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ProGReSS

Innovation *for* Society
Funder Reports

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Executive Summary

Responsible research and innovation is ethically acceptable, sustainable and drives towards the common good, i.e. adheres to societal desirability. Innovators and researchers respond to incentives, especially pecuniary incentives. As such, the state and private funding bodies have means to drive innovation towards major societal aims and challenges. This report summarises public and charitably funded efforts from around the world (Australia, Brazil, China, Germany, India, Japan, the Netherlands, South Africa, the UK, and the United States) to achieve societal desirability. In addition, it maps the action points of the European Commission's Responsible Research and Innovation (RRI) agenda (i.e. societal engagement, open access, gender equality, ethics and governance and science education) onto the approaches of funders world-wide.

Country reports cover both public and significant private or charitable funding for research utilising both direct and indirect mechanisms. In direct funding, the researcher deals directly with the funder, for instance, through applying for a fellowship, a project grant or an excellence centre. In indirect funding, the grants go through an intermediary before reaching the researcher. Most often this intermediary is a university, which - in turn - is often assessed on its performance before receiving funding for further distribution to researchers. The new UK system of Research Excellence Framework (REF) is a good example for this approach.

Diagram 1: Schematic Representation of Report

It is evident from the reports that national approaches to funding research and innovation have much in common across all countries. For instance, almost all employ both direct and indirect funding mechanisms. However, the way in which these funds are administered and the criteria by which they are made available to researchers, depend to a large extent on national political priorities and the current state of development of the countries in question. In addition, transparency about funding criteria and decision-making varies significantly between countries.

Almost all countries state that socio-economic development and societal impact are key objectives of funding research and innovation. However there are substantial differences in how socio-economic development is perceived and considerable divergence in the way that the potential for a research initiative or project to contribute to these objectives is evaluated and its subsequent impact measured. These differences relate to important factors such as national political structures and challenges, relative wealth and its distribution, burden of disease and level of overall development.

Whilst, at first sight, the wealthier nations seem to be more supportive of funding basic research and the major emerging economy (China) directing more funds towards research with the potential of addressing societal challenges directly, a shift seems to have occurred in the new millennium. The impact movement is rushing through developed nations with key mottos such as

"bench to bedside" or "translational research" requiring that research must lead to an application. This is also obvious from the US' National Science Foundation's broader impacts criterion and the introduction of impact into the UK REF. At the same time, the Chinese National Science Foundation has - since 2000 - increased its emphasis on funding basic research in order to improve international competitiveness.

For other emerging economies such as Brazil, India and South Africa, funding is still strongly connected to development goals with the aim of improving the health, wellbeing and cohesion of the national society. While this is, of course, true for all countries, it is particularly relevant to those where problems of exclusion, economic inequality, environmental concerns and the burden of disease are acute and this is reflected in the criteria used for distributing research funds to science and technology. Hence, guidance for Brazil's funding seeks to "generate knowledge and innovation that contributes to solving national problems" and "reduce geographic inequalities in research by directing a minimum of 30% of their resources to projects in the North, North-eastern and Centre-West regions". For India, the overall objective of research funding is to promote a rapid rise in the standard of living. A key aspect of the Indian research agenda is therefore to address the major developmental needs of the country, such as food security, energy and environmental needs, addressing the water challenges and providing technological solutions to affordable health care requirements. Likewise, South Africa's research funding strategically focuses on major challenges such as energy security, climate change and the role of science in stimulating development.

A more detailed analysis of the funding reports will be produced with the Funding Matrix, a separate, later deliverable. Whilst the above observations are therefore broad, specific results were obtained when mapping funding requirements against the European Commission's five RRI action points: societal engagement, open access, gender equality, ethics and governance; and science education. The following table shows that ethics governance is the most widely accepted RRI action point globally, whilst societal engagement is the least commonly practised. Only the Dutch "Responsible Innovation" program requires full societal engagement from their researchers for each funded project.

Table 1: RRI Action Points Globally

RRI criterion							**Trust**	
Societal engagement	✗	✗	→*	✗	✓	→*	→*	→*
Open access	✓	✓	✓	✗	✓	✓	✓	✓
Gender equality	→*	→*	✓	→*	✗	✓	→*	✓
Research and innovation governance	✓	✓	✓	✓	✓	✓	✓	✓
Scientific education	→*	✓	→*	→*	✓	→*	✓	✓

** limited*

It is noteworthy that almost all funders examined are moving rapidly towards an open access requirement. The principle that research outputs have to be made publicly available to advance global science is therefore almost as strong as any research ethics requirements. The open access requirement has now become an internationally driven agenda and the funding policies of Australia and the European countries also frequently include the availability of additional monies for researchers to fund open access either directly or through block grants to universities. In the UK for example, the REF now incorporates open access publication as a measure of excellence and the UK Research Councils provide universities with a block grant to fund open access. The Wellcome Trust as a charitable research funder insists that all publications from its research funding must be open access. In the US the National Institutes of Health (NIH), for instance, insist that all research publications must be deposited in the open access PubMed. The South African National Science Foundation has even expanded this requirement to data and provides both a publication repository and a data archive for researchers it has funded.

Almost all funders examined are moving rapidly towards an open access requirement.

Commitment to gender equality is much more variable from country to country even within the more advanced economies. South Africa, Germany and the US have the strongest requirements for gender equality, whilst many others have diversity policies as part of their funding programmes and collect data on participation without including gender as a criterion for funding decision-making.

Research governance in the form of ethics reviews and data protection compliance have historically been important aspects of medical research in all developed countries. Strict adherence to such research governance has also become mandatory in these countries for non-medical research involving animals or humans and their data. India now also has a strong ethics review process structure, which is becoming increasingly established in other emerging economies although important challenges still remain globally in terms of compliance, and in developing countries where "ethics dumping" remains a major issue.

> *It would therefore appear from the reports of the countries surveyed, that despite differences due to political and cultural priorities, level of economic development and societal stability, that RRI is becoming increasingly an important consideration in research funding, particularly for research which aims to compete in an international arena. This implies that there is indeed scope, building on existing criteria and current practice, for promoting the convergence of research and innovation funding systems with respect to their approach to Responsible Research and Innovation.*

Introduction

In the last decade, "science's new social contract with society" (Gibbons: 1999) has been debated and analysed in depth. The 'agora', a "public space in which both 'science meets the public', and the public 'speaks back' to science" (ibid.) has been created through a variety of participatory decision-making mechanisms. As a result, the public is no longer regarded as a separate entity, independent of the innovation process, but as an integral part to achieve outputs that are broadly accepted. Today participatory Technology Assessment is a relatively well-funded, well-researched activity. Scientific knowledge and innovation is becoming more "socially robust" (Nowotny et al: 2006). Whilst this is an important part of responsible research and innovation (RRI), it is equally important to look at the strategies of governments and funders to move towards research that tackles major societal issues. Such an analysis has not been carried out on a global scale to date, a gap which this report aims to address in the context of RRI.

Responsible research and innovation is ethically acceptable, sustainable and drives towards the common good, i.e. adheres to societal desirability (von Schomberg: 2013). Innovators and researchers respond to incentives, especially pecuniary incentives. As such, the state and private funding bodies have means to drive innovation towards major societal aims and challenges. This report summarises public and charity funded efforts from around the world to achieve societal desirability.

In the compilation of this report, a bottom-up approach was used, with individual country reports drafted without a template so as to allow the broadest scope possible within the topic of the deliverable. As a result, the information provided in the country sections is not uniform. However, in draft iterations, it was aligned closely enough to allow comparisons. This amalgamation of rigid uniformity and unstructured individuality is deemed to give the best result on a topic that has not, to date, been tackled by other researchers.

Diagram 1: Schematic Representation of Report

The countries chosen for this report cover all continents and all major innovation regions, namely (in alphabetical order): Australia, Brazil, China, Germany, India, Japan, South Africa, the United Kingdom and the United States. Specific approaches in individual countries are described in detail starting with an overview of the state funding system for research and innovation and where possible, supplementary information about charitable funding. Special emphasis is given to the requirements that researchers and innovators have to adhere to in order to obtain funding; as these are possible tools to drive innovation towards societally desirable goals or 'right outcomes' (Ozolina et al: 2012).

A separate deliverable (available in autumn 2014) will provide a matrix that analyses and summarises the funding reports. At this stage, only one summarizing section was added. A

selection of international funders were examined to see whether any funding requirements can be mapped onto the five Science with and for Society (Swafs) RRI action points, which are:

- Societal Engagement;
- Open Access;
- Gender Equality;
- Ethics and Governance; and
- Science Education. [1]

[1] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society.

RRI Action Points Globally

"In practice, RRI consists of designing and implementing R&I policy that will:

- engage society more broadly in its research and innovation activities;
- increase access to scientific results;
- ensure gender equality, in both the research process and research content;
- take into account the ethical dimension;
- promote formal and informal science education." [2]

Are the five RRI action points, as identified by the European Commission's Science with and for Society unit, applied by other funders globally?

RRI Action Points and Australia

The Australian Research Council (ARC) is a statutory agency which distributes Australian government research funding via the National Competitive Grants Program. About three quarters of this funding supports basic research (the 'Discovery' Program), and the other quarter supports applied collaborative research (the 'Linkage' Program) which requires a partner organisation to contribute an amount 'in cash' or 'in kind' that is equal to or greater than the ARC funding for each research project conducted. The following describes whether the five RRI action points from the European Commission can be found in ARC programs.

Societal engagement

Societal engagement is not a selection criterion for Discovery or Linkage Projects. Selection criteria only require "adequate strategies to encourage… dissemination… and… promotion of research outcomes", which for Discovery Projects "may be supported at up to two (2) per cent of total non-salary ARC funding awarded to the Project"; no percentage is specified for Linkage Projects (Australian Research Council: 2012a, p.9; 2013c, p. 9; p.21).

Open access

Any publications arising from a Discovery or Linkage Project are required to be deposited in an open access institutional repository. The Funding Rules for both Discovery and Linkage Projects clearly state that:

> "All… ARC-funded research projects must comply with the ARC Open Access policy on the dissemination of research findings, which is available at: www.arc.gov.au. In accordance with this policy, the ARC requires that any publications arising from a Project must be deposited into an open access institutional repository within a twelve month period from the date of publication. The ARC strongly encourages the depositing of data arising from a Project in an appropriate publicly accessible subject and/or institutional repository." (Australian Research Council, 2012a, p.22; Australian Research Council, 2013c, p.22)

Most universities within Australia now operate their own open access institutional repositories.

[2] http://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society.

Gender equality

There is nothing in the selection criteria for either Discovery or Linkage Projects which suggests that gender equality is a consideration in selection of projects for funding.

However, both participation in seeking funding, and success rates, are reported by gender. In the most recent round of funding for which statistics are available (funding commencing in 2014 for Discovery Projects; funding commencing in 2013 for Linkage Projects), participation and success rates were as follows. For Discovery Projects: approximately 25 per cent of participants in seeking funding were female, while approximately 75 per cent were male; success rates were 18.3 per cent for female and 20 per cent for male participants (Australian Research Council, not dated, p.6). For Linkage Projects: approximately 31 per cent of participants in seeking funding were female, while approximately 68 per cent were male; success rates were 40.0 per cent and 40.8 per cent respectively (Australian Research Council, 2013a). So while significantly greater numbers of men than women seek research funding, success rates are more or less gender balanced. However, the use of 'participants' as the category of reporting does obscure the degree to which the 'Chief Investigator' role on a project proposal might be gendered both at the 'seeking funding' and at the 'success' stages.

It should be noted that the ARC Annual Report 2012-2013 records support for gender equity with respect to research funding indirectly, for instance: "promoting increased opportunities to undertake fellowships part time" was mentioned, as was consideration given to gender balance in the competitive selection of new members to the ARC College, which "plays a fundamental role in identifying research excellence, moderating external assessments and recommending fundable proposals" as well as in recruiting and assigning assessors (Australian Research Council, 2013b, p.53 and p.102).

Research and innovation governance

For ARC-funded researchers, compliance with principles such as those outlined in the Australian *Code for the Responsible Conduct of Research* (2007); the *National Statement on Ethical Conduct in Human Research* (2007) and similar documents is required and clearly stated in funding rules and contracts. The Australian *Code for the Responsible Conduct of Research* itself incorporates a requirement to comply with relevant Australian laws and regulations, which relate to matters such as health and safety, environment and so on. If research misconduct allegations are made against ARC-funded researchers, there is a "formal process" for handling such allegations, including allegations "related to scientific fraud, ethical breaches and research misconduct" (Australian Research Council, 2012b, p.91).

Scientific education

One of the objectives of Discovery Projects is to "encourage research and research training in high-quality research environments". However, "research training" is not clearly reflected in the selection criteria against which research proposals are assessed for funding (Australian Research Council, 2012a, pp.8-9). Still, it is quite common for postgraduate research positions (usually involving the completion of a doctorate supporting the overall research project) or postdoctoral Research Fellow positions to be included in successful research proposals. The broader Discovery

Program also includes a Discovery Early Career Researcher Award (DECRA) targeted at applicants who "have been awarded a PhD within five years or, together with periods of significant career interruption, have been awarded a PhD within nine years of the closing time of submission of Proposals" (Australian Research Council, 2014). This award provides substantial research funding support to successful applicants for up to three consecutive years, and accounts for 19 per cent of total Discovery Program funding during the 2011-2012 financial year.

One of the aims of Linkage Projects is to "provide outcome-oriented research training to prepare high-calibre postgraduate research students" and the selection criteria include "approach and training" which is weighted at 15 per cent (Australian Research Council, 2013a).

The following table summarizes how ARC funding requirements map onto the five RRI action points.

Table 2: RRI Action Points and ARC Funding

RRI criterion	ARC
Societal engagement	✗
Open access	✓
Gender equality	→*
Research and innovation governance	✓
Scientific education	→*

** limited*

RRI Action Points and China

Currently, societal engagement is not a funding criterion for researchers in China. However, there are Programs for the Public Understanding of Science, which can be considered a precursor to societal engagement.

Publications from programs such as the General Program and the Key Program, two major funding sources for researchers in China, have to be made available open access.

Whilst ethics compliance is a strict funding criterion in China, gender equality is not even though there are some programs such as the 'Outline for the Development of Chinese Women 2011–2020', issued by the Chinese State Council in 2011, which "aims to increase the proportion of women in the professions, including science and technology, to 35 per cent."[3]

The Chinese government does attach much importance to formal scientific education. The General Program, the Key Program, the Special Fund for Key Academic Journals, the Fund for Creative

[3] http://www.scidev.net/global/capacity-building/news/china-aims-to-boost-number-of-women-scientists.html

Research Groups and so on are all intended to promote scientific education. Notably, there is also the Special Fund for Scientific Activities for Teenagers.

Table 3: RRI Action Points and Chinese Public Research Funding

RRI criterion	Chinese public research funding
Societal engagement	
Open access	
Gender equality	
Research and innovation governance	
Scientific education	

** limited*

RRI Action Points and Germany

The *Deutsche Forschungsgemeinschaft* (DFG, German Research Foundation) is the main public funder of for science and research in Germany. It serves all branches of science and the humanities. Most of the DFG funds come from the German states and the federal government, both of which are represented in all Grants Committees. One of the DFG's central programs is the individual grants program.

Societal engagement

Societal engagement is not a selection criterion in the individual grants program. However, the DFG is regarded as the "voice of science in political and social discourse" and its publications provide scientific expertise to political decision making processes.[4] Hence, it is in their interest to link research to policy needs. The DFG also runs several programs to promote "knowledge transfer" between research, industry and the general public[5].

Open access

The DFG signed the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities in 2003[6], with the aim to support the advancement of knowledge by promoting freely accessible online electronic resources.

In addition, in 2006 the DFG's Joint Committee adopted a set of guidelines for the publication of results from DFG-funded projects on an open access basis. According to these guidelines recipients of DFG research grants should make their results available online in digital format in suitable open access journals, ***if possible,*** either instead of or in addition to traditional publications. They also recommend the provision of previously published papers in open access format. In support of these guidelines the DFG runs a specific funding program called "Scientific Library Services and

[4] http://www.dfg.de/en/dfg_profile/mission/policy_advice/index.html
[5] http://www.dfg.de/en/research_funding/principles_dfg_funding/knowledge_transfer/index.html
[6] http://openaccess.mpg.de/286432/Berlin-Declaration

Information Systems". This fund provides finances for additional costs of open access publication for the authors[7]. Furthermore, the DFG funds projects that are designed to promote awareness of open access (i.e. http://open-access.net).

Gender equality

The DFG "promotes equality between men and women in the scientific and academic communities" (DFG Statutes § 1)[8]. In addition it promotes diversity because

> excellent research requires diversity and originality. To ensure long-term engagement with all socially relevant areas, it is crucial that science and academia adequately represent these areas. […] The DFG believes that no one should be excluded from a career in research on the basis of academically irrelevant factors such as gender, ethnic origin, age or health."[9]

It runs multiple programs to promote gender equality. These programs are targeted to its member institutions and to its funding programs. They are multidimensional including monitoring, target definition, information for reviewers, additional funding for child care and the acknowledgment of individual circumstanced in the process of grand application.

Research and innovation governance

DFG-funded researchers and institutions must comply with the DFG´s rules on safeguarding good scientific practice[10]. Depending on the research area, researcher and research institutions must implement additional requirements. In experiments involving humans, including identifiable samples taken from humans and identifiable data, the experiments must to be in accordance with the most current versions of the German Embryo Protection Act (*Embryonenschutzgesetz*), Stem Cell Act (*Stammzellgesetz*), Pharmaceutical Drugs Act (*Arzneimittelgesetz*), Medical Devices Act (*Medizinproduktegesetz*), and the Declaration of Helsinki. In addition all research studies must be approved by a local ethic committee. In case of funding proposals concerning research projects within the scope of the Convention on Biological Diversity (CBD) special DFG rules need to be taken into account[11]. Also, studies must adhere to the regulations and provisions of the Animal Protection Act (*Tierschutzgesetz*) and the Experimental Animals Ordinance (*Versuchstierverordnung*) and with regard to experiments involving genetically modified organisms (GMO) to the Genetic Engineering Act (*Gentechnikgesetz*)[12].

Scientific education

One of the objectives of the DFG is to promotes excellence and quality by selecting the best research projects on a competitive basis and to encourage international research cooperation. The DFG offers support for every phase of a career in research with a special emphasis on early career researchers. As a result, it is promoting scientific education, - with the individual grants program as the centrepiece of DFG research funding.

[7] http://www.dfg.de/formulare/12_20/12_20_en.pdf
[8] http://www.dfg.de/en/dfg_profile/statutes/index.html
[9] http://www.dfg.de/en/research_funding/principles_dfg_funding/diversity/index.html
[10] http://www.dfg.de/en/research_funding/principles_dfg_funding/good_scientific_practice/index.html
[11] http://www.dfg.de/formulare/1_021e/1_021e.pdf
[12] http://www.dfg.de/foerderung/programme/einzelfoerderung/sachbeihilfe/formulare_merkblaetter/index.jsp

The following table summarizes how DFG funding requirements map onto the five RRI action points.

Table 4: RRI Action Points and DFG Funding

RRI criterion	DFG
Societal engagement	
Open access	
Gender equality	
Research and innovation governance	
Scientific education	

** limited*

RRI Action Points and India

Currently, only ethics governance is a strict requirement within Indian research programs funded by the government. Other funding decisions are based on technical and intellectual merit criteria only. However, the Department of Science and Technology has specific programs to increase the participation of women in science and technology and the participation of younger researchers (e.g. the "Innovation in Science Pursuit for Inspired Research" program).

Table 5: RRI Action Points and Indian Public Research Funding

RRI criterion	Indian Public Research Funding
Societal engagement	
Open access	
Gender equality	
Research and innovation governance	
Scientific education	

** limited*

RRI Action Points and South Africa

The National Research Foundation (NRF) is the main South African body promoting and supporting research in all fields of knowledge. Funding from the NRF is largely directed towards academic research, developing high-level human resources, and supporting national research facilities. The following describes whether the five RRI action points from the European Commission can be found in NRF programs.

Societal engagement

NRF funding instruments such as the Thuthuka Programme do not specifically require researchers to undertake 'societal engagement' or public/community outreach, but several of the NRF's divisions do include support for public outreach. For example, the main function of one of the NRF's divisions – the South African Agency for Science and Technology Advancement (SAASTA), is to stimulate the interaction between science and society and to coordinate science and technology education, communication, outreach and advancement across the NRF.

