funding to be allocated to multiple projects, which can adjusted to larger funding for fewer teams at later stages. Among the lessons learned is the need to de-risk the portfolio at each stage.
Private foundations are also important providers for HRHR funding. The mechanism set up at the Danish Lundbeck Foundation is a good illustration, in a country (Denmark) where up to 60% of research funding to academia is funded by private foundations.

One of the main challenges for funding HRHR research is the peer review system: The peer review system was designed for ~30% success rate and worked well then. But these days, with success rates often lower than 20%, this is not the case anymore. We have a challenge funding HRHR research through a peer review system that is ill equipped to make fine distinctions between proposals and that tends toward conservatism.

The Foundation is trying to find ways to fund truly innovative projects through identifying new ways to fund “out of the box” research. It set aside 10% of the portfolio for innovative mechanism. An experimental scheme requires a 4-page anonymous idea that is reviewed separately from the accompanying CV, which is reviewed by a different set of people. Reviewers do not meet in panels but give ratings. Each reviewer has one decisive vote, that is the ability to approve one proposal even if other reviewers rate it low. This can ameliorate the problem of risky proposals having high variance in review scores.

Also challenging is the support of HRHR research for addressing societal challenges. Societal challenges tend to favour "what we already know" or "more of the same". Societal challenges as research areas are often established in connection to one or a few scientific disciplines. The owners of this research area, or perhaps even the advocates, often play a significant role in shaping the research. Furthermore, there is a challenge in being truly interdisciplinary. Thus, call for proposals, assessment methodology, carrying out research in actual interdisciplinary teams, communication and publication process are all different from traditional research.

Danish research programmes on societal challenges are built from a new Research Catalogue (presently Research 2025) developed every five years, that identify a number of societal challenges. This catalogue provides policymakers with a framework to fund mission-oriented research. Developing the catalogue involved a broad number of stakeholders and processes. However, the present COVID19 pandemic shows that foreseeing important societal challenges is not always straightforward.

Research on societal challenges often has strong connexions with political agenda and raises strong expectations for results. However, public funders have an accountability issue with taxpayers and therefore have less tolerance for risk. In societal challenge research, everybody wants the High-Rewards but few are ready for the High-Risk element. It should be underlined that, particularly in this domain, focussing on outcome and expected results is not the right way to go.

In the general discussion that followed the speakers presentations, it was stressed that a portfolio approach was very important when constructing or evaluating HRHR research. Having a portfolio of funding schemes is also important to allow for innovative approaches.

When evaluating projects, there is a need to look carefully at both positive and negative reviews. The temptation is to go for all-positive reviews when success rates are low. In a ranking process, one negative review can put a proposal below the pay line. Having a system where each reviewer can identify one high-risk proposal for funding, even if other reviewers are negative, is a potential solution.

Connecting immediate outputs to solving societal challenges remains a complex issue. There are various opinions whether it is enough to just put research results out there, or whether there is a need for the funder to be more active in connecting research teams and potential users.
Key lessons

- The criteria and evaluation process for HRHR proposals are very important and must be carefully developed to encourage risk-taking and avoid bias – including gender bias. Reviewers need to be briefed and trained;
- Continuous contact between funding programme managers and research teams is important to lower risk at the various stages of a project, facilitate potential re-orientation and optimise the likely impact;
- Evaluating success of HRHR research should not be carried out at the individual project level but rather through a portfolio approach.

Session 3: Assessing the effectiveness of HRHR programmes (session chair: Heung-Deug Hong, co-chair GSF Expert Group on HRHR)

Speaker presentations:

- From blinkering to broad-based bibliometrics
  Diogo Machado, Senior Consultant/Economist at Technopolis and consultant for the OECD GSF

- From traditional to HRHR funding mechanisms - A comparative perspective from Japan
  Tateo Arimoto, Professor at the National Graduate Institute for Policy Studies (GRIPS), and Kazuhito Oyamada, Fellow at the Center for Research and Development Strategy (CRDS), Japan Science and Technology Agency

- The European Research Council (ERC) experience
  Jean-Pierre Bourguignon, former President of the European Research Council (2014-2019)

Bibliometric indicators are widely used in research funding and evaluation decisions. However, their misuse may have a detrimental effect on HRHR research. Novel research often tends to be published first in lower impact journals, and take longer to be fully recognised. The solution is not necessarily to take unassessed risk but to balance risk and to use indicators that better integrate risk-taking.

A number of new indicators have been developed in recent years that try to integrate HRHR knowledge. One example is that developed by Wang et al (2017) which is designed to assess novelty, and is based on the principle that the further apart scientific domains are combined into a work or publication, the riskier is the combination and the more likely is the research novel.