Another division - Research and Innovation Support and Advancement (RISA), issues grants for community engagement. The South African Astronomical Observatory (SAAO), includes education and public outreach as core activities. Furthermore, SAAO contributes to the development of society through a benefits programme aimed at the fields of education, public outreach and community development.

Open access

The NRF maintains an institutional repository for open access publications and other digitised materials created by staff of the NRF such as power point presentations, print materials, photographs, audio materials, videos, manuscripts and other original works. The NRF Institutional Repository is also a source for the research outputs of the staff of the NRF Business Units and National Research Facilities, thus raising the visibility and accessibility of NRF publications to the wider world.

NRF-funded researchers, such as those in the Thuthuka Programme, are requested to make the data generated from their research available to other researchers working in the same field. They are expected to ensure data is provided to domain-specific databases or, in the absence thereof, to the South African Data Archive (SADA).

The South African Environmental Observation Network (SAEON) aims to enhance free and open access to information by providing data online and by offering management tools for the development of data searches and geospatial visualisation.

Gender equality

One of the core principles guiding all NRF investments is a requirement for making a contribution to the transformation of society in terms of race, gender and disability in order to redress systemic social and economic inequalities.

Certain programmes, such as Thuthuka, are specifically aimed at female researchers, with clear demographic targets that offer support to emerging black and female researchers. Although open to all applicants, the funding instrument aims to develop human capital and to improve the research capacities of designated researchers (black [African, Indian and Coloured], female or disabled).

The Department of Science and Technoloy-NRF Centres of Excellence also pursue the mandate of advancing the gender and race transformation agenda; the NRF Annual Performance Report

2012/2013 indicates that female student numbers increased by 23% and black student numbers by 79% since 2004.

Research and innovation governance

Grantholders in the Thuthuka Programme are required to maintain the highest ethical and safety standards in conducting the research, particularly when human and animal subjects are involved. It remains the responsibility of the project leader to comply with all relevant regulations in this regard, including those of the institution at which the research is carried out. An ethical clearance certificate (where applicable) has to be submitted to the NRF in respect of successful applications before funding can be released.

Scientific education

As an entity of the national Department of Science and Technology, the NRF promotes and supports research through funding, human resource development and the provision of national research facilities in all fields of natural and social sciences, humanities and technology.

One of the main goals of the South African Research Chair Initiative (SARChI) is to strengthen and improve the research and innovation capacity of universities for producing high quality postgraduate students. Research Chairs are expected to dedicate at least 95% of their time to conducting research, supervising an average of 10 masters and doctoral students per annum and mentoring emerging researchers. The following table summarizes how NRF funding requirements map onto the five RRI action points.

Table 6: RRI Action Points and the NRF

RRI criterion	**NRF**
Societal engagement	→ *
Open access	✓
Gender equality	✓
Research and innovation governance	✓
Scientific education	→ *

** limited*

RRI Action Points and the United Kingdom

To give an example of a charitable foundation's match to the five RRI action points, the UK-based Wellcome Trust was chosen. The Trust was set up by Sir Henry Wellcome in 1936 and is the second largest global charitable funder of medical research after the Bill and Melinda Gates Foundation. The following describes whether the five RRI action points from the European Commission can be found in Wellcome Trust programs.

Societal engagement

The Wellcome Trust has a two-tiered approach to societal engagement (termed public engagement). First, application forms include a section in which the applicant can detail public engagement efforts to strengthen the proposal. This section is not compulsory. Hence, it is not a strict funding requirement. Second, every applicant is made aware of the possibility to obtain additional public engagement funding. "We want people to consider, question and debate the key issues in science and society and aim to support innovative projects that engage audiences with biomedical science."[13]

Open access

The Wellcome Trust has a strict open access policy, which is described as follows:

> The Wellcome Trust believes that maximising the distribution of [high-quality, peer-reviewed...] papers - by providing free, online access - is the most effective way of ensuring that the research we fund can be accessed, read and built upon. In turn, this will foster a richer research culture. The Wellcome Trust therefore supports unrestricted access to the published output of research as a fundamental part of its charitable mission and a public benefit to be encouraged wherever possible.[14]

From 2014 onwards, the Trust also applies its open access policy to scholarly monographs and book chapters, thereby subscribing to the widest possible open access requirement.

Gender equality

At the level of individual applications, the Wellcome Trust does not operate a specific policy to increase the number of women in science and technology. However, through research and input into national policy, they influence the broader institutional framework. For instance, in September 2013 they presented research to the UK House of Commons Science and Technology Committee: Women in STEM careers.

Their response to the House noted that "the decline in the numbers of women in more senior positions is not unique to STEM professions but is seen in business, the law and politics. Recently the UK was ranked 39 out of 45 countries on the proportion of women in senior management positions, with only 19% filled by women, compared to 51% in China."

A tracking system of successful applicants and a qualitative study undertaken by the Trust showed that the uncertainty of academic careers, including the pressure to move and the long working hours culture, were regarded as the main challenges to staying in research careers.[15] Other notable features include the Trust's Career Re-entry Fellowship, which is targeted at "postdoctoral scientists who have recently decided to recommence a scientific research career after a

[13] http://www.wellcome.ac.uk/funding/public-engagement/
[14] http://www.wellcome.ac.uk/About-us/Policy/Policy-and-position-statements/WTD002766.htm
[15] http://www.wellcome.ac.uk/stellent/groups/corporatesite/@policy_communications/documents/web_document/wtp055447.pdf

continuous break of at least two years".[16] Whilst this is not exclusively aimed at women, it is most often taken up by women returning to paid employment after taking time out for family commitments. In addition, across all of its funding schemes, the Trust will make allowances when judging the strength of applicants' CVs, for gaps in publishing track records attributable to family related career breaks.

Research and innovation governance

All Wellcome Trust grantholders are required to show how they comply with national and international legal and ethical frameworks through local ethics approval.

Scientific education

The Wellcome Trust operates a range of programs dedicated to the development of future generations of scientists (e.g. doctoral studentships). At the same time, other programs broaden the outlook and research activity of people already established in one discipline but wishing to develop careers in research areas covered by the Trust's remit. For instance, the Research Fellowships for Health Professionals scheme "is intended for practicing health professionals who wish to carry out research in any area within the remit of the Society and Ethics Programme, either full-time or part-time, while maintaining their work commitments".[17] In addition, applicants in more senior positions (e.g. senior investigator award) are required to show how they build the capacity of younger researchers as part of the application process. Finally, the Trust "has a long-standing enthusiasm and commitment to ensuring an excellent science education for all students. This is because it is impossible to have extraordinary science without extraordinary scientists and a public eager to understand and gain from their work."[18] For instance, in collaboration with a range of partners (e.g. the US National Science Foundation), the Trust runs the Science Learning+ initiative, "an international initiative that aims to understand the power of informal learning experiences inside and outside of school."[19] The following table summarizes how Wellcome Trust funding requirements map onto the five RRI action points.

Table 7: RRI Action Points and the Wellcome Trust

RRI criterion	Wellcome Trust
Societal engagement	→ *
Open access	✓
Gender equality	→ *
Research and innovation governance	✓
Scientific education	✓

** limited*

[16] http://www.wellcome.ac.uk/Funding/Biomedical-science/Funding-schemes/Fellowships/Basic-biomedical-fellowships/WTD004380.htm
[17] http://www.wellcome.ac.uk/Funding/Society-and-ethics/funding-schemes/Research-fellowships-for-health-professionals/index.htm
[18] http://www.wellcome.ac.uk/Education-resources/Education-and-learning/index.htm
[19] http://www.wellcome.ac.uk/Funding/Public-engagement/Funding-schemes/Science-Learning/index.htm

RRI Action Points and the United States

The National Science Foundation (NSF) is an agency of the US federal government that supports fundamental research and education in all *non-medical* fields of science and engineering. With an annual budget of about $7 billion (€5.2 billion) (fiscal year 2012), the NSF supports approximately a fifth of all federally supported *basic* research conducted in US institutions of higher learning. The following describes whether the five RRI action points from the European Commission can be found in the NSF program.

Societal engagement

Though the NSF has funded a number of projects aimed at improving societal engagement with science and technology, there is no requirement currently that principal investigators focus time or resources on this. The NSF does, however require all principal investigators to discuss how they will disseminate the results of their projects, and this can include societal engagement activities.

Open access

The NSF expects investigators to share with other researchers, at no more than incremental cost and within a reasonable time, the primary data, samples, physical collections, and other supporting materials created or gathered within the course of work under an NSF grant. The federal government defines data as "the recorded factual material commonly accepted in the scientific community as necessary to validate research findings." In practice, many principal investigators deposit their research data in their institution's repositories, which can be accessed by the public.

In addition, the NSF expects investigators promptly to prepare and submit publications that describe all significant findings from work conducted under an NSF grant. However, the NSF does not require these publications to be submitted to any publically accessible database. In contrast, the National Institutes of Health (NIH) require all its principal investigators to submit final peer-reviewed journal manuscripts to their open-access database, PubMed Central, upon acceptance for publication.

Gender equality

A core strategy in support of the NSF's mission is broadening opportunities and expanding the participation of groups, institutions, and geographic regions that are underrepresented in science, technology, engineering and mathematics. This strategy is considered essential to the health and vitality of science and engineering. The NSF is committed to this principle of diversity and deems it central to the programs, projects, and activities it considers and supports. Diversity is a key criteria used in deciding what proposals are funded, and all principal investigators are required actively to recruit women, minorities, and individuals with disabilities to be part of NSF-funded educational and other activities.

Research and innovation governance

The National Environmental Policy Act of 1969 requires that Federal agencies consider the environmental impact of major Federal actions significantly affecting the quality of the human environment. If a proposed project might have an environmental impact, the proposal must

furnish sufficient information to assist NSF officials in assessing the environmental consequences of supporting the project. NSF will determine:

- the adequacy of the information submitted;
- whether or not additional information is needed;
- whether or not an environmental assessment or environmental impact statement will be necessary.

The NSF also requires institutions to provide training and mentoring in regard to the Responsible Conduct of Research to students and post-doctoral researchers who are employed on grant projects submitted for funding after January 4, 2010. (National Science Foundation, 2013, see Award & Administration Guide (AAG) Chapter VI.D.4).

Scientific education

The NSF requires all applicants to explain the potential educational significance of their proposed activity, and/or how it will have an effect on the infrastructure of science, engineering, or science or engineering education.

The following table summarizes how NSF funding requirements map onto the five RRI action points.

Table 8: RRI Action Points and NSF Funding

RRI criterion	NSF
Societal engagement	 *
Open access	
Gender equality	
Research and innovation governance	
Scientific education	

** limited*

RRI Action Points and the Netherlands

The following section describes a program on "Responsible Innovation" funded by the Netherlands Organisation for Scientific Research (NWO). The NWO is the national research council in the Netherlands with a budget of 625 million euros per year.[20]

The main aim of the Responsible Innovation (RI) programme is to encourage "research in which the ethical and social aspects of new technology are considered right from the design phase [in order to prevent] expensive adjustments having to be made in retrospect or society rejecting the

[20] The Netherlands are not covered in other parts of this report, but since the program is arguably the most ambitious of its kind it warrants inclusion here. Insights are partly based on personal information, as Doris Schroeder was a member of the program's International Advisory Board (a grant-decision-making body) from 2008 - 2010.

new technology.[21] The following describes whether the five RRI action points from the European Commission can be found in the NWO program on 'Responsible Innovation'.

Societal engagement

The societal engagement of the NWO's RI programme operates at two levels. First, applicants have to form and engage with a user panel ahead of submitting any proposals. The *valorization* panel consists of users and potential users of any technology whose input is sought at all stages of the research. An example panel of a funded project is shown below.

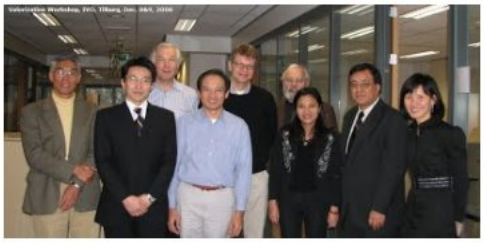
Valorization panel

One of the main priorities for NWO and project partners is to be able to use the research results. In order to do so, a valorization panel was set up consisting of users and potential users, i.e. people who are prepared to valorise the research results and disseminate them among the target group they represent. The primary duty agreed on with the valorisation panel is to ensure that the research team is aware of the existing issues and needs in order to allow the researcher to take them into consideration in his or her choices.

The valorization panel of the IVO-UvT MVI research comprises representatives of:

- Vietnamese Ministry of Science and Technology (MOST);
- National Council for Science and Technology Policy in Vietnam Department of Science and Technology (DOST), Hanoi Ha Tay Province;
- UN Industrial Development Organization (UNIDO);
- UN International Labor Organization (ILO);
- Vietnam chamber of Commerce and Industry (VCCI);
- International Development Enterprises (IDE);
- NUFFIC;
- Profound, Utrecht, The Netherlands;
- Cordaid, The Netherlands;
- Dutch Ministry of Foreign Affairs/Development Cooperation.

The research team exchanges on a regular basis its research plans, methods and intermediary outcomes with the panel members in order to obtain feedback and suggestions. IVO organize meetings in Vietnam and The Netherlands as well as an overall workshop for all panel membersat the end of the project.



Source: https://sites.google.com/site/responsibleinnovation/valorization-panel-2

The second level of societal engagement is the civil society panel, which examines the social relevance of the planned research as part of the application process. This second panel consists of the business community and relevant civil society or non-governmental organizations. This approach to societal engagement presented the most ambitious requirement amongst the research funders examined.

Open access

It is an NWO principle that "research results that have been obtained using public funds must be made as public as possible."[22] In order to support researchers in being compliant with the open access policy, the *Incentive Fund Open Access* provides both awareness raising initiatives (such as conferences) as well as funding for open access fees to successful principal investigators.

[21] http://www.nwo.nl/en/research-and-results/programmes/responsible+innovation/background
[22] http://www.nwo.nl/en/funding/our-funding-instruments/nwo/incentive-fund-open-access/incentive-fund-open-access---publications/incentive-fund-open-access---publications.html

Gender equality

The NWO operates no specific policy on gender equality.

Research and innovation governance

Whilst research ethics compliance is a prerequisite for applicants in all programs examined in this report, the RI NWO programme goes further in incorporating potential ethical concerns about the outcome of the research (e.g. the product or service developed) from the start. This stands in marked contrast to many other funders whose emphasis is on protecting research participants or avoiding negative environmental impact.

Several tools are employed to incorporate ethical and social aspects from the start in the design process. The previously mentioned valorization panels give an early opportunity for the inclusion of user concerns. Equally noteworthy is the requirement that each research group has to be interdisciplinary, made up of so-called alpha, beta and gamma researchers (humanities, natural sciences, social sciences).

Scientific education

The informal learning that derives from the requirement for collaboration of alpha, beta and gamma researchers in each project contributes innovatively to science education. In terms of formal learning, most projects are focused on PhD level research and therefore on the next generation of scientists.

Table 9: RRI Action Points and the NWO's Program on Responsible Innovation

RRI criterion	NWO Inclusion
Societal engagement	✓
Open access	✓
Gender equality	✗
Research and innovation governance	✓
Scientific education	✓

** limited*

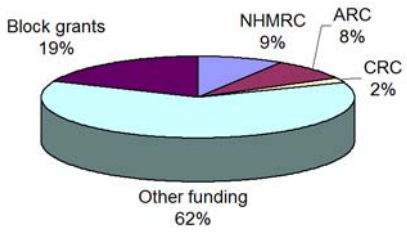
This concludes the mapping of the 5 RRI Action points onto requirements from funders in Australia, China, Germany, India, the Netherlands, South Africa, the United Kingdom and the United States. The remainder of the report will focus on how states and private funders distribute research funding and in particular on whether they use incentives or requirements to drive innovation towards societally desirable goals.

Australia

In this section of the report, direct and indirect funding for researchers and innovators from the Australian national government is examined. Funds are provided *directly* to researchers who are successful, for instance, in applying to the Australian Research Council (ARC) with specific projects. Funds are provided *indirectly* to researchers through block grants, which their universities can receive based on particular merit criteria.

In the 2011-2012 financial year, the total Australian Government support for science, research and innovation was just over AUS $9 billion (Australian Government, 2013, p.2). This section focuses on some of the major components of this support: National Health and Medical Research Council (NHMRC) research funding ($808 million), ARC research funding ($741 million), Cooperative Research Centres (CRC) research funding ($165 million), and Research Block Grants ($1.67 billion). Together, these account for approximately 37% of total Australian Government support for science, research and innovation.

Diagram 2: Australian Government Funding for RI, 2011-2012



With respect to direct funding, three major national government research funding programs are considered in this section: the program administered by the National Health and Medical Research Council (NHMRC), the program administered by the Australian Research Council (ARC) and the Cooperative Research Centres (CRC) Program.

The Australian government's provision of Research Block Grants to universities for internal distribution is a source of indirect funding considered here. In particular, the Australian Government's proposal to measure research impact in the future is reviewed, given the link between impact and societal desirability.

Whilst the focus within this report is on the 'socially desirable' aspect of RRI, brief mention is also made of research funding criteria related to ethical acceptability and sustainability.

Direct research funding in Australia

Direct research funding is distributed by the Australian Government to individual researchers and research teams (who must be under the auspices of an eligible organisation, that is, a university or other approved higher education provider) through competitive processes co-ordinated by various Commonwealth Government Departments. The most significant of these national government research funding programs are administered by the National Health and Medical Research Council (NHMRC) and the Australian Research Council (ARC); additionally, given their link to research end-users and potential to societal desirability, the program of Cooperative Research Centres (CRCs) is important in the context of this report.

National Health and Medical Research Council (NHMRC)

The NHMRC is an independent statutory authority that (among other functions) distributes Australian government funding for health and medical research. In the 2011-2012 financial year it distributed research support, not only to research centres and projects but also to fund scholarships, fellowships, and research infrastructure (National Health and Medical Research Council, 2012a, pp.26-28). Over the ten year period 2002-2011, on average, almost half of its research funding was directed at basic science, with a further approximately 30% going to clinical medicine and science and 13% to public health; the small proportion remaining went to health services research or was not allocated (National Health and Medical Research Council, 2012a, pp.42).

The NHMRC "will fund any area of research of relevance to health" (National Health and Medical Research Council, 2012b, p.3) but there is a focus on National Health Priority Areas, which are designated as such by the Australian Health Ministers (within the national and state and territory governments) (National Health and Medical Research Council, 2012b, p.4). Together these areas "represent almost three quarters of the total burden of disease of Australians" (National Health and Medical Research Council, 2012b, p.4). They are:

1. Arthritis and Musculoskeletal Conditions;
2. Asthma;
3. Cancer Control;
4. Cardiovascular Health and Stroke;
5. Dementia;
6. Diabetes Mellitus;
7. Injury Prevention and Control;
8. Mental Health (with a focus on depression);
9. Obesity (National Health and Medical Research Council, 2012b, p.4).

By linking research funding directly to the total burden of disease of Australians, a match to societal desirability is already achieved.

During the 2011-2012 financial year, approximately 57% per cent of total NHMRC research funding was spent in these areas (National Health and Medical Research Council, personal communication). By linking research funding directly to the total burden of disease of Australians, a match to societal desirability is already achieved. Rather than linking research to market recovery of research and development costs, as is generally the case with privately funded research, leading to the famous 90/10 gap[23], societal needs have thus already been taken into account.

The NHMRC Strategic Plan for 2013-2015 puts the National Health Priority Areas first in its list of nine Major Health Issues (National Health and Medical Research Council, 2012b, p.4). However, whilst the health of Australians overall is thus prioritized in publicly funded research, positive health outcomes for Aboriginal peoples and Torres Strait Islanders remains a major challenge. Improving the health of indigenous Australians, who have significantly lower health status than Australians generally (Aboriginal and Torres Strait Islander Social Justice Commissioner, 2005) comes second, with the promise of continued commitment of "at least 5% of our funding of

[23] http://www.who.int/intellectualproperty/submissions/InternationalPolicyNetwork.pdf

research, capacity building and translation to Indigenous Health research" (National Health and Medical Research Council, 2012b, p.6).

NHMRC: References to ethical acceptability or sustainability

One of the key performance indicators for the NHMRC in 2011-2012 was to advocate high ethical standards in research (with a focus on protecting the welfare and rights of participants in health and medical research); it conducted three monitoring and six information exchange visits to administering institutions (funding recipients) to promote compliance with NHMRC funding conditions; and it claimed 100 per cent researcher and institutional compliance with the *Australian Code for the Responsible Conduct of Research* (2007) and the *National Statement on Ethical Conduct in Human Research* (2007) (National Health and Medical Research Council, 2012a, p.82, p.104, p.107).

The *Australian Code for the Responsible Conduct of Research* itself specifies that institutions have responsibilities to "maintain an environment that fosters responsible research" and that this includes the provision of a research governance framework that demands compliance with laws and regulations (National Health and Medical Research Council, Australian Research Council and Universities Australia, 2007, p.1.3). In Australia, such laws and regulations cover the broad range of areas characteristic of industrialized nations, including areas relevant to sustainability such as Work Health and Safety (previously known as Occupational Health and Safety) and Environment, including the handling of hazardous substances. The full range of relevant laws and regulations is too extensive to be discussed here. To give one example, Gene Technology is regulated in Australia under the Gene Technology Act 2000, the object of which "is to protect the health and safety of people, and the environment, by identifying risks posed by or as a result of gene technology, and by managing those risks through regulating certain dealings with genetically modified organisms (GMOs)" (Office of the Gene Technology Regulator, 2014).

As a statutory body, the NHMRC has an Environmental Management Plan and associated Committee for its own office-based operations, and annually reports on consumption of energy and water to the Australian Government Department of Climate Change and Energy Efficiency (National Health and Medical Research Council, 2012a, pp.129-130).

Australian Research Council (ARC)

The ARC is a statutory agency which distributes Australian government research funding via the National Competitive Grants Program. This incorporates the Discovery Program, which supports fundamental research (sometimes called 'basic or blue sky research') and the Linkage Program, which supports more applied research (research and development (R&D); projects which are collaborative between higher education researchers and other parts of the national innovation system) (Australian Research Council, 2013a). In the 2011-2012 financial year, the National Competitive Grants Program distributed AU$741.8 million, of which about three quarters was spent on the Discovery Program and the remaining 25 per cent on the Linkage Program (Australian Research Council, 2012, pp.190-192).

Both Discovery and Linkage Projects are assessed, amongst other criteria, against the economic, environmental and/or social benefit to Australia that the proposed research would provide. For both types of project, this type of criterion first appeared in the 2012 funding rules, and for Discovery (but not Linkage) Projects, it has since been expanded to include cultural benefit and benefit to the Australian and international community (Australian Research Council, 2010a, p.7; 2011, p.10; 2012a, p.8; 2013e, p.9).

The Linkage Projects scheme is more immediately linked to the public interest in that Linkage Projects must include at least one Australian Partner Organisation which must make a significant contribution in cash and/or in kind, to the project that is equal to, or greater than, the ARC funding (Australian Research Council, 2013a). That is, an Australian Partner Organisation that may come from the government, industry or not-for-profit sector must be interested enough in the results of the research to be prepared to contribute a significant proportion of the funding for it. The funding rules specifically exclude projects which are not suitably innovative, or which appear to be "essentially contracted research or a Consultancy arrangement" (Australian Research Council, 2013e, p.12). Over half of the Linkage Program funding is distributed through such Linkage Projects, leveraging substantial additional research support from Australian Partner Organisations (Australian Research Council, 2012, pp.191-192).

> ***Research-User Focus***
> *"An Australian Partner Organisation, which may come from the government, industry or not-for-profit sector, must be interested enough in the results of the research to be prepared to contribute a significant proportion of the funding for it."*

The ARC link the Discovery Program to the public interest in a more generic way: "A strong capability in fundamental research … will result in the development of new ideas, the creation of jobs, economic growth and an enhanced quality of life in Australia" (Australian Research Council, 2013a).

Additionally, in the past, both Discovery and Linkage Program funding has been strongly directed towards Australia's National Research Priorities, which were:

- an environmentally sustainable Australia;
- promoting and maintaining good health;
- frontier technologies for building and transforming Australian industries;
- safeguarding Australia

(Australian Research Council, 2012, p.49).

Selection criteria for both programs have previously included specific significant contribution to the advancement of knowledge in one or more areas of national research priority (Discovery); or asked about the potential for the research to contribute to the National Research Priorities (Linkage) (Australian Research Council, 2009, p.12; 2010, p.11).

During the three-year period (July 2009-June 2012), over 90 per cent of funded proposals under the Discovery Program, and over 96 per cent of funded proposals under the Linkage Program addressed the National Research Priorities (Australian Research Council, 2012, p.50, p.69). While the National Research Priorities are relatively broad, their inclusion in the selection criteria may discourage funding applications which cannot claim to address them in any way. In the three year period for projects seeking funding to commence between July 2009 and June 2012, only around 10% of Discovery Project applications and only around 3% of Linkage Project applications did not claim to address the National Research Priorities (Australian Research Council, 2013f; 2013g). It is notable however that success rates for such projects were comparable to the average success rates for Discovery and Linkage Projects, with just over 20% and just over 40% of applications successful respectively (Australian Research Council, 2013f; 2013g).

Examples of research funded under the Discovery Program and showcased by the ARC as addressing National Research Priorities include:

- 'An Environmentally Sustainable Australia' - research on the response of marine ecosystems to rising sea temperatures;
- 'Promoting and Maintaining Good Health' -research on the potential of a protein in sunflower seeds in cancer prevent prevention;
- 'Frontier Technologies for Building and Transforming Australian Industries' - research into the development of thin film solar cell technology;
- 'Safeguarding Australia' - research developing robotic targets used in army training (Australian Research Council, 2012, pp.54-57).

Sunflowers - Foto: Uwe Nestler

Examples of research funded under the Linkage Program and showcased by the ARC as addressing National Research Priorities include:

- 'An Environmentally Sustainable Australia' - research on the design of marine reserves, which are important to lessen the impact of fishing, conserve biodiversity and enhance ecosystem resilience (Partner Organisations: the Queensland Department of Environment and Resource Management and the Commonwealth Scientific and Industrial Research Organisation);
- 'Promoting and Maintaining Good Health' - the development of a rating system designed to improve the ability of health care professionals, communities and individuals to develop effective response pathways to cardiac events (Partner Organisation: AlphaPharm Pty Ltd);
- 'Frontier Technologies for Building and Transforming Australian Industries' - the development of a chipless Radio Frequency Identification (RFID) scanning system, which makes scanning technology practical at much lower cost (Partner Organisation: FE Technologies);

- 'Safeguarding Australia'; the development of a new method for controlling a major pest species in Australia, the cane toad, using bait for cane toad tadpoles (Partner Organisations: Australian Wildlife Conservancy, Foundation for Australia's Most Endangered Species Inc., Lismore City Council Tweed Shire Council, NSW Office of Environment and Heritage and Northern Rivers Catchment Management Authority) (Australian Research Council, 2012, pp.70-73).

Cane Toad - Wikimedia Commmons

The new Strategic Research Priorities aim to drive investment in areas that are of immediate and critical importance to addressing the societal challenges facing Australia and the world, and for the three year period July 2013 to June 2016, they are:

- Living in a changing environment
- Promoting population health and wellbeing
- Managing our food and water assets
- Securing Australia's place in a changing world
- Lifting productivity and economic growth (Australian Government, n.d.)

The Strategic Research Priorities were set by the Australian government through the Australian Research Committee (ARCom) as part of the development of the first National Research Investment Plan, which aims to maximise the effectiveness of Australia's investment in research by setting such investment "within a comprehensive planning framework" (Australian Government, n.d.). Over time an increased proportion of Australian Government research investment is likely to be allocated on a strategic basis so as to meet government needs for research, but precisely what proportion has not yet been "mandated" by the Government (Australian Government, n.d.). However, the continuing need for a strong, cohesive research fabric is acknowledged, and it is specified that the Australian Government will continue to support a range [a balance of mission-led and investigator-led research] of high-quality basic and applied research to provide the multidisciplinary capacity required to respond flexibly to evolving challenges (Australian Government, n.d.).

ARC: References to ethical acceptability or sustainability

For ARC-funded researchers, compliance with principles such as those outlined in the *Australian Code for the Responsible Conduct of Research* (2007); the *National Statement on Ethical Conduct in Human Research* (2007); and similar documents; is required and clearly stated in funding rules and contracts (Australian Research Council, 2012, p.91). The ARC draws on this information when providing reports on ethical compliance to the Australian government.

As discussed above, the *Australian Code for the Responsible Conduct of Research* itself incorporates a requirement to comply with laws and regulations, many of which are relevant to sustainability (health, safety, environment and so on). As legislatively required, the ARC also

reports on "Measures being taken to minimise the impact of the ARC's activities on the environment" (Australian Research Council, 2012, p.94, pp.224-225).

Cooperative Research Centres (CRC) Program

The CRC program is administered by the Department of Industry. The objective of the CRC program is to deliver significant economic, environmental and social benefits to Australia by supporting end-user driven research partnerships between publicly funded researchers and end-users to address clearly articulated, major challenges that require medium to long-term collaborative efforts (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013a, p.1).

End-User Focus
The objective of the CRC program is "to deliver significant economic, environmental and social benefits to Australia by supporting end-user driven research partnerships between publicly funded researchers and end-users to address clearly articulated, major challenges."

Each CRC is a partnership between at least one university (or associated research institute) and at least one end-user (from the public, private or community sector), and all partners must contribute resources to the CRC, and the total of these resources, "must at least match the amount of funding sought from the CRC Program over the funding period" (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013a, p.2, p.7). In the 2011-2012 financial year, the CRC Program distributed AU$165 million to 40 Cooperative Research Centres (Australian Government, 2013, p.10). CRC funding is awarded on a competitive basis, against selection criteria that falls under three main headings:

- research (the "proposal will undertake excellent-quality research that addresses issues of economic, environmental and/or social significance to Australia");
- results ("outputs from the proposed research, when implemented, will deliver high levels of economic, environmental and/or social benefits to Australia");
- resources (the "proposed collaboration will marshal the appropriate participants and other resources necessary to achieve the proposed outputs")

(Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013a, pp.11-12).

When the CRC program was evaluated in 2012 with regards to its economic, social and environmental impacts for the period of 1991 to 2017, it was found that it had generated a net economic benefit to the community, which has exceeded its costs by a factor of 3.1 (Allen Consulting Group, 2012, p.vi). Environmental benefits included: reduced green house gas emissions; avoidance of the emission of pollutants; reduced energy consumption; reduced water consumption; reduced environmental costs; protection of areas of environment and of endangered species (Allen Consulting Group, 2012, p.xiii). Social benefits included improved health and wellbeing; establishment of international collaborations; provision of education and training; labour force participation; business diversity; participation in community services; improved safety; and social costs saved or avoided (Allen Consulting Group, 2012, p.xvi).

CRC Program: References to ethical acceptability or sustainability

CRC Program Guidelines state that for each funded CRC, the Commonwealth Agreement (the legal agreement between the CRC company or agent and the Australian Government) will address obligations including compliance with relevant national, and where applicable international, research integrity and ethics codes and guidelines (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013a, p.15). It is also stated that each CRC must employ a sound governance model, and the principle that this model promotes ethical and responsible decision-making is highly recommended, along with seven other principles of good governance: lay solid foundations for management and oversight; structure the CRC Board to add value; safeguard integrity in financial reporting; make timely and balanced disclosure; respect the rights of shareholders/participants; recognise and manage risk and remunerate fairly and responsibly (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013a, pp.8-.9).

The only reference to 'sustainability' in the CRC Program Guidelines is to the sustainability of a CRC's work during the transition period after that CRC's grant has ceased. The generation of environmental benefits is one option among a group of selection criteria for inclusion in the CRC program (economic, environmental and/or social benefits to Australia), but there is no consideration of the relationship of such environmental benefits to the environmental costs of the program (important in genuine consideration of sustainability). However, as discussed earlier, compliance with the *Australian Code for the Responsible Conduct of Research* (which is a relevant national research ethics code, as referred to in the CRC Program Guidelines) incorporates a requirement to comply with laws and regulations, many of which are relevant to sustainability (health, safety, environment and so on).

Indirect research funding in Australia

Indirect research funding is received by each university via annual 'Research Block Grants', which during 2013 totalled AU$1.67 billion (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, n.d.d). These grants are provided in a range of categories including: Research Training Scheme; Joint Research Engagement; Research Infrastructure Block Grants; Australian Postgraduate Awards; International Postgraduate Research Scholarships; and Sustainable Research Excellence.

The annual amount for each type of Research Block Grant for each university is calculated on the basis of complex formulae designed to take into account the past research performance of that university. The formula for each type of grant varies, but includes one or more of:

- research income;
- research publications (both quantity, measured through the Higher Education Research Data Collection (HERDC), and quality, measured through the Excellence in Research for Australia evaluation process (ERA));
- higher degree by research (HDR) student load;

- HDR student completions (this provides a financial incentive for Universities to supervise effectively and manage their research students, in order to minimise the 'drop-out' rate);
- research staff numbers (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, n.d.b).

The funding received by each university from the various annual Research Block Grants is then distributed within that university to researchers following criteria decided by the university itself. Typically, the criteria for distribution within each individual university will be significantly motivated by an attempt to position the university best to receive an increase in future research funding.

However, there is more to be said about indirect research funding and RRI. Whilst certain funding formulae which determine the Research Block Grant amounts for each university aim to link the receipt of funding to research excellence (hence ERA, Excellence in Research for Australia), it is difficult to design effective measurement systems for aspects of research which are not easily quantifiable such as quality or impact, and there is a genuine risk that a poorly designed measurement system will have unintended consequences which undermine the very research that the introduction of a measurement system seeks to reward.

Research Impact Assessment: Measurement of research impact

To date, there has been no national-level assessment of the impact of all university-based research (beyond the academy) conducted by the Australian Government or others. However, the Department of Industry and the Department of Education (which together have oversight of national research funding) are currently developing "a mechanism to assess the public benefits arising from university-based research", known as 'Research Impact Assessment' (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, n.d.c).

This mechanism would clearly contribute towards driving research towards societally desirable goals, as it aims to measure public benefits generated from funding. It is emphasised that during the development of this mechanism, particular attention will be paid to the ongoing implementation of the United Kingdom's (UK) Research Excellence Framework (REF) to ensure that "wherever possible lessons are learned from the UK governments and university sectors experience with the REF" (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013, p.2). The UK section of this report provides a discussion of the concerns to date around UK attempts to measure impact through the REF. In the Australian context, it has been acknowledged that one future purpose or use of research impact assessments is to link "outcomes [of impact assessment] to funding allocations" (Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, 2013, p.6), but how such assessment will influence the future research funding formulae is not yet clear.

Currently, there is a partial assessment of the impact of research beyond academia in the *Excellence in Research for Australia* (ERA) evaluation, which aims to measure research quality

across the University sector in Australia (Australian Research Council, 2013b). The ERA exercise is conducted periodically (every two or three years since 2010) by the ARC. ERA uses a suite of indicators and peer review to measure research performance, some of which highlight research impact beyond academia. These include indicators such as research commercialisation income, patents, plant breeder's rights, or NHMRC endorsed guidelines as well as other income categories including government and public sector income, and industry income. Moreover, in the past, there have been various attempts to measure different forms of impact at a discipline level in Australia, but none have been comprehensive in terms of the types of impact measured. For example, a number of reports have looked at the economic returns on the investment of health and medical research funding in Australia (Access Economics, 2003 and 2008; Deloitte Access Economics, 2011). At this point it is therefore too early to say whether Australia will succeed in developing tools that might assist other countries in terms of assessing the societal desirability of specific publicly funded research.

Brazil[24]

Brazil is Latin America's largest country. Indicators on Science, Technology and Innovation (STI) show a rapid growth of the Brazilian research system. For example, Brazil is 13th in the world for producing scientific publications with a growth rate of 8% each year. Compared to this, the number of patents and human resources in STI, however, is rather weak. Though innovation is seen as the main driver for the prosperity of the country, the Global Innovation Index placed Brazil 58th in 2012 (for comparison: China 34th; India 64th).

The following questions are addressed in this section of the report: How is public research funding organised in Brazil? Is there any awareness of RRI issues recognisable among the public funders of the Brazilian research and innovation system?

Public funding is the main source of financing research in Brazil. In 2010, public sector expenditure in R&D totalled R$ 23 billion (approximately €7.5 billion). In 1951, the National Council for Scientific and Technological Development (CNPq) was founded, which has been linked to the Ministry of Science, Technology and Innovation (MCTI) since the 1980s. The CNPq is still the main funding agency of the country. The federal government is the main source of funding for research in universities and public research organisations, as well as the main source, albeit still small, of funding of research in companies.[25]

Though there was a short period some years ago where private R&D investment outperformed public funding (50.3% of GERD, i.e. Gross domestic Expenditure on Research and Development, in 2005), the current situation sees strong public sector dependence for research funding. The source of public funding is divided into federal and state funding. The federal government of Brazil provides the lion share of funds (36.7% of GERD in 2010), while the 26 states and one federal district of the federation divide among them around half of the federal funds (16% in 2010).

Most publicly funded research is undertaken at the universities in two states of the federation: mainly in Sao Paulo, and to a lesser extent in Rio de Janeiro. Rio is the place where the biggest university of the country *Universidade Federal do Rio de Janeiro* (UFRJ) is based. A small number of governmental research institutes remain from the time when Rio was Brazil's capital. In addition the largest public enterprise, Petrobras (oil and gas), is based in Rio with its huge research expenditures and activities. For instance, the company has its own corporate research centre with in-house R&D, and many on-going collaborations with university-industry research projects, and with university-based thematic corporate laboratories. Sao Paulo has two large and very research-active public universities, the University of Sao Paulo (USP) and the University of Campinas

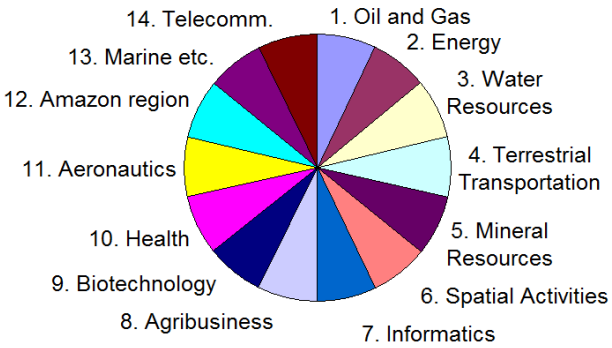
[24] This contribution to the Funder Reports of the PROGRESS is based on (i) observations and discussions with Brazilian researchers having a background in Brazilian research and innovation policy during a visit in March 2014, (ii) document analysis of Brazilian STI funding agencies, (iii) an overview on the research and innovation context in Brazil provided by ERAWATCH updated on an annual basis, a policy document by the European Commission on "Approaching Brazil" based on a questionnaire completed in 2012/2013, and (iv) results from a project called B.BICE+, which draws on information from participating Brazilian STI funding agencies.

[25] http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/br/country

(UNICAMP), where a very high concentration of public research funding can be found (Strategic Forum Document SFIC 2013: p. 9).

Research funding cannot only be categorized by political or territorial distinctions, but also by sectorial perspectives. Within the last 15 years, extra-budgetary sectorial funds have been established. These '*Fundos de Apoio ao Desenvolvimento Científico e Tecnológico*' (Funds to Support the Scientific and Technological Development), also known as '*Fundos Setoriais*' (Sectorial Funds), finance research in universities with strong links to Brazilian companies, each with a different financial resource formula.

Diagram 3: Vertical Sectorial Funds - Brazil



There are currently 14 vertical sectorial funds (see diagram 3). Furthermore, there are two horizontal sectorial funds: Yellow-and-Green *Fundo Verde Amarelo* (FVA) to promote university-industry cooperation and Infrastructure and *Científico e Tecnológico Infraestrutura* (CT-Infra) to fund improvements of infrastructure in science and technology institutes. These horizontal schemes are funded through the vertical ones.

The guidance for the use of all sectorial funds has been geared towards RRI aspects. They intend to:

- Promote sustainable research and innovation structures;
- Generate knowledge and innovation that contributes to solving national problems;
- Reduce geographic inequalities in research by directing a minimum of 30% of their resources to projects in the North, North-Eastern and Centre-West regions.

Strategies, priorities, allocations and all other activities of the funds are managed by joint-sector, public-private committees consisting of government, academia and industry representatives. These committees also select projects for funding. University-industry collaborative research is mandatory for the projects funded under the sectorial schemes.

Federal public research funding

At the federal level, the main actor for defining research and innovation policy is the Ministry for Science, Technology and Innovation (MCTI). The two major research-funding agencies linked to the MCTI are FINEP and CNPq. AS FINEP deals mostly with the incentivization of business activities through, for instance, zero interest loans, it will not be described here. For CNPq, see below.