A test analysis was presented for an algorithm, which identifies scientific articles that cite journals, which have never previously been cited together. Each new journal combination can be weighted and related to the level of novelty. This “novelty indicator” can be used to explore publication outputs, globally or per field of research. Time series analysis suggests a potential link between novelty and the overall level of research funding (novelty seems to decline 2-3 years after drops in research funding).

It should be noted that, although this indicator is based on relationships between science domains, it is not a measure of interdisciplinarity but a measure of how risky/novel combinations of disciplines are.

These results show that it is possible to develop new indicator tools that can help assess knowledge production beyond citation impact, and integrate novelty or other characteristics.

Japan has, over the last ten years, become increasingly aware of the need to develop more HRHR projects, and three funding mechanisms have been launched sequentially to respond to policy demand for more transformative research: FIRST (2009-13), IMPACT (2014-18) and MOONSHOT (2020-2030).

FIRST was not initially geared towards HRHR but focused on the excellence of the Principal Investigators (PIs), which enabled it to support a number of HRHR projects. IMPACT provided a lot of responsibility and autonomy to programme managers and was based on the US DARPA system. MOONSHOT is still in preparation and is more of a mission-oriented programme.

These programmes delivered a number of successful cutting-edge projects, which led to longer term research and development initiatives, including some practical developments in industry. Flexibility was very important in project management and the adoption of a stage-gate selection system helped promote HRHR projects. However, the absence of explicit criteria for risk taking, and the lack of a culture of risk taking among research agencies and researchers presented significant challenges.

Another specific issue for the first two programmes was the lack of continuity. Both of these programmes were discontinued, at which point most of the PIs went back to their original laboratory rather than follow up their projects, which had to be transferred to other groups for further development.

Evaluating the success of projects also proved challenging, both ex ante (as traditional evaluators do not necessarily have a culture and understanding of risk-taking) and ex post, as “success” may not be understood the same way by different stakeholders.

In the European Union, the European Research Council (ERC) was designed from the start to privilege HRHR research; HRHR research is a priority for the ERC leadership and for its scientific council (similar to the US National Science Board). Scientific quality is the only criterion for ERC funding, which helps in the selection of potentially challenging projects as no other criteria interfere in the review process.

Applicants are told they need to be ambitious. PIs are fully in control of their project and they are free to make amendments during the course of their research. Reviewers are strongly advised to look for risk taking. It is notable that there are a number of ERC grantees whose projects were originally rejected by national funding agencies because they were not considered to be feasible.

External evaluation of ERC programmes suggests that a significant number of projects have led to breakthrough research; evaluators consider about 12-15% projects to be of HRHR nature. True “failures” are rare because of the flexibility of the system that allow investigators to change course during their research.

The general discussion that followed explored how best to evaluate the long-term impacts of HRHR projects. There was a consensus on the need for better indicators than the standard and limited set of bibliometric indicators, and there are opportunities for new quantitative indicators beside citations analysis. Applying the scientific method to evaluation of research and including robust counterfactual analysis is important.
The question of how impact relates to the objectives of HRHR research was also raised. The impact of HRHR research that is directed towards defined (societal) challenges may be easier to evaluate than more fundamental research, where the scientific impact may be fully understood only after many years. There was general consensus that whilst HRHR research and interdisciplinarity are often linked, this is not always the case.

**Key lessons**

- New indicators, such as those assessing novelty, should be used and further developed alongside traditional bibliographic indicators for evaluating HRHR research;
- Flexibility, in both proposal selection and in the use of research funding by researchers, is very important for the success of HRHR projects;
- A culture of risk-taking needs to be acquired by evaluators.

**Session 4: Policies that may affect HRHR research programmes (session chair: Frédéric Sgard, GSF secretariat)**

**Speaker presentations:**

- **Towards a new balance in the recognition and rewards of academics**  
  *Johan Huysse, policy advisor at the Association of Universities in the Netherlands (VSNU)*

- **Supporting research through research assessment**  
  *Catriona Firth, Associate Director for Research Environment at Research England*

- **Promoting risk-taking and HRHR research**  
  *Jessica Robin, Section Head of Integrative Activities in the Division of Earth Sciences at NSF and co-chair of the GSF Expert Group on HRHR*

- **The LIGO gravitational waves project: a successful HRHR story**  
  *Michael Turner, Senior Strategic Advisor at the Kavli Foundation*

Human resource management is important in HRHR research. It is important for researchers to be able to demonstrate personal achievements in order to have career progression. In the Netherlands and in many other nations, teaching and research are equally important at research universities and individual performance evaluations relate to both activities.

Researcher evaluation is traditionally based on publications and citations, but impact and social relevance are becoming increasingly important. There is a need for a new evaluation matrix that should be agreed at an international level because researchers are internationally mobile.