Other federal ministries are involved in defining and allocating the annual research budgets, especially: Education (48% of federal R&D expenditures, but mostly graduate education funding), Agriculture (11.6%), and Health (7%). Though the research budget is released on an annual basis, it

is subject to a multi-year government-wide budgetary planning tool, designed and coordinated by the Ministry of Planning, Budget and Administration. The current budget (2011-2014) is based on the National STI Strategy 2012-2015 (*Estratégia Nacional de Ciência, Tecnologia e Inovação 2012-2015* ENCTI). ENCTI's strategic objective is geared towards RRI aspects. ENCTI sees science, research and innovation as the main driver for sustainable growth in Brazil. It identifies five challenges:

- to reduce the scientific and technological gap that still separates Brazil from developed nations;
- to expand and consolidate Brazilian leadership in the natural knowledge economy (including green innovation and agribusiness);
- to enlarge the basis for environmental sustainability and the development of a low carbon economy;
- to consolidate a new pattern of international insertion for Brazil;
- to overcome poverty and reduce social and regional inequalities.

The strategy's three main drivers are the promotion of innovation; human resources training and capacity building; as well as the strengthening of S&T research and infrastructure. The related improvements in STI policy are aimed at refining the innovation regulatory framework, improving and enlarging the S&T funding structure and strengthening the National Science, Technology and Innovation System (*Sistema Nacional de Ciência, Tecnologia e Inovação* SNCTI) (cf. ERAWATCH 10.4.2014).

CNPq (federal level)

One of the two main federal funding agencies of the MCTI is the National Council for Scientific and Technological Development CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*). It directs and funds basic and applied research including the development of human resources. CNPq's mission is to promote and stimulate the scientific and technological development of Brazil and to contribute to the formulation of the national STI policy through funding capacity building in STI (at undergraduate, master, doctoral and specialization level) and financing research projects in key areas. Through its programmes, CNPq supports the development of research, strengthens research groups and institutions, and encourages international cooperation of Brazilian researchers.

CNPq houses the Lattes Platform named after a Brazilian, physicist Cesar Lattes, an information system (integrated data-base, web-based query interface, etc.) to manage information on science, technology, and innovation related to individual researchers and institutions working in Brazil. Since all researchers and institutions are required to keep their records up to date, the Lattes Platform can be used not only to obtain information on individual researchers but also to conduct performance evaluations at the organizational level.
In order to select, monitor and evaluate the research projects financed by the Institution, CNPq relies on the support of several teams that form a Technical and Scientific Advisory Council. These teams of consultants have specific assignments, according to their specialized fields and to each

member's terms of office. The Body of Consultants involves approximately 300 researchers, chosen in accordance with their academic knowledge and field of action. These specialists are selected by CNPq on the basis of nominations from the scientific community to take part in the Advisory Committees (CAs). Their task is to judge proposals received by CNPq requesting financial support for research and for the training of human resources.

The Multidisciplinary Committee of Articulation (CMA) composed of 15 members of the Body of Consultants, acts as a collegiate entity and is responsible for assisting the Executive Board of Directors in matters related to the incentive system and to the researchers. Ad Hoc Consultants are high-level specialists, responsible for analysing the scientific merit and the technical feasibility of the funding requests sent to CNPq. These consultants are chosen by the Executive Board of Directors, normally from among those receiving CNPq Research Productivity Scholarships.

The Deliberative Council has the ultimate power of decision-making in CNPq. It is composed of the president and vice-president of CNPq; the presidents of Finep and Capes; the Executive Secretary of MCTI and representatives of the S&T community and the business community, as well as staff of CNPq. Among other matters, this Council deals with the investment of resources, the definition of the budget and actions concerning CNPq policies.

In 2014, CNPq and FINEP financed multiple conferences, symposia, workshops and seminars jointly. The objective was to encourage national and international events linked to science, technology and innovation. CNPq, together with FINEP, receive proposals for holding conferences, symposia, workshops and seminars, in Brazil or abroad, linked to science, technology and innovation and taking place in the period from 1 July 2014 to 31 June 2016.

CNPq supports many RRI-relevant funding programmes. For example, the Program of the Long-Term Ecological Research (PELD, created in 1996) is a pioneering initiative in obtaining information relevant to biodiversity conservation and sustainable use of natural resources in Brazilian ecosystems. Currently 31 sites are conducting research and working in various ecosystems, which are integrated in a network for the development and monitoring of long-term ecological research. Projects are approved by specific notices, for a period of 10 years, renewed annually. Results are obtained through involvement with local communities, several successful experiences in environmental education projects, partnerships with local governments and work with populations in the vicinity of environmental preservation areas.

Lately, there is some awareness of RRI aspects in CNPq potentially following up on social desirability issues: In April 2014, MCTI through CNPq commissioned a new study of the public perception of STI. The idea was to compare the results obtained in the studies of 2006 and 2010 with the third edition to support discussions of STI. Another objective is to understand the role of the media in shaping opinions about science and technology and to identify possible bases for the formulation of public policies.

CAPES (federal level)

The *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) [Coordination for the Improvement of Higher Education Personnel], is an organization of the Brazilian federal government under the Ministry of Education (MEC), devoted to the funding and evaluation of graduate education in the country. This federal agency for the support and evaluation of Higher Education supports the MEC in formulating policies in the context of higher education and coordinates the Brazilian evaluation system of graduate studies. CAPES is dedicated to fostering Brazil's human capacities in S&T through offering support for training activities. Furthermore, it also funds international research cooperation at the federal level. Several international cooperation agreements between Brazil and partner countries are operated through CAPES.

Since 1951, CAPES has funded all federal public universities; it awards a large number of scholarships at all levels and evaluates and certifies higher education institutions and graduate programmes. At present CAPES supports around 22,000 students in Brazilian graduate programs and 1,500 in other countries (http://www.iie.org/en/Programs/CAPES, 10.04.2014). Grants cover scholarships abroad (individual fellowships), joint research projects and university partnerships, bi-national doctoral colleges, visiting professorships, outstanding visiting professorships, and general international cooperation programmes. For example, the "Science without Borders" Programme (CsF) is a mobility programme under the hospices of CAPES and CNPq.

With regard to an RRI perspective, CAPES is especially focused on the North of Brazil to promote cohesion and equality through research funding policies. In April 2013, an agreement was signed between the Southern Common Market (Mercosul) and the European Union, of which Brazil is a signatory. It started a work programme to support the creation of Networks of Teacher Training Institutes to allow the development of a joint study to find common solutions for the problems of teacher training. Initially 12 networks are supported. The Program of Support of the Educational Sector of the Mercosul (PASEM) is a joint action of the Mercosul with the European Union that demonstrates the central role that education has in the processes of regional integration. The overall goal of this Program is to contribute to the improvement of the quality of education by strengthening the professional training of teachers in Argentina, Brazil, Paraguay and Uruguay.

Nearly all European or Associated Countries have bi-lateral STI agreements with Brazil. With CAPES the following countries have agreements: Belgium, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, UK, Israel, and Norway; with CnPq the following countries have agreements: Belgium, Finland, France, Germany, Italy, Portugal, Slovenia, Spain, UK, qne Switzerland; and with FINEP Denmark, Finland, France, Germany, Portugal, Spain, UK, and Israel have agreements (information from Strategic Forum document SFIC 2013, p. 2).

State public research funding

FAPESP

There are 25 Research Support Foundations (FAPs) at the state level, located in each federal state (except Rondonia and Roraima) and in the Federal District of Brasilia. These Research Support

Foundations aim to support the research and innovation community of their respective state. All the FAPs are organized under one umbrella organization, the Confederation of National State Funding Agencies: CONFAP (Conselho Nacional das Fundações Estaduais de Amparo à Pesquisa) [National Council of State Research Support Foundations] was officially formed in 2007 as a not-for-profit organisation. While all FAPs financially support research and innovation activities, the individual budgets of the FAPs vary greatly. The actions of the FAPs include a broad range of funding instruments in support of research, innovation and teaching. Below, the three most prominent FAPs are listed.

FAPESP is the São Paulo state Research Support Foundation. FAPESP (www.fapesp.br/en) is a public foundation, funded by the taxpayer in the State of São Paulo. São Paulo has a population of forty million and generates 35% of Brazil's GNP. The constitution of the State establishes that 1% of all state taxes belong to the foundation, and the government transfers these funds monthly. The stability of the funding and the autonomy of the foundation allow for an efficient management of the resources that has had a sizable impact: while São Paulo has 22% of the Brazilian population and 30% of the scientists with a doctorate in the country, the state is responsible for 52% of the country's scientific articles published in international journals.

The foundation works in close contact with the scientific community: all proposals are peer reviewed with the help of area panels composed of active researchers. Apart from funding research in all fields, the foundation supports large research programs in Biodiversity, Bioenergy, Global Climate Change, and in the Neurosciences. FAPESP's expenditures in 2013 were R$ 1.085 billion (approximately US$ 500 million, €367 million). 37% of the expenditures supported fundamental research; 10% supported research infrastructure; and 53% supported application oriented research, in many cases performed by small businesses or in joint research performed by academia in collaboration with industry. The percentage invested in applied research has been growing in recent years, consistently with the foundation's mandate to foster the scientific and technological development in the State of São Paulo.

FAPESP maintains cooperation agreements with national and international research funding agencies, higher educational and research institutions and business enterprises. The international cooperation covers a broad range of countries and agencies (www.fapesp.br/en/6812) including the UK Research Councils, the Agence Nationale de Recherche (ANR) in France, the Deutsche Forschungsgemeinschaft (DFG) in Germany, and the National Science Foundation (NSF) in the U.S. FAPESP offers many programs to support foreign scientists willing to work in research institutions in the state of São Paulo, Brazil.

Concerning FAPESP awareness of **RRI**: Under the British Council and FAPESP Researcher Links Scheme, funding has recently been awarded to hold a workshop on "Responsible Innovation and the Governance of Socially Controversial Technologies" in UNICAMP, Campinas, Brazil on 19-21 MARCH 2014. The workshop was coordinated by Phil Macnaghten (Durham, UNICAMP) and Jack Stilgoe (UCL, London), with contributions from other UK (Brian Wynne, Lancaster; Richard Owen, Exeter) and Brazilian researchers (Marcelo Knobel, UNICAMP; Marko Monteiro, UNICAMP). Early

Career Researchers from the UK or Brazil (within the State of Sao Paulo) were invited to apply to attend this workshop (defined as researchers [postdocs, fellows or lecturing staff] who have completed their PhDs within 10 years). The workshop was promoted on the PROGRESS website.

In February 2014, at the Annual Meeting of the American Association for the Advancement of Science (AAAS), "Meeting Global Challenges: Discovery and Innovation" at Chicago, USA, Marko Monteiro (State University of Campinas, Sao Paulo, Brazil) and Phillip Macnaghten (State University of Campinas (UNICAMP), Campinas, Brazil) gave a presentation preceding the Campinas workshop entitled "Towards a Framework of Responsible Research and Innovation in Brazil". They explored what **RRI** might mean in a Brazilian context and the challenges that it faces in relation to current 'live' debates on science policy. They examined the capacities and propensities of research bodies in Brazil to be anticipative, reflexive, inclusive and responsive in relation to key areas of controversy, such as the exploration of deep-sea petroleum (known as "pre-salt") and the development of bio-energy technologies (e.g. ethanol fuel for cars) (cf. abstract of that talk).

The State of Sao Paulo supports many bilateral agreements with European countries and their respective funding agencies, where **RRI** issues are central. For example, the German DAAD finances an academic network coordinated by the University of Hohenheim, Germany, on bio-economy (BECY – Strategic Network Bio-based Economy), where the Universidade de São Paulo and the Universidade Estadual Paulista are partners: this network, which deals with issues such as world-wide food security, green biotech, energy systems transition, land use and sustainable agriculture, healthy and secure food, industrial use of renewable resources, sustainable innovation and energy supply through biomass etc. The academic exchange scheme BECY concentrates on RRI issues such as how to combine sustainability, innovation and social desirability in the context of ecology, land use, economy and new technologies. In the area of agro-biotechnology, Brazil can be considered a world-leader (cf. Strategic Forum document SFIC 2013, p. 8).

China

In this section of the report, one public funder and one private funder are introduced to explore how socio-economic development targets are driven by general funding criteria and implementation mechanisms in China. The public funder is the Natural Science Foundation of China (NSFC). The private funder is the China Medical Board (CMB).

Funding agencies operate in compliance with the national strategic demands to construct a harmonious society and promote economic sustainable development. The Communist Party of China's (CPC) Central Committee made the strategic decision to strengthen China's capacity for innovation and establish China as an innovative country at the 16th National Congress of the CPC in 2002. The core of the country's national development strategy, namely to enhance China's capacity for independent innovation and make China an innovative country, was decided at the 17th National Congress of the CPC in 2007. In order to promote independent innovation and enhance capacity for producing original innovations and integrated innovations as well as making further innovations on the basis of absorbing advances in overseas science and technology, the CPC Central Committee further put forward the strategy of innovation-driven development and placed greater emphasis on driving innovation through international collaboration at the 18th National Congress of the CPC in 2012.

The Natural Science Foundation of China

Founded in 1986, the Natural Science Foundation of China (NSFC) is an official funding institution affiliated with the State Council and in charge of the National Natural Science Fund. In China, it is one of the most important organizations that accept applications for basic research from Chinese researchers. The majority of the funding budget comes from the central government; the annual increase rate in the past ten years was about 25%. In 2013, the total amount of funding available was 23.8 billion RMB (2.99 billion Euros), 17 billion (2.13 billion Euros) of which comes from the central government[26].

To achieve social and economic development, the NSFC together with the Ministry of Science and Technology formulate the principles, policies and plans for the development of science and technology. The NSFC compiles and promulgates the annual Guide to Programs for basic research and applied research heeding the opinions from scientific communities as well as related state organs and enterprises[27]. During the late 1980s and the 1990s, the NSFC funded many small programs to tackle specific needs such as research in medical drugs and agricultural chemicals, scientific instruments and so on. Since 2000, the NSFC has also attached a high level of importance to deep-seated driving forces of national economic and social development such as basic research, upholding free exploration and cultivating innovative talents and teams.

[26] '2013 Annual Subsidy Scheme of National Natural Science Foundation : 17 Billion RMB Financial Appropriation', http://news.xinhuanet.com/fortune/2013-05/29/c_115946902.htm, accessed 12 April 2014.

[27] Every year a large number of research programs are derived from national strategic demands and the opinions collected at institutions of higher learning, scientific research organizations, academic groups, as well as related state organs and enterprises. Although only those which pass scientific review by related experts can be included in the annual guide to programs of the NFSC, it is an important bottom-up approach to funding in China.

In order to lay the foundation for the strategy of innovation-driven development of China, the NSFC also developed an original innovation strategy, a talented personnel strategy, an open cooperation strategy and an innovative environmental strategy in its 12th Five-Year Plan. The original innovation strategy is designed to stimulate transformative non-consensus innovation and transformative research[28] which may nurture new ideas and new concepts, and encourage original breakthroughs and leapfrogging[29] in priority fields. The talented personnel strategy is focused on: creating favourable environments for the support of talent and accumulate intellectual capital supporting the construction of an innovative country. The open cooperation strategy takes into consideration the use of scientific and technological resources at home and abroad; it creates a favourable environment for scientists to better participate in international or regional, scientific and technological cooperation.

In view of the fact that capacity for innovation heavily depends on basic research, frontier research and talented personnel, the above factors are greatly emphasized in the 12th Five-Year (2011-2015) Plan of the NSFC. During the 12th Five-Year period, the NSFC will promote innovation through the following three channels: first, for basic research, the NSFC will strengthen the support of fundamental disciplines, traditional disciplines, weak and endangered disciplines, and look after the accumulation of basic data and the building of databases. Secondly, for frontier research, the NSFC will make forward-looking arrangements which will lead to technological, economic and social development; promote disciplinary collaboration and integration to cultivate and develop emerging disciplines; conquer the scientific and technological highlands which may affect the future development of strategic emerging industries; and pay close attention to transformative research which may bring forth new ideas and new concepts. Thirdly, for talented personnel, the NSFC will develop funding chains for talented personnel and teams, attract overseas talents while maintaining domestic ones, and combine the cultivation of leading personnel with fostering innovative teams[30].

The NSFC continuously improves the program portfolio in order to cater for the development of society and economy. Until the mid-1990s, the NSFC mainly focused on scientific research, or to be exact, the General Program, and provided only a little infrastructural funding for scientific equipment and instrumentation. From 2001 to 2006, the NSFC gradually increased funding for talent, and all programs were broadly divided into the category of research and the category of talent. However, the former still accounted for about 70% of the overall funding. From 2006 onwards, the category of infrastructure construction was further strengthened to include the

[28] Non- consensus innovation and transformative research are both different and interrelated. The former refers to potential innovation on which there is a sharp divergence of opinion in the peer review. And the latter involves ideas, discoveries, or tools that could radically change the understanding of an important existing scientific or engineering concept or educational practice or may lead to the creation of a new paradigm or field of science, engineering, or education. Non-consensus innovation often results from transformative research, but also may be caused by other factors such as reviewer's risk preference, personal experience and values.

[29] For the purpose of the report, "leapfrogging" means that scientific and technical research passes over a stage or obstacle and moves into a leading or dominant position.

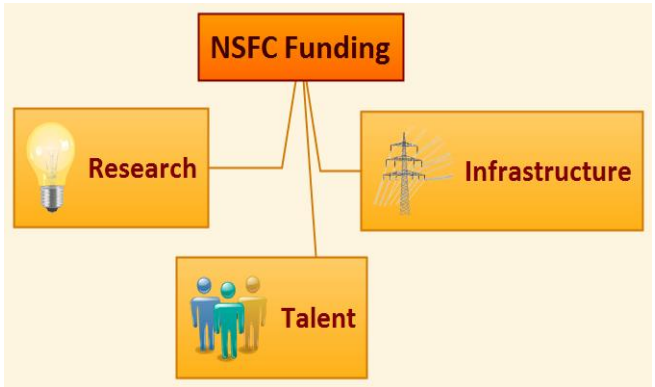
[30] 'The 12th Five - Year Plan for the Development of the National Natural Science Fund',<http://www.nsfc.gov.cn/publish/portal1/tab284/> accessed 14 April 2014.

Special Funds for Basic Research Instruments, International Cooperation and Exchange, Public Understanding of Science, etc. As a result a relatively sound funding portfolio has come into being which consists of the research block, the talent block and the infrastructure block.

In order to ensure good socioeconomic performance of funded programs, the NSFC has established a review and evaluation system. In accordance with the *Constitution of the National Natural Science Foundation of China*[31], the evaluation principles for NSFC projects are "relying on experts and developing democracy to select excellent projects for support in a fair and reasonable way"[32]. Additionally, the four funding criteria are[33]:

1. research values
2. innovation
3. social influence
4. feasibility of research schemes.

Diagram 3: NSFC Funding



In practice, the review and evaluation process include two stages which are peer review and expert panel review. At the peer review stage, five experts are chosen from the NSFC expert database according to their specialty, knowledge and scientific positions to conduct the peer review for each of the applications that are eligible. At the expert panel review stage, each expert panel is comprised of 5 scientists with great attainments, extensive knowledge, honest working style, and high prestige in the scientific communities.

For most research programs funded by the NSFC, the peer review criteria are comprised of general criteria and specific criteria. The former consists of theoretical or methodological innovation, merit of the research and feasibility of the research scheme, while the latter involves research competence of applicants, research budget and talent training. In addition, some aspects may also be further emphasized depending on the type of programs corresponding to different socio-economic goals.

The following aspects are general review criteria for most programs[34]:

[31] The Constitution of the National Natural Science Foundation of China, adopted at the 2nd Plenary Session of the 5th NSFC General Assembly on March 17, 2005. Revised at the 1st Plenary Session of the 6th NSFC General Assembly on May 28, 2008.
[32] See Article 22 of the Constitution of the National Natural Science Foundation of China.
[33] See Article 26 of the Constitution of the National Natural Science Foundation of China.
[34]The general review criteria and the Regulations on the National Natural Science Funds as well as the 2014 Guide to Programs Funded by NSFC, and the Requirements and Instructions for Peer Review Proposed by the Department of Management Sciences, NSFC can be found on the following websites:http://www.nsfc.gov.cn/publish/portal1/tab283/; http://www.nsfc.gov.cn/nsfc/cen/xmzn/2014xmzn/index.html; http://www.iss.ac.cn/managesci/manage.html#.

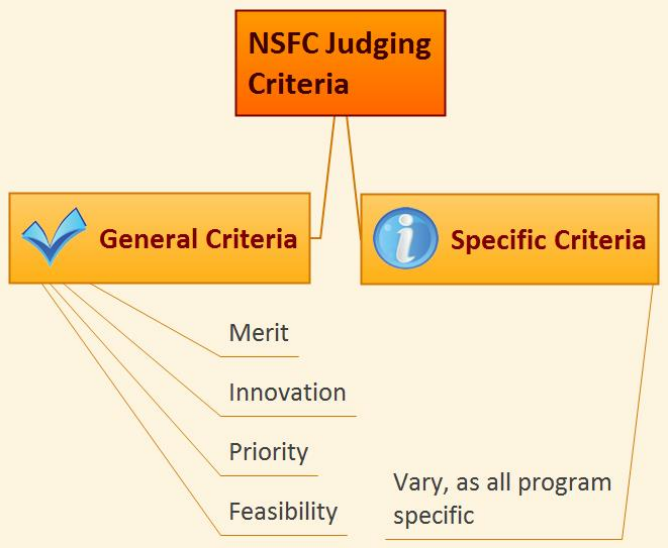
1. Merit of the research:
Basic research - how well does the research proposal deal with scientific significance, frontiers and exploration of the issue?
Applied research - what may be the application perspectives besides research merit?

2. Innovation:
Have any innovations been incorporated with regard to theory, method and technique? Generally, programs with a high degree of innovation should be especially identified and protected, and interdisciplinary research should be actively supported. Furthermore, the panel review committees focus their review on the non-consensus innovative projects and put forward funding suggestions in light of the overall funding strategy.

3. The scope and priority of the research:
Is the scope of the research appropriate? Are issues selected accurately? Are key problems prioritized?

4. The feasibility of the research scheme.
Is there a well-reasoned scheme for the proposed activities? Is the rationale for choosing the approach well-justified? Are there adequate resources available to the research group to carry out the proposed activities?

Diagram 4: NSFC Judging Criteria



Apart from review criteria that apply to all programs, a number of program-specific factors are also taken into account. For example, the specific criteria for the General Program, the Major Program, and the Fund for foreign Distinguished Young Scholars are as follows[35]:

1. Specific criteria for the General Program:
E.g. the Free Application Program, which is one category of the General Program, emphasizes the following aspects - *How well qualified are the applicant and members of the research group to carry out the proposed research? Is the proposed research related to previous research conducted by the applicant and members of the research group? If the applicant has obtained funding from other programs, how is their past performance?*

2. Specific criteria for the Major Program:
Is there a critical scientific issue with strategic significance defined from the perspective of socio-economic development? Is the program director highly influential in academic circles at home and

[35] The specific review criteria analyze and encapsulate by the authors in accordance with the Regulations on the National Natural Science Funds, the 2014 Guide to Programs Funded by NSFC, and the Requirements and Instructions for Peer Review Proposed by the Department of Management Sciences, NSFC. The related documents can be found from the following websites:http://www.nsfc.gov.cn/publish/portal1/tab283/; http://www.nsfc.gov.cn/nsfc/cen/xmzn/2014xmzn/index.html; http://www.iss.ac.cn/managesci/manage.html#.

abroad? Have the director and principal investigators got a solid academic track record on the issue? Is the division of scientific research clear? Are all sub-projects organically integrative? Is the program coordinated with national plans for the development of science and technology? Is the program closely related to other projects? Is it conducive to integrated innovation?

3. Specific Criteria for the Fund for foreign Distinguished Young Scholars:
The applicant has to be a Chinese scholar with foreign nationality, less than 45 years old, and committed to China's scientific development and economic construction. Additionally, the applicant has to be formally hired by a university or research institute in China (i.e. they do not have official employment relations with foreign units), and will undertake full-time basic research in mainland China within the funding period covered by the employment period. The applicant must have a Ph.D. degree and have been formally granted the title of professor or professional position equivalent to professor by the supporting institution. The applicant has to be influential in his or her discipline, and his or her academic achievements are recognized by peers at home and abroad. The proposed project matches urgent domestic needs, is at the international frontier, and can drive talented personnel training and the development of related research areas.

NSFC: References to ethical acceptability

The NSFC actively promotes ethically acceptable research and innovation. It has endeavoured to promote the construction of academic norms conducive to the healthy development of science and technology and to advocate widely accepted science ethics. Furthermore it aims to guide the personnel engaged in science and technology administration and scientific research to form ethical performance views and value preferences. Meanwhile the NSFC has rigorously implemented the provisions of the Regulations of the NSFC on original records, credit files, misconduct handling and fund supervision, and further improved the misconduct penalty and prevention systems.

With regard to programs on medicine and the life sciences, the NSFC has forwarded a series of ethical requirements and regulations published by authorities concerned, which include the Regulation on the Administration of Affairs Concerning Experimental Animals, the Regulation on the Administration of Laboratory Animal Quality Control, the Regulation on the Administration of Laboratory Animal License, the Guideline on the Humane Treatment of Laboratory Animals, the Regulation on the Administration of Biosafety in Pathogenic Microorganism Laboratories, the Regulation on the Administration of National Laboratory Animal Seed Centres, the Detailed Rule on National Rodent Seed Centres to Introduce and Supply Laboratory Animals, the Regulation on the Administration of Genetic Engineering Safety, the Interim Regulation on the Administration of Human Genetic Resources, the Technical Norms of Human Assisted Reproductive Technologies, the Regulation on the Administration of Human Assisted Reproductive Technology, the Ethical Principles for Human Assisted Reproductive Technology & Sperm Banks, the Basic Standard and the Technical Norms of Human Sperm Banks, the Regulations for Human Organ Transplantation, the Ethical Guiding Principles for the Research involving Human Embryonic Stem Cells, the Draft Recommendation for Ethical Review of Biomedical Research Involving Human Subjects, the

Regulation on the Administration of the Clinical Application of Medical Technology, the Good Clinical Practice and more.

An example is the Draft Recommendation for Ethical Review of Biomedical Research Involving Human Subjects, this stipulates the main principles for ethical review, which states that "the safety, health and rights of subjects must take priority over science and social interests"[36] According to these ethical requirements and regulations, the applicant judges whether the program involves ethical issues. If the program does, the applicant must attach to the research proposal ethical qualification documents checked and approved by the ethics committee of the supporting units.

NSFC: References to sustainability

An innovation-driven economy is the inevitable alternative to the current focus on manufacturing that protects resources for future generations and is more environmentally friendly. As is well known, China acts as the Manufacturing Factory of the Globe in global production networks and therefore consumes a large amount of natural resources and pollutes the environment as it provides low-cost and low added-value products for the world. Low added-value and polluted environments go against the social wellbeing of China. And what's more, China's natural resources cannot meet the tremendous demand of a world factory, which means China's current economic development mode is unsustainable. In order to drive China's sustainable development, China has to transfer from a manufacturing-driven economy to an innovation-driven economy.

NSFC: References to Societal Desirability

Socio-economic development is the fundamental way to meet the ever-growing material and cultural needs of the people. In view of the fact that China is still the largest developing country in the world; both Hu's report at the 18th Party Congress and Jiang's report at the 16th Party Congress stress that development is the fundamental principle, and development still holds the key to addressing all the problems in China. The Twelfth Five-Year Plan for National Economic and Social Development of the People's Republic of China (2011-2015) further states: "we are carrying out strategies of accelerating development through developing science and technology … continuing to improve people's lives … enhancing social services".[37] In this regard, science and innovation are driven in a focused manner towards socially desirable goals to improve people's lives.

The NSFC fosters scientific solutions for problems of strategic importance encountered during the course of social and economic development. For instance, the Major Program intends to solve major scientific problems emerging from either scientific or socioeconomic development through

[36] See article 14 of the Draft Recommendation for Ethical Review of Biomedical Research Involving Human Subjects. The Draft Recommendation for Ethical Review of Biomedical Research Involving Human Subjects was published by National Health and Family Planning Commission of the People's Republic of China in 1997.
[37]'The 12th Five-Year Plan for the Development of the National Natural Science Fund',<http://www.nsfc.gov.cn/publish/portal1/tab284/> accessed 15 April 2014.

interdisciplinary and inter-departmental efforts, and provide scientific support for the optimization and upgrading of industrial structures and the development of strategic emerging industries. The Major Research Plan intends to deal with key scientific issues of strategic importance by integrating projects with different disciplinary backgrounds, varying academic thinking at different levels, striving for leapfrog development of the national economy and breakthroughs in several important research directions.

Private Funding Agency: China Medical Board[38]

Founded in 1914 as the second major program of the Rockefeller Foundation, the China Medical Board (CMB) was endowed in 1928 as an independent American foundation in New York. Now it is headquartered in Cambridge, Massachusetts, USA, and has a new representative office in Beijing, China. With the endowment of over $200 million, its annual grants add up to more than $10 million US dollars. In China, the CMB was originally committed to the establishment and operation of the Peking Union Medical College in Beijing from 1914 to 1950, then withdrew and extended its capacity across Asia in 1950, and has expanded support in medical education and research to more than a dozen medical universities in China after returning in 1980.

Its broader mission is to promote health equity by means of capacity strengthening in the fields of health policy and health systems and associated educational activities in China and neighbouring Asian countries. In China, the CMB is dedicated to supporting solutions to challenges in providing universal, high quality, affordable healthcare to its people. In 2008, the CMB launched a fresh initiative to enhance scientific excellence in critical capabilities. In 2011, the CMB has launched Collaborating Programs (CMB-CP) and Open Competition Programs (CMB-OC) which give priority to research activities involving diseases with a high 'burden of disease'; health policies and health systems related to health governance, ethics, financing, human resources, care delivery systems, health technology assessment, and health informatics in line with the above initiative.

The CMB targets its grant and support medical activities at carefully selected grantees. Eligible applicants are from the 17 selected medical universities or institutions. The CMB-CP generally consists of a core multidisciplinary research group that addresses a high-priority challenge in health policy and health systems. The CMB-CP must demonstrate the potential to achieve national excellence in advancing specific areas of health policy and health systems, and the Principal Investigator (PI) must be a distinguished faculty leader. The CMB-OC emphasizes broadening opportunities in health policy and health systems for junior researchers and eligible applicants are usually excellent junior faculty or post-doctoral fellows or researchers with high potential who illuminate the measurement, causes, conditions, strategies and interventions to inequity in health.

In line with the CMB's mission, the funding criteria for CMB-CP and CMB-OP are related to capacity strengthening in the fields of health policy and health systems and associated educational activities. The general funding criteria are the quality, relevance, and topical significance of the

[38] The introduction of CMB and the analysis of funding criteria for the programs are based on documents published by CMB website,< http://www.chinamedicalboard.org/> accessed 16 April 2014.

proposal, and sometimes the promotion of multidisciplinary work and cost-effectiveness in producing key knowledge and educational products given the requested budget. The specific funding criteria for the CMB-CP are PI's leadership qualities, academic credentials, and the potential to mobilize resources and to achieve results, as well as the demonstrated involvement with a collaborative team of researchers of different levels to work on the program, plans to nurture junior faculty and foster emerging leaders, and the potential to develop the chosen field to obtain national recognition. The particular funding criteria for the CMB-OP are topical importance of the project, as explained in its "justification, soundness of the research design and appropriate methods used, feasibility of the project, potential of the PI to achieve academic excellence."[39]

The review process of CMB-OP and CMB-CP consists of initial review and final review via peer review. At the first Stage, applicants submit a 1-2 page abstract of the proposal for initial review; at the second stage, the PIs of the projects that are considered suitable are invited to develop complete proposals for final review. In particular, the full proposal of CMB-OP will go through peer review again, with promising proposals invited for revision, and then the revised proposals will be reviewed again to determine the final selection. Generally speaking, funded proposals are typically those which are thought of highly by peer reviewers, and CMB officers make the final selection and announce the final funding decisions.

The CMB is an example of a private funding agency operating in China. By contrast to the NSFC, the goals of projects are more specific, and the review process differs, but it adopts similar criteria for review and evaluation of submitted proposals which are also oriented towards social or economic development. To be exact, programs funded by the CMB focus on equity in health - a major goal of China's health care reform. Hence, the focus of the CMB's strategies on societal desirability is clear from the above. For instance, to give priority to research activities involving diseases with a high 'burden of disease' are likely to be beneficial to the population at large and improve people's lives, in line with the 12th Five-Year Plan.

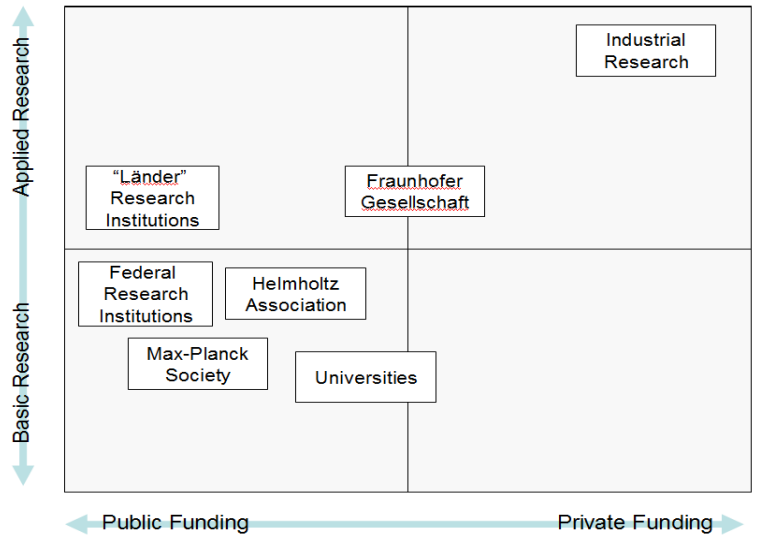
[39] 'China Medical Board Open Competition Research Program in Health Policy and Systems Sciences 2014 Request for Proposals (RFP)',< http://wcums.scu.edu.cn/userfiles/files/2014/OC2014RFP.pdf > accessed 17 April 2014.

Germany

Simplified, German public funding for research and innovation is divided between universities and non-university research institutions. Germany is host to around 390 universities specialising in a broad range of research and scholarly disciplines. In addition, a range of non-university research institutions are funded by the German state. These include:

- The **Helmholtz Association of German Research Centres**, which is the largest scientific organisation in Germany, providing top scientific outputs for society, science and industry and aiming to address the grand challenges of today. For instance, one of the funded energy alliances aims to establish a flexible and stable electricity network that can cope with the fluctuating supply produced by renewable energies.[40]
- The **Max Planck Society**, an independent non-profit research organisation, which funds numerous Max Planck Institutes to perform basic research in the natural sciences and the humanities. For instance, the Max Planck Institute for Experimental Medicine conducts basic medical research in the neurosciences with the aim to develop new diagnostic and therapeutic approaches in autism, schizophrenia or multiple sclerosis.[41]
- The **Fraunhofer-Gesellschaft**, which conducts applied research for private and public enterprises as well as for the general benefit of the public. With 80 institutes (60 of which are based in Germany) it is the largest organisation for applied research in Europe. For instance, the Fraunhofer Institute for High Frequency Physics and Radar Techniques develops high-tech radars to increase ship security, including pirate control.[42]
- In addition, the **Federal Government** funds 41 Federal Research Institutes to provide a scientific basis for policy making and the **Federal States of Germany** (*Länder*) fund another 100 institutes to support local research needs.

Diagram 5: Focus and Funding of German Research Institutions



Modified and Adapted from: Federal Ministry of Education and Research 2012a

[40] http://www.helmholtz.de/en/helmholtz_centres_networks/helmholtz_energie_allianzen/
[41] http://www.mpg.de/152284/experimentelle_medizin?section=nb
[42] http://www.fhr.fraunhofer.de/

In 2011, the Government provided approximately 21 billion Euros for research and innovation (Federal Ministry of Education and Research 2013b) and in 2013, the Federal Ministry of Education and Research and the Federal Ministry of Economy alone spent around 8.9 billion Euros and 2.9 billion Euros respectively on R&D in Germany.

Diagram 5 maps funding sources against research missions of the different German research institutions. Predictably, most of the basic research is supported by public funds, whereas applied research is funded by private companies, state institutions and institutes of the Fraunhofer-Gesellschaft. Additionally, many of the approximate 19,000 foundations in Germany and private donors also promote research. The "**Stifterverband für die Deutsche Wissenschaft**" – an umbrella of numerous single funding foundations – provides almost 36 million Euros in funding for education, research and science.

Two specific funding initiatives from the Federal Ministry of Education and Research are introduced in this report to give an overview of how the German state aims to direct funding towards societal benefit. Research funding in Germany is driven especially by two policy motives: scientific excellence, and the demands and expectations of the economy and society at large. These motives were central in the formulation of the Excellence Initiative and the joint strategy "Biotechnologie 2020+", which address university as well as non-university research.

The Excellence Initiative

The German Excellence Initiative was initiated in 2005 as part of the national implementation of the EU Lisbon Strategy.[43] The initiative's aim is to strengthen the quality and visibility of university-based science in Germany and to improve its international competitiveness (Federal Ministry of Education and Research 2012b). The desired outputs from the initiative are in three areas:

(1) More successful graduate schools to promote early career researchers;
(2) More clusters of excellence to promote top-level research;
(3) Focused institutional strategies to promote top-level university research.

Diagram 6: Location of German "Elite Universities"

To be eligible to apply for funding of the third line (institutional strategies); a university has to succeed first in obtaining funding for at least one graduate school and one excellence cluster. When a university is successful in all three funding lines, they are widely called an "elite university", even though the term is not used by the funder. At the time of writing (2014) the following cities have universities with elite status: Aachen, Berlin (2), Bremen,

[43] The EU's Lisbon Strategy deals primarily with strategies for the creation of jobs and growth to increase European productivity and competitiveness.

Cologne, Dresden Heidelberg, Konstanz, Munich (2) and Tübingen.

During three consecutive calls, the Excellence Initiative has been jointly managed by the German Research Foundation (DFG) and the "Wissenschaftsrat" (German Council of Science and Humanities). Funding decisions are mostly based on scientific evaluation criteria, namely (ExV II 2009):

(1) excellence in research and in the promotion of postgraduates within broad and promising knowledge areas, scientific programmes, relevant faculties and collaborating institutes;
(2) visibility, concepts and potentials for cooperation with other universities and research institutions as well as for interdisciplinary and international networks;
(3) gender mainstreaming and – in follow-up cases – proof of progress and achievement of interim goals.

Other excellence criteria aimed exclusively at the following specific funding lines: (1) Graduate schools had to prove their attractiveness for graduates and their provisions for supervision and autonomy of the young researchers; (2) Excellence clusters had to demonstrate the coherence and organisation of their networks as well as their capabilities and perspectives. They also had to verify the planned knowledge transfer and its economic relevance; (3) Elite universities had to add innovative concepts for research-oriented education and plans for maintaining their excellence.

For this aim, both organisations constituted a joint commission, which formulated the specific funding conditions and the initiation of the external evaluations of the received universities' applications. On the basis of these evaluations, the commission made recommendations for the selection of schools, clusters and universities to be funded by the Excellence Initiative. Subsequent funding decisions were taken by a granting committee, which was constituted itself from members of the joint commission and from the federal and regional minsters of research and education.

Until 2017 – at the end of the current programme period – a total of 4.6 billion Euros will have been spent throughout the excellence initiative. The funding is mainly provided by the Federal Government and to a lower degree (25%) by the regional home state of the funded university (Wissenschaftsrat 2012a). After several years of experience with this instrument of targeted governance of scientific excellence, some criticism has arisen, including the following:

1. The initiative aims exclusively at excellent research. This could lead to an **imbalance between research and education**. As a result, the quality of higher education for future junior scientific staff at under-graduate levels could suffer (Irle 2012). This governance problem is partly related to political responsibilities. Educational matters are delegated to states whilst the federal government is in charge of the Excellence Initiative.
2. The **uneven geographical distribution** of "elite university" sites among the federal states has been criticized as unfair.
3. The additional funding for "elite universities" may favour them in the competition for limited third parties funds. Corresponding disadvantages of competing "non-elite universities" would

deepen the gaps between both groups. This could lead to **quality losses at most other university campuses** (ORF 2012).