Changing evaluation criteria might help to create more innovation and risk-taking in research, since as long as traditional criteria are being used, risk-taking and HRHR research may be detrimental to a researcher’s career.

If the evaluation individual researchers can impact on their capacity to undertake HRHR research, so also do the research assessment processes for institutions. In the UK, the Research Excellence Framework (REF) is used to conduct a periodic assessment of UK core funding to Universities. For each REF submission, three distinct elements are
assessed: the quality of outputs, their impact beyond academia, and the environment that supports research. Equity is important, and expert review panels are now requested to use metrics sparingly. Interdisciplinarity, often an attribute of HRHR research, is increasingly recognised and valued, and evaluation panels have been structured to take it into account.

However, experience shows that universities remain risk averse in their submissions to REF and it is unclear whether the framework is truly able to evaluate HRHR research performance. Nevertheless, block funding can be used to experiment with bold ideas, so it is worth investigating as a funding mechanism to foster HRHR.

As indicated during the introductory keynote presentation from Professor Kurose, the need for HRHR research in the United States was underlined in several reports in the 2000s. In a more recent 2012 report from the President’s Council of Advisors on Science and Technology on The Future of the U.S. Research Enterprise, the authors still noted that there was too much federal spending on incremental research and highlighted the need to support more HRHR and transdisciplinary research. This led the NSF to include a special criterion related to risk taking in its standard merit review process for research proposals.

Several dedicated NSF funding mechanisms have been developed for HRHR. These included the Small Grant for Exploratory Research (SGER) up until 2007 and this was followed by the Early Concept Grant for Exploratory Research (EAGER) and the Research Advanced by Interdisciplinary Research and Engineering (RAISE) initiatives. These latter two funding schemes are largely complementary. EAGER supports exploratory work in early stages on untested, but potentially transformative, research ideas or approaches for two years. RAISE proposes larger grants for five years to fund discoveries at the interface of disciplinary boundaries. To lower the traditional risk-adverse effect of external panels, only an internal merit review is conducted for RAISE, and a proposal needs approval from two NSF program managers in distinct fields.

As indicated earlier, HRHR projects may take a long time to come to reach fruition and require long-term commitments. The Laser Interferometer Gravitational-wave Observatory (LIGO) is a good example. LIGO was a very ambitious project, which required many elements for success. Ambitious and expensive long-term infrastructure projects must be selected carefully and need strong and sustained community support if they are to succeed.

One of the lessons from the LIGO case is that, if understanding high risk is relatively easy (in this case, the technical difficulties were numerous and some even doubted that gravitational waves existed), what is really needed is to have a deep understanding of the potential for high reward. This can be very difficult for fundamental research and the role of experienced and scientifically knowledgeable programme managers is crucial.

Ambitious projects cannot always be done in small steps, sometime a big leap is needed; this requires sufficient time and resources, a tolerance to failure and a will to keep trying, lots of flexibility as well as a good risk-mitigation strategy (review, oversight).

All research funders are not necessarily equally well equipped to support HRHR projects. This relates to their mandate and remit as well as their governance, staffing and mechanisms for support. The LIGO story lasted for over 30 years before success was achieved. The creation of the NSF Major Research Equipment and Facilities Construction (MREFC) budget line was critical for the project, as well as the flexibility and understanding of several successive NSF Directors. In the end, decision-makers must be convinced that such long-term, HRHR projects can pay-off, so when success arrives, it should be well communicated.

5 https://orise.orau.gov/cdc/documents/pcast-future-research-enterprise.pdf
The general discussion that followed focused on the conditions for success for HRHR projects. Flexibility on the part of program managers is important. However, to make the flexibility work, you need expertise. Checks and balances are also needed to make sure HRHR research support is does not conflict with the need for transparent accountability of public funds.

There is no one-size-fits-all mechanism to support HRHR research: People-based approaches, such as the Howard Hughes Medical Institute awards, can work very well, as can DARPA’s idea-based approach at the other end of the spectrum. For both mechanism, you need very different review systems, but the key to both is encouragement and tolerance of risk.

Another important element that emerged is the need for funders and researchers to work together. Active engagement and permanent dialogue between funders and researchers is critical: funders should not just fund and forget.

Finally, the balance between core institutional funding and competitive grant funding can be important; core institutional funding may be very useful for exploratory or preliminary research but may be inadequate for more ambitious HRHR projects. The intra-institutional mechanisms for allocating core funding also vary considerably but in the ideal situation core and competitive research funding can play complementary roles in supporting HRHR research.

**Key lessons**

- Evaluation criteria for both individual researchers and research institution can play an important role to encourage or discourage HRHR research;
- Support for HRHR requires a diversity of complementary funding mechanisms, which are adapted to different objectives and the nature of the projects required to achieve these;
- HRHR research requires long-term commitment from funders and science policy-makers.