4. At the same time, even the "elite universities" could suffer in the long run due to the limited periods of time of extra-funding: Their long-term development commitments, which were decisive for being funded in the first place, could be in danger, when the funding period is not continued. For instance, the "Karlsruhe Institute of Technology" (KIT)[44] is one of the institutions, which has been affected by the discontinuation of excellence funding. This endangers the **universities' planning security** and thus the sustainability.
5. The Excellence Initiative has a strong focus on the economic and/or societal utility of funded research. It has been argued that this is short-sighted and might violate the established **freedom of universities** to choose their subject matters. Especially basic research and the humanities could be weakened, which might harm unbiased academic knowledge generation in the long run. However, to date, early assessments gave no clear evidence for the latter concern (see Sondermann et al. 2012).

The current excellence funding mechanism will end as planned in 2017. Its extension is not foreseen by the federal and state governments. Instead and as a reaction to the lessons learned so far, a **"Future Pact"** for the scientific system was recently developed by the German Council of Science and Humanities. This concept will transfer the Excellence Initiative into a bundle of improved long-term measures for graduate schools, for thematic and regional research clusters and for universities. The future pact would also open new funding lines for major non-university research institutions as well as enhanced support for higher education (Wissenschaftsrat 2013).

The "Biotechnologie 2020+" strategy

Biotechnology is a cornerstone of German research, as shown in the recent German "Biotechnologie 2020+" initiative. The initiative is a joint strategy of the Federal Ministry of Education and Research and the four largest non-university institutions in Germany, which aim at concerted thematic action to strengthen broad biotechnological research. In the course of the framing of the research strategy a consultation with technology assessment experts took place to discuss chances and risks of the different applications[45]. A memorandum of understanding has already been signed by the partners and the results of the joint dialogue have now entered the phase of specific funding measures (Federal Ministry of Education and Research 2013c). To date, more than 80 million Euros have been spent by the Federal Ministry of Education and Research and the four research partners. The participating institutions pursue the following research objectives:

- Several centres of the **Helmholtz Community** have set up a research network on "Molecular Interaction Engineering" for new systems approaches for the synthesis of catalysators, headed by the Karlsruhe Institute of Technology (KIT).
- Nine institutes of the **Max Planck Society** started a research initiative on synthetic biology. It aims at the synthesis of protein-building mechanisms and of cellular units.

[44] The KIT is – in a structurally sense – a unique institution within the German research landscape: it is the result of a merger of the University of Karlsruhe with the former "Forschungszentrum Karlsruhe".
[45] http://www.biotechnologie2020plus.de/BIO2020/Navigation/DE/root,did=164942.html

- Eight institutes of the **Fraunhofer Gesellschaft** are investigating systems for the cell-free synthesis and production of proteins and other biomolecules.
- The **Leibniz Community** aims at novel production units at micro-levels for the synthesis and production of new medical agents. A "Leibniz Research Cluster" of five of its institutes will investigate new processes and surface technologies for the design of appropriate micro-reactors.

The main scientific results of the German biotechnology initiative may be expected between 2014 and 2020. The findings will have a clear application-oriented industrial perspective, as described above. This is in some contradiction with the official wording of the strategy, which had been announced as "basic research".

The DFG case

In German funding policy the *Deutsche Forschungsgemeinschaft* (DFG, German Research Foundation) is an important pillar and unusually the only German funding organization that is run by the scientific community itself. The DFG is an association under private law and its members are research institutions, research universities, the academies of sciences and humanities, the Max Planck Society and the Fraunhofer Society. The DFG is funded by public money. Its annual budget of about 2.5 billion Euros is underwritten by Germany's federal (67.1 %) and state governments (32.7 %) as well as the EU and private donors.

The DFG promotes science and research in all its branches. Even though representatives from the states and the Federal Government are members in all Grants Committees, the majority of the reviewers are members of the scientific community. The DFG is thus the only self-organising research funder in science in Germany. Its goal is to support and coordinate research projects in all scientific disciplines - from philosophy to engineering. In fulfilling this mission, its particular attention focuses on advancing young researchers.

The programs do not predefine specific research topics. Therefore in the setting of *research goals* **RRI-criteria** like sustainability or social desirability do not play any direct role. However they do play a role in the *framework requirements* for the research, as has been outlined in the relevant section above, where the ethics requirements of the DFG were listed.

With respect to **sustainability** studies must avoid significant adverse effects and in the case of studies falling under the remit of the Convention on Biological Diversity (CBD) special DFG rules apply[46]. With regard to studies involving genetically modified organisms (GMO) researchers and institutions need to adhere to the Genetic Engineering Act (Gentechnikgesetz)[47].

[46] http://www.dfg.de/formulare/1_021e/1_021e.pdf
[47] http://www.dfg.de/foerderung/programme/einzelfoerderung/sachbeihilfe/formulare_merkblaetter/index.jsp

It is not a prerequisite however, that the research drives towards the common good, i.e., **societal desirability**. However the central goal of the DFG that is formulated in it statutes §1 can be judged as a common good and can therefore be interpreted as socially desirable: That is that the

> "The *Deutsche Forschungsgemeinschaft* (German Research Foundation) serves all branches of science and the humanities by funding research projects and facilitating cooperation among researchers. It devotes particular attention to the education and advancement of young researchers. It promotes equality between men and women in the scientific and academic communities. It advises parliaments and public authorities on scientific matters and fosters relations with the private sector and between scientists and academics at home and abroad."[48]

[48] http://www.dfg.de/en/dfg_profile/statutes/index.html

India

The funding of research and innovation in various sectors in India is closely linked to the overall priorities set by the Planning Commission. The Planning Commission was set up by a Resolution of the Government of India in March 1950 in pursuance of declared objectives of the Government to promote a rapid rise in the standard of living by efficient exploitation of the resources of the country, increasing production, and offering opportunities to all for employment in the service of the community. The Planning Commission was charged with the responsibility of assessing all national resources, augmenting deficient resources, formulating plans for the most effective and balanced utilisation of resources and determining priorities.

The 12th Five-Year Plan

The Planning Commission, through its Five-Year National Plans, takes stock of the situation prevailing in various sectors such as Science and Technology, Environment, Education and Health; then decides on the sector-wise priorities for the plan-period with the possible tentative financial outlays. Based on these priorities, individual ministries make or align their annual plans and submit the budget proposal to the Ministry of Finance, which finally makes a decision on the allocations.

The current plan is the 12th Five-Year Plan agreed by the Planning Commission for the period 2012-2017. The broad vision and aspirations which the plan seeks to fulfil are reflected in the subtitle: 'Faster, Sustainable and More Inclusive Growth'. The simultaneous achievement of each of these elements is critical for the success of the plan; it recognizes that the objective of development is broad-based improvement in the economic and social conditions of the people. Accordingly, the 12th Plan mentions that its strategy for growth depends crucially on productivity gains as one of the key drivers of growth. It categorically states that the traditional sources of growth are not likely to be enough for India in the coming years and in this context the country must focus on productivity improvements using Science and Technology (S&T) to drive innovation along with other constituents such as infrastructure and business regulatory environment, amongst other things (GOI, 2012).

The Plan recognizes that S&T is a vital aspect of national capability. Science Departments/Agencies have played a significant role in solving the country's socio-economic issues. It intends to give a renewed push to emphasize creative and relevant research and innovation. The central focus, according to the 12th Plan, is to ensure that S&T becomes a major driver in the process of national development; aiming for three outcomes:

1. to realise the Indian vision to emerge as global leaders in advanced science;
2. to encourage and facilitate Indian Science to address the major developmental needs of the country like food security, energy and environmental needs, addressing the water challenges and providing technological solutions to affordable health care requirements;
3. to gain global competitiveness through a well designed innovation ecosystem, encouraging global research centres of multinational corporations (MNCs) to be set up in India.

The Document seems to suggest that India's aspiration to emerge as a stronger scientific power at the end of the Twelfth Plan period will require additional funding and also an effort to interconnect available resources and competitiveness. The need for much greater flexibility in the way scientific establishments work, and the need to 'encourage collaboration with universities, with private and public sector corporations and also with global research centres' is discussed (GOI, 2012).

S&T endeavours over the last decade have placed increasing emphasis on contributing to the societal development and quality of life of citizens. Such new initiatives in turn have created - in some cases - societal reactions stemming from issues like health and environmental safety. Recently, the introduction of genetically modified (GM) foods and Nuclear Energy are two such examples. The Twelfth Plan envisages a more effective institutional framework in linking S&T with society through a variety of outreach strategies. This is proposed to be carried out both through the scientific establishments, as well as through educational programmes including initiatives from nongovernmental organisations (NGOs). The 12th Plan proposes to achieve the following:

- Evolve a new Science, Technology and Innovation policy to bring in more resources from both the public and the private sector for R&D for socially and strategically relevant projects and mainstream innovation-related activities with a focus on affordable and sustainable innovations;

- Ensure that S&T becomes an integral component of the national developmental processes by interconnecting competencies and research resources and strengthening interconnections with the weakly connected stakeholders to the R&D outputs;

- Increase the number of full-time researchers/scientists; the volume of publication outputs in basic research from a global share of 3 per cent to 5 per cent; improve the global publication ranking from 9th to 6th by the end of the Twelfth Plan period; focus on doubling the number of patents and increase the commercialization of patent portfolio to 5–6 per cent from a level of less than 2 per cent;

- Increase R&D expenditure to 2 per cent of GDP and significantly enhance corporate sector R&D expenditure to at least 1 per cent of GDP by attracting investments and engaging the corporate sector in R&D through policy and reforms processes; earmark 10–15 per cent of public investment exclusively for public–private partnership (PPP) and provide R&D funds to the private sector through a competitive grant process with a stipulation that comparable funding would be provided by the private sector under PPP model;

- Build technology partnerships with States through new models of technological solutions, design, development and delivery.

On the basis of broad aspirations and policy guidelines expressed in the 12th Plan and S&T Policies, funding of Science, Technology and Innovation projects in India is prioritized and

executed. The DST plays a major role in this through its SERB component (Science and Engineering Research Board), which calls for research proposals from individual scientists/organizations from all across the country.

Science and Engineering Research Board (SERB)

The SERB Secretariat receives applications under various schemes. The proposals undergo a peer review process which involves at least two levels of appraisals. The proposals are first sent to a minimum of 6 or 7 domain experts for their comments. If the comments are favourable, the Project Investigator (PI) is called for a brief presentation before the designated advisory committee. The decisions on proposals which are below the benchmark, as set by each Programme Group of the Board, are taken in absentia.

If the recommended cost of the proposal is greater than Rs. 50.0 lakh (USD 80K, 59,134 Euro), the proposal is referred to an Empowered Committee of the Board. The Empowered Committee is empowered to approve projects up to 5.0 crore (USD 800K, 591,436 Euro) and for proposals costing more than Rs. 5 crore this Committee will serve as an appraisal body to the Board.

The role of the Advisory Committees is highly important in the peer review process. The advisory committees evaluate individual R&D proposals received from the project investigators and make appropriate recommendation for funding or otherwise. Identification of priority areas of R&D are done through the advisory committees. Each Scheme is guided by an Advisory Committee. These committees comprise of eminent scientists and technologists in various fields of science and engineering. SERB accepts proposals under a variety of schemes.

Extra Mural Research Funding (EMR)

Competitive funding given to individuals is provided under the EMR. The Board supports successful scientists in undertaking research in frontier areas of S&T such as the Life Sciences, Physical Sciences, Chemical Sciences, Engineering Sciences, Earth and Atmospheric Sciences and Mathematical Sciences.

Start-Up Research Grant (Young Scientists)

This scheme provides opportunities to Young Scientists (below 35 years) for pursuing exciting and innovative research in frontier areas. The Start-up Research Grant is a structured scheme to reap the benefit of research potentials of young minds for speeding up the processes and enhance the relative position of the Indian R&D system in global competitiveness.

Track Based Research Funding

Track Based Research Funding is designed to promote originality in research with the potential for high impact and for targeting long term research goals. It aims to tap the expertise of outstanding researchers. The grant is given for a period of 10 years. The selection is based on parameters such as citations per paper, papers in high impact journals, impact factor aggregate and the awardee should possess a prior record of executing projects in any competitive grant scheme of R&D

funding agencies in the world during the last 7 years, and completed at least 2 projects with the grade greater than very good.

Intensification of Research in High Priority Area (IRHPA)

The IRHPA program supports proposals in high priority areas where multidisciplinary / multi-institutional expertise is required which will put India on the international science map in that particular discipline. The Board identifies the priority areas in consultation with the stakeholders. The necessary facilities required for implementing the identified high priority areas is supported through this scheme.

However, the Twelfth Plan stressed that:

> "We must experiment with new models of funding scientific research. Instead of all government research funds being allocated to the budget of different scientific departments, there is a case for creating a new National Research Fund which can receive competing research proposals from different research institutions, or combinations of institutions, and select from these proposals to fund the most promising on a project basis. Research funding for particular projects should be continued only on the basis of periodic peer reviews which indicate whether progress is satisfactory and also point to corrective steps which might help" (GOI, 2012).

Science for Equity, Empowerment and Development (SEED)

As part of the S&T Programme for Socio-Economic Development the sub-programme Science for Equity, Empowerment and Development (SEED) has been set up under the Department of Science and Technology, established with the broad objectives of providing opportunities to motivated scientists and field level workers to take up action oriented and location specific projects aiming towards socio-economic development of poor and disadvantaged sections of the society through appropriate technological interventions especially in the rural areas. Under this program efforts have been made to associate concerned national laboratories or other specialist S&T institutions with each major program so as to build-in expert input, utilize the national S&T infrastructure and link it up with grassroots S&T interventions/initiatives.

Following Schemes under SEED are operational for an action oriented, innovative and field based technology generation and adaptation program/projects are for specific targets groups:

A. Beneficiary oriented Schemes:

- S&T For Women
- Tribal Sub-Plan: Technological Interventions for Tribal Empowerment (TITE)
- Scheduled Caste Sub Plan (SCSP).

B. Technology Development related Schemes:

- Long Term Core Support - Technological Advancement for Rural Areas (TARA)
- Technological Intervention for addressing Societal Needs (TIASN)
- Scheme for Young Scientists & Technologist (SYST).

The Indian Council of Medical Research

The Indian Council of Medical Research (ICMR) has its roots in the Indian Research Fund Association, which was established in 1911, by the officers of the then Indian Medical Services. After 1947 it was renamed Indian Council of Medical Research. Since then the ICMR has expanded and diversified its activities and it now comprises 32 Institutes/Centres, over 70 field stations, and employs over 5,000 personnel, of which 750 are scientists. Most of the Centres/Institutes of the ICMR are discipline/disease-specific institutions. They have over the years become national institutions of research in their respective discipline/disease (e.g. National Institute of Nutrition at Hyderabad, Tuberculosis Research Centre, Chennai).

The ICMR controls 21 mission-oriented national institutes working on specific diseases or health issues such as tuberculosis, leprosy, cholera and diarrheal diseases, viral diseases (including AIDS, malaria, and kala-azar[49]), vector control, nutrition, and reproduction. Six regional medical research centres conduct research on regional health problems and five units or centres focus on food and drug toxicology, viral diseases, micro-organisms of a highly infectious nature and prenatal diagnosis for neonatal retardation.

The ICMR is the nodal body for health research, international collaboration in health research, regulation of new/novel therapies, establishing ethical norms in trials, administering international fellowships in health, and providing policy advice to the government on health research and global health issues. The ICMR is under the auspices of the Department of Health Research, which was established in 2007 and is part of the Department of Health and Family Welfare.

The Indian Council of Medical Research[50] (ICMR) provides financial assistance to promote biomedical and health research and it covers a wide range of research. The proposals can be submitted by individual scientists, institutions and NGOs throughout the year. While the ICMR funds all areas of health and biomedical sciences research, priority areas are identified by ICMR. Current priority areas include communicable diseases including viral diseases, cholera and enteric diseases, tuberculosis, leprosy, malaria, maternal and child health and reproductive health. Proposals are vetted by Project Review Committees and expert reviews are also sought. Proposals are evaluated by the ICMR on the basis of relevance of the proposal to national health priorities, advancement of knowledge and capacity of the institution and individual to do the research as proposed.

Given the mandate and size of India in terms of geographical coverage and population as well as India's disease burden and needs for research in health, the ICMR needs to expand and diversify to enhance its capacity according to a Report of the Working Group on Health Research for the 12th Five Year Plan. The Plan observed that "the human resource within the ICMR is very small in terms of the numbers with many institutes/centres functioning with sub-critical scientific pools. It is

[49] A chronic and potentially fatal parasitic disease of the viscera (the internal organs, particularly the liver, spleen, bone marrow and lymph nodes) due to infection by the parasite called *Leishmania donovani*.
[50] http://icmr.nic.in/ad-hoc.htm

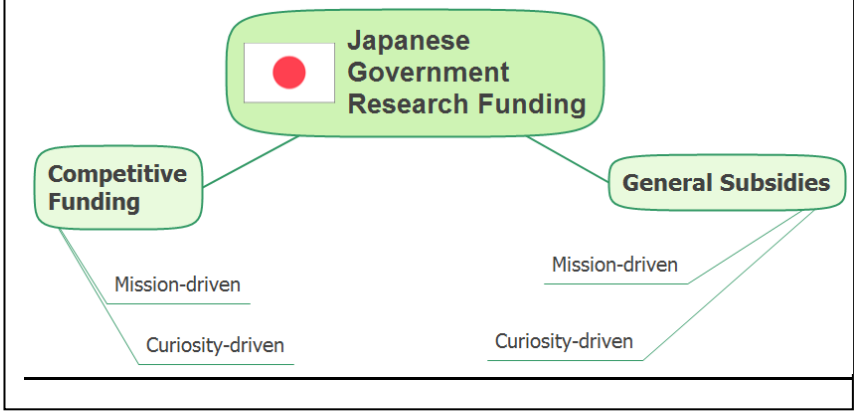
absolutely essential to enhance the number of researchers and supportive workforce in the ICMR" (GOI, 2012). Further the Working Group proposed an increased allocation of INR 85Bn for the ICMR in the 12th five year plan (2012-2017). This proposed allocation was twice the earlier allocation under the 11th five year plan (2007-2012).

These preliminary reflections indicate that health research funding by the ICMR is at a critical juncture today. The ICMR is considered as the NIH of India. Whether the NIH of India can meet the challenges ahead and the increasing expectations from its research community is a big question.

Japan[51]

In Japan, public funding for research is provided both directly and indirectly to researchers. The Japanese government allocates funding in four main categories. The first two categories refer to the type of research being undertaken (1a and 1b, see below), the second two categories refer to the allocation procedures (2a and 2b).

Diagram 7: Japanese Funding



1a: curiosity-driven, competitive funding
In this category, scientific research is funded based on researcher's creative ideas and advanced through individual grants. Hence, this is a bottom-up mechanism where project proposals are presented by researchers to the funders based on their own suggestions.

1b: mission-oriented, competitive funding
In this category, scientific research is funded based on policy imperatives. The purposes of the research are set by ministries and researchers are recruited top-down to work on specific topics.

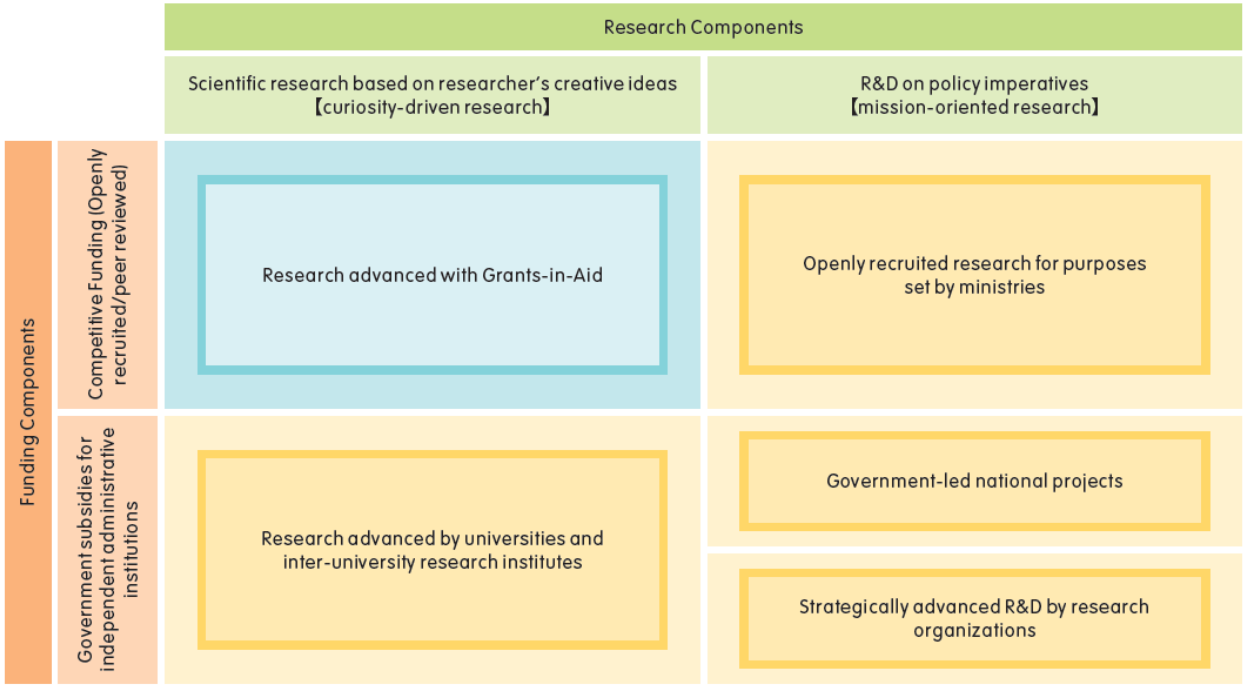
2a: curiosity-driven, subsidies
In addition to project specific curiosity-driven research, the Japanese government also allocates subsidies to universities or approved research institutions (e.g. Riken[52]). These subsidies are not allocated for specific topics; instead the institutes themselves make allocation decisions.

2b: mission-oriented, subsidies
Equally, broad subsidies are given to some institutes for government-led strategic research.

Among these four categories, 1a is the most transparent scheme of research funding. A typical funding scheme in category 1a is the 'Grants-in-Aid for Scientific Research' program administered by the Japan Society for the Promotion of Science (JSPS) and funded through the government.

[51] This contribution to the Funder Reports was written by an external advisor to PROGRESS (Shunzo Majima) and is therefore shorter than the partner contributions.
[52] RIKEN is Japan's largest comprehensive research institution. Founded in 1917 as a private research foundation in Tokyo, RIKEN has grown rapidly in size and scope, today encompassing a network of world-class research centers and institutes across Japan, http://www.riken.jp/en.

Diagram 8 - Overview of Grants Administered by the JSPS



Source: JSPS 2014

Direct Research Funding in Japan

Direct research funding in Japan is primarily distributed by the Japan Society for the Promotion of Science (JSPS). In the financial year 2013, the total budget for direct funding is 297 billion Yen (approximately 2.15 billion Euros). The major programs include the Leading-edge Research Promotion Fund (32.8 billion Yen), the Multi-year Fund for Grants-in-Aid (97.5 billion Yen), and the Grants-in-Aid for Scientific Research (135.1 billion Yen).

Grants-in-Aid for Scientific Research (KAKENHI)

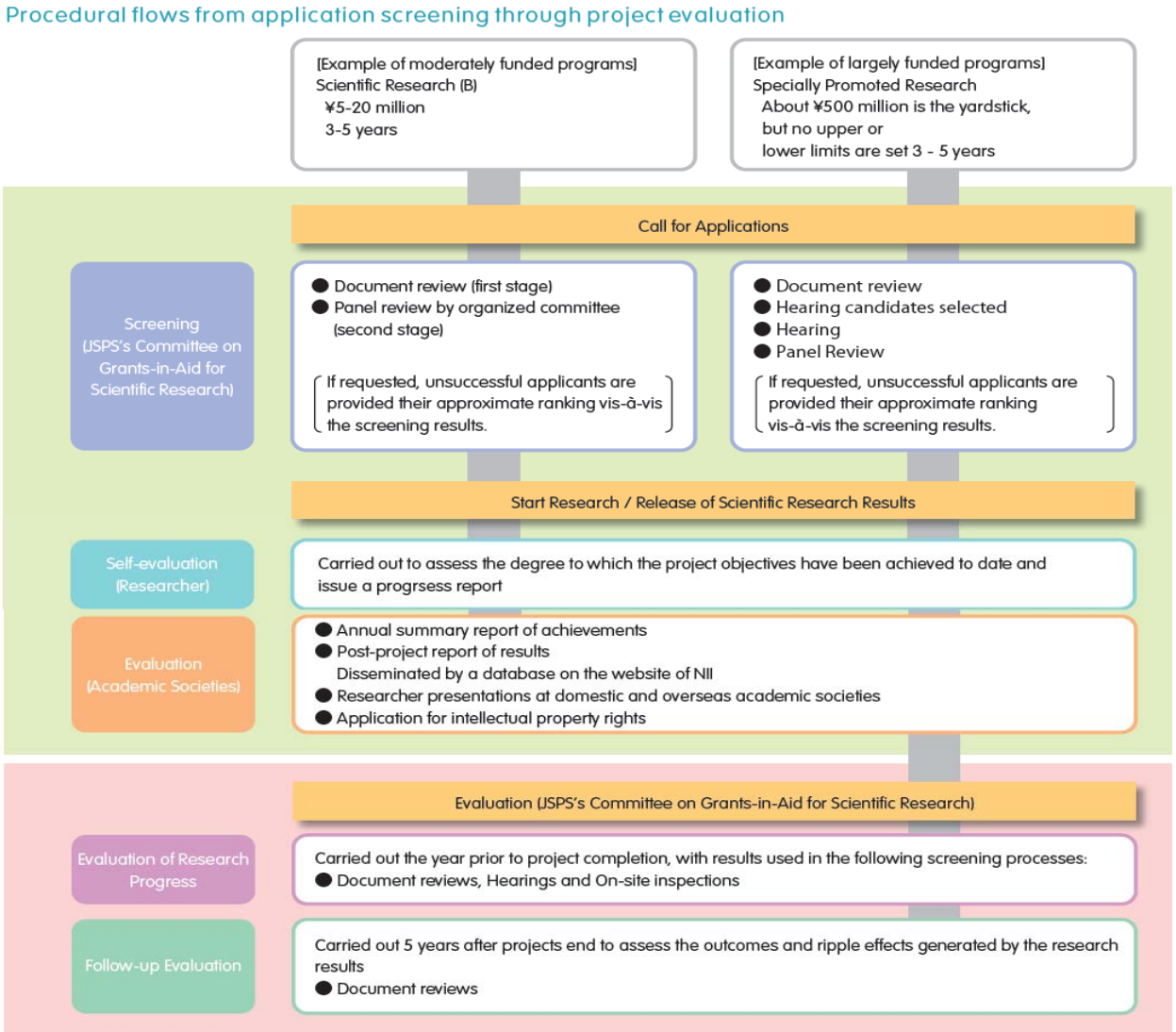
The Grants-in-Aid for Scientific Research (KAKENHI) comprise approximately 60% of all the Japanese government's competitive funding. These grants typically fall into the category of curiosity-driven, competitive funding. They are directly disbursed to an individual researcher or a research team at a university, an approved higher education provider, or an approved research institution such as Riken.

The Grants-in-Aid for Scientific Research are, according to the JSPS, "specifically designed to seed curiosity-driven research and then nurture it through its budding and blooming stages", and they are "awarded based on a rigorous screening process, in which applicants are graded on their ability to conceive and articulate research plans that are not only cutting edge but also rich in originality" (JSPS 2014).

Various grant categories are available based on the objectives and nature of the research. Among them, the most prestigious category is the 'Specially Promoted Research', which funds "internationally appraised research expected to produce outstanding results". Its term is 3-5 years, depending on the details of the project, and the applicant can designate the term for which funding is sought. There is no specific upper or lower grant limit but "about ¥500 million [€3.6 million] is used as a yardstick for the upper grant limit of one project" (JSPS 2014). In the financial year 2013, 15 projects out of 112 applications were selected.

'Scientific Research' is one of the most common and popular categories within KAKENHI which funds "creative and pioneering research by a researcher or a group of researchers". Its term is also 3-5 years, depending on the details of the project, and again the applicant can designate the term. This funding category has three sub-classes: Class A provides 20-50 million Yen per project; Class B 5-20 million Yen per project; and Class C up to 5 million Yen per project. The success rate for this category is around 20-30%. The following diagram shows the application and evaluation procedures of the JSPS (2014).

Diagram 9 - Administration Procedures JSPS



Indirect Research Funding in Japan

Indirect research funding is primarily provided by The Ministry of Education, Culture, Sports, Science and Technology (MEXT). The MEXT disburses subsidies to national university corporations and private universities as an all-inclusive budget for research, education, and administration[53]. In the financial year 2013, the total amount of subsidies for national universities for education, research, and administration was 1792 billion Yen (approximately 13 billion Euros). The total amount of subsidies for private universities was 317.5 billion Yen (approximately 2.3 billion Euros).

The amount each university receives is primarily determined on the basis of the number of students. How each university then allocates its funding to researchers is context-specific and cannot be schematised since each university has its own discretion to allocate the budget to research, education and administration. After the central university administration has allocated and distributed the budget to each department/school by using complex formulae, the amount allocated to individual researchers is determined by the department/school s/he belongs to. Each department/school allocates research expenses to its faculty again by using complex formulae, which often differ within universities.

Indirect competitive research funding

In addition to the block funding that is primarily allocated against student numbers, indirect, not project based competitive funding is available. In the financial year 2013, MEXT made available 45.6 billion Yen for this purpose (0.3 billion Euros).

Programs for which universities can apply to obtain competitive block grants are:

- the Program for Establishing Centres of Excellence (CoEs) (26.4 billion Yen);
- the World Premier International Research Center Initiative (WPI) (9.6 billion Yen);
- the Initiatives for Globalizing Higher Education (9.7 billion Yen).

To give an example of such a program; the World Premier International Research Center Initiative was issued in March 2006 based on the government's third Science & Technology Basic Plan. MEXT inaugurated the program in 2007 fiscal year and commissioned the JSPS to carry out grant selection, using a procedure prescribed by the ministry. The program provides support for research in scientific fields in which Japan has already reached a high global level. By funding autonomous initiatives suggested by universities, the program seeks to elevate the level of research in these fields even more. As a result spaces with excellent research environments are created that also attract high-profile researchers from around the world.

[53] The third type of universities in Japan are municipal university corporations. The national government does not disburse subsidies to these corporations, since they are governed or subsided by municipal governments. It also means, however, that researchers at a municipal university are not eligible for the Grants-in-Aid for Scientific Research scheme distributed by the JSPS.

South Africa

Funding allocations for research and development have come a long way in South Africa. Prior to democracy and the lifting of international sanctions the climate was dominated by military technologies, and food and energy self-sufficiency (OECD 2007). Institutions and researchers that built competencies in these areas only, were therefore supported. The funding landscape has however, shifted dramatically since 1994, beginning with the development of the Science and Technology White Paper in 1996 and the subsequent development of a National System of Innovation as the framework for implementation. Socio-economic goals have featured strongly in this system although many have questioned the extent to which these goals have been realised (Cherry 2010; Nordling 2013).

Research and development (R&D) in South Africa is currently funded by a large number of public and private sector agencies, including the Departments of: Higher Education and Training (DHET); Science and Technology (DST); Trade and Industry (DTI); Minerals (DoM); Agriculture, Forests and Fisheries (DAFF); Health (DoH); Water and Environmental Affairs (DWEA), and the National Treasury. However, there is no overarching body responsible for overseeing, or advising government as a whole on the entire spectrum of research and innovation funding policy (OECD 2007).

While private research funding falls largely outside of the national policy framework, all government funding must align to the ten-year Science and Technology Innovation Plan (DST 2008), which builds on the government's broad socio-economic mandate - particularly the need to sustain and advance economic growth; and the National Development Plan (NDP) which aims to eliminate poverty and reduce inequality by 2030 (NPC 2012).

Reporting to, and largely funded by the DST, the National Research Foundation (NRF) is the main governmental body responsible for allocating funding to researchers in South Africa.

The National Research Foundation

Established through the National Research Foundation Act (Act No. 23 of 1998), the NRF promotes and supports research in all fields of knowledge. Originally focused on natural science and engineering disciplines only; since 2002 the NRF has funded social science research too. Funding from the NRF is largely directed towards academic research, developing high-level human resources, and supporting national research facilities. Beneficiaries include academics, postgraduate students, and to a lesser extent, the private sector. Apart from its main role as a grant-making agency, the NRF also *conducts* research, although this is a much smaller part of its activity.

The mandate of the NRF is to promote and support research through funding, human resource development and the provision of the necessary facilities in order to facilitate the creation of knowledge, innovation and development in all fields of science and technology, including indigenous knowledge; thereby contributing to the improvement of the quality of life of all the

people of the Republic. The NRF adds value to the National System of Innovation through pursuing its five strategic goals, which are to:

- Promote internationally competitive research as the basis for a knowledge economy (research);
- Grow a representative science and technology workforce in South Africa (human capital);
- Provide cutting-edge research, technology and innovation platforms (infrastructure);
- Operate world-class evaluation and grant-making systems (evaluation and grant-making systems);
- Contribute to a vibrant national innovation system (national system of innovation).

Sources of funding

The annual budget of the NRF is around R2 billion[54] (approximately 135 million Euro) which is derived from various governmental departments – designated funds for specific projects and programmes, and a parliamentary core grant (NRF 2011-2012). National departments which provide funding are the Department of Labour (DOL), the Department of Science and Technology (DST), the Department of Trade and Industry (DTI), the Department of Water and Environmental Affairs (DWEA) and the Department of Higher Education and Training (DHET).

NRF Funding Allocations

Since 2008, the NRF has spent the majority of its funding reserved for the five grand challenges, which the DST's ten-year innovation plan for South Africa identified as:

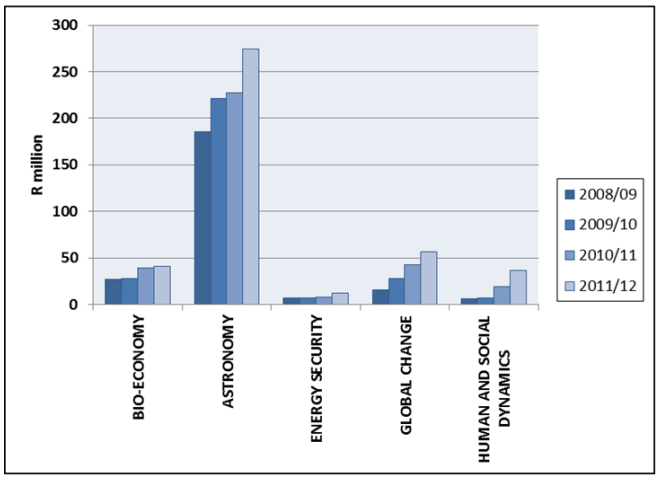
- To strengthen the **bio-economy** with the intention of placing South Africa as a world leader in biotechnology and pharmaceuticals, based on the nation's indigenous resources and expanding knowledge base.
- **Astronomy**, or space science and technology, with the aim of developing South Africa as a key contributor to global space science and technology.
- **Energy security**, focused on safe, clean, affordable and reliable energy supply.
- **Global change science** with a focus on climate change.
- **Human and social dynamics** focused on improving understanding of shifting social dynamics, and the role of science in stimulating growth and development.

On the astronomy challenge – a total of R980 million (65 million Euro) over the five-year period was spent, in contrast to R69 million (4.6 million Euro) on the human and social dynamics challenge over the same period (Figure 10). Although the percentage of funding for astronomy has gradually decreased since 2008/09 (from 77% in 2008/09 to 65% of total support in 2011/12) and the percentage of funding for human and social dynamics has increased (from 3% in 2008/09 to 9% of total support in 2011/12), it is evident that NRF funding for projects related to human and social dynamics lag far behind support for large technical initiatives (NRF 2011-2012).

[54] Exchange rate at 14 January 2014: Euro $1 = R15 (approximately)

NRF funding is allocated through a number of programmes open to both rated and non-rated researchers. Some programmes are aimed at junior researchers (e.g. Thuthuka), whilst others aim to retain and reward experts in certain fields, such as the South African Research Chairs Initiative (SARChI). Still others aim at stimulating innovation, competitiveness and growth in South Africa, for example the Technology and Human Resources for Industry Programme (THRIP). The NRF also supports Centres of Excellence, which are physical or virtual centres of research which consolidate existing capacity and resources, and facilitate collaboration across disciplines and institutions on long-term projects. The following section introduces the rating system and SARChI.

Diagram 10: Expenditure trends in NRF support of the grand challenges (2008/09 – 2011/12)



Researcher rating system

The rating system is a central tool used by the NRF to allocate funding and aims to benchmark South African researchers against others in the world and build a globally competitive science system. The rating is based primarily on a researcher's recent research outputs and impact as perceived by international peer review. In 2009, 2,144 researchers held an NRF rating, with 86% of these researchers attached to South African universities (NRF 2010). Rating is linked to an incentive scheme, with researchers receiving an annual grant for any research-related expenses. The amount allocated is linked to the weight their rating carries: A, B and C-rated researchers receive R100,000 (6,660 Euro) R80,000 (5,330 Euro) and R40,000 (2,670 Euro) respectively, each year for the six-year period in which their rating is valid. Incentive funding to rated researchers constitutes about 10% of the NRF's annual research investment but produces about 70% of research students and outputs (NRF 2010).

The South African Research Chairs Initiative

The South African Research Chairs Initiative (SARChI) was implemented in 2005 to strengthen research capacity and leadership at public universities in South Africa by attracting established researchers from industry and abroad into higher education institutions and retaining those already in the system. The main goal of SARChI is to strengthen and improve research and innovation capacity of universities for producing high quality postgraduate students, research and innovation outputs. Chairs are not pre-allocated to institutions; universities bid for Chairs in a competitive process. However, those institutions which have not historically participated, such as those in rural areas and universities of technology, are given preference if requirements are met. In April 2013, 154 research chairs had been established, with 118 chair positions filled.

Each call for Research Chairs is accompanied by a different set of thematic foci which are determined by wider policy prescriptions. In 2011, for example, proposals were required to show, in addition to scientific research and innovation, how they would respond to the government's medium-term strategic framework and its five priorities: **job creation and sustainable livelihoods; education; health; rural development, food security and land reform; and crime and corruption**.

Application criteria - The Research Chair application process is two-phased. In Phase 1 the university due to host the Research Chair is identified; whereas in Phase 2 a suitable candidate is selected. The bidding in Phase 1 is an open process, and there are no limits on the numbers of Chairs a university may host. Preference is given, however, to universities of technology, universities based in rural areas, or those that have not historically participated in the programme (Maharaj 2010).

The objective of the Phase 1 review is to evaluate the:

- alignment of the proposed Research Chair with the mission and research strategy of the host university;
- alignment of the proposed Research Chair with national R&D strategies;
- alignment of the proposed Research Chair with the **thematic or directed research areas** identified for the particular call for applications; (see below for more information)
- potential for the Research Chair to advance research, innovation and postgraduate training at the host university and partner institution;
- potential of the research to impact on social and/or economic development of the country.

Proposals submitted by candidates in Phase 2 undergo a postal review process by experts in relevant subjects who make recommendations to a panel, who in turn forward the names of suitable candidates for approval by the NRF. To some extent, the conceptualisation of the SARChI programme responds to the societal desirability requirement of RRI in that the five priorities of government's medium-term strategic framework are expanded into a number of outcomes, with the following eight outcomes prioritised in formulating the themes for the awarding of Chairs in 2010:

- A long and healthy life for all South Africans;
- Vibrant, equitable, sustainable rural communities and food security for all;
- Protection and enhancement of environmental assets and natural resources;
- An efficient, competitive and responsive economic infrastructure;
- Sustainable human settlements and improved quality of households;
- Skilled and capable workforce to support inclusive growth;
- Quality education;
- All people in South Africa are, and feel, safe.

The proposed thematic areas are intended to support scientific research and innovation generally, but also to respond to the five priorities of government, and the related preferred outcomes listed above, they are divided into: **technology missions, science missions, priority research areas, poverty alleviation and sustainable rural development, innovation, engineering and technology development, and an open area.**

By March 2014, 129 of the 157 Research Chairs awarded across 21 public universities by the programme had been filled (SARChI 2013 and 2014). Of the 129 active Chairs, 25 (or 19%) belonged to the social sciences (see Table 10 below).

Table 10. SARChI – Chairs awarded by March 2014

	Research Discipline	Number of Chairs awarded
1.	**Natural and Agricultural Sciences**	**Total [63]**
	Agricultural Sciences	**2**
	Biological Sciences	**18**
	Chemical Sciences	**13**
	Earth and Marine Sciences	**10**
	Information and Computer Sciences	**2**
	Mathematical Sciences	**4**
	Physical Sciences	**14**
2.	**Engineering and Applied Technology**	**Total [7]**
	Engineering Sciences	**6**
	Technology and Applied Sciences	**1**
3.	**Health Sciences**	**Total [20]**
	Health Sciences	**6**
	Medical Sciences	**14**
4.	**Humanities**	**Total [14]**
	Humanities	**8**
	Law	**6**
5.	**Social Sciences**	**Total [25]**
	Social Sciences	**21**
	Economic Sciences	**4**

Evaluating the SARChI initiative - The first five-year review of the SARChI programme found that there were a number of shortcomings related to monitoring and evaluation of the programme (NRF 2012). The first observation by the review panel questioned the level of transparency between the NRF, DST and universities. The panel learnt that only two annual performance reports had been completed by the NRF in the first five-year period of the programme; and additionally found that some Chairs did not complete their annual reports, with 17% of the annual progress reports for 2011/12 still outstanding by the end of the 2012 reporting period (NRF 2012).

The panel further questioned the confidential nature of the SARChI Mid-Term Internal Review which was not shared widely.

Criteria for evaluation and rating of the programme were found to be quite broad, but little evidence of their use in assessing individual SARChI Chairs was uncovered. The panel identified *meaningful* criteria such as: 'influencing public policy, contributing to industrial practice, or being acknowledged by international peers through invitations to give keynote talks or sit on international review panels' (NRF 2012, p20) to be lacking. This suggests that there has been an absence of rigorous analysis as to whether or not SARChI is indeed contributing to the five priorities of government's medium-term strategic framework and thereby it's societal desirability.

The review panel further found that Chair holders were discouraged to take risks as evaluation criteria focused on quantities of publications rather than quality. The panel also found that the system was overly rigid and bureaucratic; and that student bursary levels were perceived to be too low, with budgetary inflexibility making it difficult to attract students from disadvantaged socio-economic backgrounds.

The NRF and Responsible Research and Innovation

The NRF strives to support an internationally competitive research community whilst contributing to a vibrant national system of innovation. On paper, it is also clear that the NRF aspires to achieve a research and innovation system that aims to achieve societally desirable goals, i.e. that aims to benefit the citizens and residents of South Africa equitably, and to do so in an ethically acceptable and sustainable manner. The extent to which this aspiration is met is however, unclear, with a number of components requiring further research or elaboration:

- At a broad level the goals that have been set by government, through the DST, are to some extent based on national policy and development priorities. However, some thematic areas such as Astronomy and its hugely disproportionate allocations are difficult to link back to national priorities and societal desirability.

- The manner in which funding criteria are determined is difficult to ascertain. For example, there is little clarity about how thematic areas are identified, such as those for the Research Chairs, nor how they are prioritised. While the technical merits of proposals are screened by panels and expert reviewers, there is less transparency about how the societal desirability of proposals is determined. The NRF has, for example, been encouraged by an external review panel to give more holistic recognition of research outputs and outcomes, which would include the research impact of the Chair on the discipline, the institution, and society at large (NRF 2012).

- A central criterion for funding allocation is the rating of an individual researcher, thus it is pertinent to note that the NRF's rating system has come under fire from a number of quarters. Even though only a small portion of South African scholars are rated by the NRF – 10% in 2009, representing 2,144 researchers (Cherry and Gibbons 2007; NRF 2010), obtaining funding

without being rated is problematic. This means that a large pool of researchers is effectively excluded from the research funding system, no matter how innovative their research. Moreover, because the rating system was originally designed by and for natural scientists, the social science and humanities are poorly represented. Although emphasis has been given to increasing the pool of social scientists over the past decade, most still fall outside of the NRF system, constituting only about 30% of rated researchers (Cherry and Gibbons 2007).

- Even researchers who are rated by the NRF may struggle to support their research efforts (Cherry 2010). According to Illing (2012), shifts in funding priorities since 2007 have resulted in a funding crisis for science researchers and their post-graduate students. Between 2007 and 2012 the NRF phased out its peer-reviewed grant-making process - the Focus Area Programme (FAP) - replacing it with a number of other programmes such as the Incentive Programme, Blue Skies Research and Thuthuka Programme grants. Instead of increasing funding amounts, the introduction of these programmes was however, accompanied by a decrease in funding, with overall funding for these programmes declining by R3 million (200,000 Euro) between 2006 and 2011 (Illing 2012). Post-graduate students have also been affected by the funding crisis. For example, the Incentive Programme for rated researchers, introduced in 2008, does not cover studentships and running expenses like FAP did, resulting in a drop in student numbers (McKune 2009).

- The NRF's monitoring and evaluation system is acknowledged to be weak and is strongly reliant on self-assessment. Feedback on annual reports is seldom, if ever, received and while researchers may purport to be pursuing research that is societally desirable, this is rarely scrutinised. It may well be possible that researchers are simply modifying the language in their proposals to "fit" priority areas, but without necessarily adjusting their research in any significant way. In the review of the first five years of the SARChI programme for example, the evaluators found that: "The overall utility of current progress reporting was raised throughout the key informant interviews, and some asked whether the submitted reports were even being read. The lack of feedback tended to suggest that their utility was more intended to serve bureaucratic needs rather than fostering a dialogue with Chairs and institutions." (NRF 2012, p17). Partly in response to the five-year SARChI evaluation, which found that reporting needed to include the wider outcomes of research and the impact of said research on the country's problems (NRF 2012), an assessment has been commissioned by the NRF to assess the social impact of its programmes. Scheduled to conclude in mid-2014, the evaluation will focus in particular on the Centres of Excellence, the Incentive, Thuthuka and SARChI funding programmes and the National Equipment Programme (Z. Ophir, pers comm., 4 February 2014).

In conclusion while important strides have been made towards achieving a responsible research and innovation system in South Africa, the extent to which this has been achieved in practice remains questionable. Attention needs to be given to improving transparency in the manner in which funding categories are determined and funding is allocated; strengthening the monitoring and evaluation system to assess social impact; and increasing the pool of non-rated researchers and postgraduate students.

United Kingdom

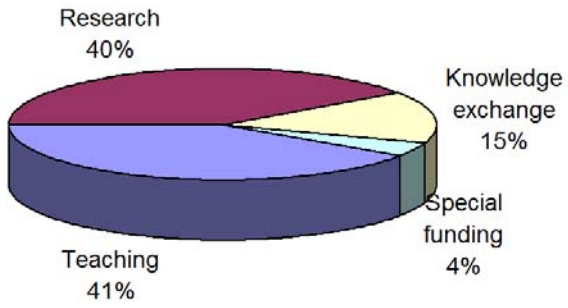
The UK operates a dual support system for research funded through public monies (as does Australia). Block grants are given to universities to support the research infrastructure and research council grants support specific projects. Seven research councils operate in the UK, namely:

- Arts & Humanities Research Council (AHRC)
- Biotechnology & Biological Sciences Research Council (BBSRC)
- Engineering & Physical Sciences Research Council (EPSRC)
- Economic & Social Research Council (ESRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Science and Technology Facilities Council (STFC)

The investment from the seven research councils amounts to around 3 billion pounds on a yearly basis (approximately 3.6 billion Euros)[55].

Block grants are administered by the four higher education funding councils, the Higher Education Funding Council for England, the Welsh Assembly Government, the Scottish Funding Council, and the Northern Ireland Department for Employment and Learning. The Higher Education Funding Council for England (HEFCE) has the highest allocation for research amongst the four regions, due to its geographic size. For 2014-15 approximately 1.6 billion pounds (around 1.9 million Euros) will be distributed to universities and colleges in England.[56] HEFCE aims to "ensure that this money is used to deliver the greatest benefit to students and the wider public".[57]

Diagram 11: HEFCE Funding Allocations 2014-15



Simplified, funds for teaching are distributed on the basis of student numbers, whereas funds for research depend on the quality and volume of research activity, which will be described in the next section.

The Research Excellence Framework (REF) and its Origins

In 1986, the British government under Margaret Thatcher started to distribute research funding to universities on the basis of quality rankings. In the 1986 *Research Selectivity Exercise,* universities provided submissions on their research strengths, which were assessed and then ranked as "outstanding", "above average", "average" or "below average". The subsequent research funding

[55] http://www.rcuk.ac.uk/
[56] http://www.hefce.ac.uk/whatwedo/invest/institns/annallocns/
[57] http://www.hefce.ac.uk/about/

obtained by universities was dependent on the quality ratings achieved. Further assessment exercises were undertaken in 1989, 1992, 1996, 2001 and 2008.

In 2007, a decision was made to streamline the process, so that the assessment was simpler and less burdensome. The new Research Excellence Framework (REF) was developed to determine allocation of funding to British higher education institutions (HEIs) from 2015 onwards (The National Archives: 2010). This new framework *makes reference to impact on society for the first time* since the institution of the process in 1986. It is therefore an interesting case to look at from the point of view of RRI, in particular the third element, societal desirability.

The REF is a process of expert review of research statements submitted by universities, carried out across all disciplines. Expert panels consist of practising researchers and 'research users' and each research submission is assessed on three elements. [58] (ibid.) (REF 2014: 2011):

- the quality of research outputs (65%);
- the impact of research beyond academia (20%);
- the research environment (15%).

Research merit, i.e. the quality of outputs, and the research environment were considered before, for instance in the research assessment in 2008. Impact beyond academia is a new criterion, added to the 2014 procedure. One of the aims of the REF is to "reward and encourage HEIs that deliver benefits to business, the economy and society by building on excellent research" (HEFCE: 2009) With this emphasis on societal benefits, the REF seems to stand in marked contrast to the aims of universities as defined in earlier times. For instance, John Henry Newman famously summarised the purpose of university teaching and research as follows:

> "A University is a place ... whither students come from every quarter for every kind of knowledge; ... It is the place to which a thousand schools make contributions; in which the intellect may safely range and speculate. It is a place where inquiry is pushed forward, ... error exposed, by the collision of mind with mind, and knowledge with knowledge" (Newman: 1852).

Lord Rowan Williams, who retired as the Archbishop of Canterbury in 2012, believes that:

"the good university expresses certain philosophical commitments – to civil discourse, to liberty of expression, to careful and honest self-questioning, and to the possibility of creating trust through the processes of fair argument and exploration of evidence" (Christian Academic Network: 2005).

A **bibliometric indicator** of research quality or research impact would, for instance, be citation scores. How many people have cited a published article in other academic journals would indicate its quality or impact.

[58] http://www.ref.ac.uk/media/ref/content/pub/decisionsonassessingresearchimpact/01_11.pdf

These two views, which focus on academic freedom, the production of knowledge and critical thinking, seem far removed from an emphasis on benefits for business, the economy and society. However, it was a consultation with universities and other stakeholders in 2008, which requested to "recognise and reward research that has a positive economic and social impact".[59]

The main drive towards more societal impact, however, came from the Secretary of State for Innovation, Universities and Skills (The Rt Hon John Denham MP), who wrote to the Chair of the Higher Education Funding Council for England requesting that the REF should take into account the impact that research has on the economy and society (HEFCE: 2012).

Criticism of the Impact Criterion

Recognizing that public funds should be used for public benefit through societal impact and successfully establishing a system for doing so are two different things. In particular, the methodological complexity of assessing impact was recognized early on.[60]

During 2008 – 2009 the possibility of using bibliometric indicators to assess research impact was explored in a pilot exercise.[61] However, it was concluded that this method of impact assessment was not yet sufficiently robust and therefore should not be used in the REF.[62] One of the most obvious limitations of the method included the fact that "good citation evidence lags publication by several years" (Times Higher Education: 2008).

As a result of disagreements about the new impact criterion and especially the methodology for assessing impact, a second consultation was launched. This consultation lasted from 2009 to 2010 and included proposals of how impact would be assessed.[63] At this point, major criticisms against requiring impact on business, the economy and society from university research were voiced. In particular, it was argued that:

1. Impact assessment will have a damaging effect on "blue skies", "curiosity-driven" or" "speculative" research (Times Higher Education: 2009). This is not only detrimental to curiosity-driven researchers, but it ignores the fact that this type of research has led to significant benefits to society over time (University and College Union: 2010). It was also argued that major scientific discoveries in the past would probably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Universities braced for heavier research burden

New rules on research funding will force academics to prove the impact of their work outside their own university

Anthea Lipsett
The Guardian, Tuesday 1 March 2011
Jump to comments (21)

[59] http://www.ref.ac.uk/background/firstconsultation
[60] http://www.ref.ac.uk/background/firstconsultation
[61] http://www.ref.ac.uk/background/bibliometrics
[62] ttp://www.hefce.ac.uk/pubs/year/2009/200939
[63] http://www.ref.ac.uk/background/secondconsultation

not have survived the proposed REF impact assessment.[64]

For example, Max Perutz and John Kendrew (Nobel Laureates, Chemistry, 1962) worked on the problem of haemoglobin structure for 25 years. For most of that time they made (in their own words) only 'modest' progress (ibid.). If continued funding for their work had depended on the demonstration of economic and/or social impact stipulated by the current REF assessment criteria, then the major breakthrough in haemoglobin understanding may not have happened. In 1998 Sydney Brenner (Nobel Laureate, Medicine, 2002) wrote: "For many years it was widely held that molecular biology was a completely useless subject, a 'fundamental' science of no interest to those working on practical matters" (Brenner: 1998). However, the field of molecular biology, once not held in great esteem, has given rise to significant advances in medicine, but would probably not have survived the REF impact criteria in its early days. Assessing research impact is methodologically complex (Martin: 2011) and suggestions to assess impact according to REF proposals "are founded on a lack of understanding of how knowledge advances", as "it is often difficult to predict which research will create the greatest practical impact" (Times Higher Education: 2009b).

2. Impact assessment can only measure short term impact, not long-term impact, which may only occur after decades (Tunnicliffe; 2009)

An impact assessment pilot exercise undertaken in 2010 was reported to be successful, but uncovered further possible concerns[65] which needed to be addressed, in particular:

- Demonstrating impact assessment is labour-intensive for researchers, in particular securing evidence from end-users is highly time-consuming (Times Higher Education: 2010);
- Providing information about research for the assessment, could conflict with the commercial sensitivity of research (ibid.);
- Methodological concerns were deepened, as some previously highly rated research departments scored poorly in the pilot exercise in comparison to their lower-rated counterparts (Times Higher Education: 2011);
- The impact criterion biases funds towards lower quality research, should such research have more concrete evidence of impact;
- It also produces a focus on short-term, current policy agendas, rather than more long-term policy-relevant issues to the detriment of society (Times Higher Education: 2012; Parker and Teijlingen: 2012).

REF definition of impact:
Any social, economic or cultural impact or benefit beyond academia that [is] underpinned by excellent research.

In an effort to take concerns into account, decisions were made in 2011 on how to assess impact. Assessment of impact would be based upon expert review of case studies submitted by universities. These case studies should demonstrate "any social, economic or cultural impact or benefit beyond academia that…[is]

[64] http://www.ucu.org.uk/media/pdf/0/s/ucu_notsurvivingtheREF.pdf
[65] http://www.ref.ac.uk/pubs/refimpactpilotexercisefindingsoftheexpertpanels/

underpinned by excellent research..."[66] A weighting of 25% for impact assessment was thought appropriate but was reduced to 20% for the REF 2014, given that the method of impact assessment would still be in a development phase (ibid.).

Still, the REF remains contentious amongst academics, especially due to the impact criterion. As reported in the Guardian in 2011: "*Most controversial is the proposal to judge the quality of research based on its impact outside of academic circles*" (The Guardian: 2011), remains the case after several consultations in early 2014.

The National Institute for Health Research (NIHR) funding programmes[67]

The NIHR was set-up in 2006 and is a national organisation funded by the Department of Health. It seeks to improve the health and wealth of the nation through research. The Health and Social Care Act 2012 places a statutory duty on the Secretary of State and on all levels of the NHS to promote research, and the NIHR is the key means by which the Secretary of State enacts this duty. The NIHR works in partnership with many sectors (including the public and service users, the NHS, public health, other Government funders, the academic and third sectors and industry). It is overseen by both an NIHR Advisory Board and an NIHR Strategy Board. The **mission** of the NIHR is "to maintain a health research system in which the NHS supports outstanding individuals, working in world class facilities, conducting leading edge research focused on the needs of patients and the public." Its **aims** are to:

- Establish the NHS as an internationally recognised centre of research excellence;
- Attract, develop and retain the best research professionals to conduct people-based research;
- Commission research focused on improving health and social care;
- Increase the opportunities for patients and the public to participate in, and benefit from, research;
- Promote and protect the interests of patients and the public in health research;
- Drive faster translation of scientific discoveries into tangible benefits for patients;
- Maximise the research potential of the NHS to contribute to the economic growth of the country through the life sciences industry;
- Act as a sound custodian of public money for the public good.

The NIHR manages its activities through four main work strands:

1. *NIHR Faculty:* supporting the individuals carrying out and participating in research
2. *NIHR Research:* commissioning and funding research
3. *NIHR Infrastructure:* providing the facilities for a thriving research environment
4. *NIHR Systems:* creating unified, streamlined and simple systems for managing research and its outputs.

[66] http://www.ref.ac.uk/media/ref/content/pub/decisionsonassessingresearchimpact/01_11.pdf
[67] Where paraphrasing information might have lost the precision of the original formulation from the research funder, the wording was kept.

There are a number of NIHR-funded research programmes, including Programme Grants for Applied Research, Research for Patient Benefit, Health Technology Assessment, Efficacy and Mechanism Evaluation programme, Public Health Research programme, Invention for Innovation programme, Health Services and Delivery Research programme and a variety of review programmes.

The NIHR Fellowship programme[68]

The Fellowship Programme is one of a number of NIHR training and career development awards. Research conducted as part of such an award must be relevant to the NHS and is expected to produce an outcome that will benefit patients and/or the public within five years of completion.

The Fellowship programme provides funding to cover the salary costs, research costs and training and development costs of a specified research project to be undertaken by an individual with potential to become a health research leader of the future. The research work should focus on people and patient-based clinical and applied health research. The Fellowship programme is open to any individual working in a scientific discipline or sector that can demonstrate a role in, and contribution to, improving the health or health care of the population served by the NHS. The Fellowship programme is awarded at a number of levels, including Doctoral Fellowships, Senior Research Fellowships, Transitional Fellowships and others. Fellowship Programmes are advertised annually and may include 'themed calls', in which specific themes are highlighted as being particularly important. Nevertheless, research proposals that fall outside these themes are still eligible for the programme.

The applicant requirements for one particular Fellowship programme, the **Doctoral Research Fellowship**, are further explored in more detail below.

There are four broad areas to the Doctoral Fellowship application form: applicant; research; site, training and supervision; finance. The applicant section includes demographic details, the applicant's research experience, the applicant's curriculum vitae and previous research output, and the applicant's career intentions. The section on research includes a description of the background and rationale for the proposed research project, an explanation of the project's relevance to the NHS, and a description of the likely impact of the research. The section on site, training and supervision requires details to be provided of the proposed training programme, the proposed supervisor(s) and the academic host and institutional support. The finance section includes details of costs required for training and development, for consumables and materials, for equipment, and project-specific costs.

Upon exploring the guidance provided to applicants for completion of the form, it is clear that there are a number of aspects that relate directly to the RRI criterion of 'societal desirability'.
Applicants are required to write both a brief 'plain English' summary of the proposed research and also a scientific abstract for the research. For both of these, the applicant is expected to state the expected outcomes of the research and the "anticipated benefits to the ongoing improvement of

[68] Based on The National Institute for Health Research 2013a, b and c.

health or social care" (The National Institute for Health Research: 2013b). In the section that covers the background and rationale for the proposed research, the applicant is required to justify the importance of the research and state its relevance to the improvement of health, health care or services, and to describe the potential benefit to patients and to the NHS.

There are sections to complete on both the dissemination plans for the research and the expected outputs and their impact. As part of the guidance for the latter section, it is stated that "it is expected that … all research funded by DH or through the NIHR, should be able to demonstrate that it is capable of generating outcomes that are likely to contribute to the benefit of those who use the services of the NHS" (ibid.). Finally, within the finance sections, the applicant is asked to provide a detailed breakdown of costs required for the Fellowship. Justification of resources requested is an important component of these sections, and the applicant is asked to indicate how the research will potentially benefit the NHS, e.g. in terms of cost-savings or treatment times.

The NIHR and the Societal Desirability of Research

The NIHR is explicit in both its mission statement and aims, and in the requirements for applications to Fellowship programmes; that it's funding is to be used for research that will lead to direct benefits to patients, to the NHS and/or to health and social care as well as contribute to the economic growth of the country. Improvements to health and social care and benefits to patients clearly fall within the category of 'societal desirability' and therefore in these ways the NIHR is explicitly seeking to only fund research that achieves these aspects of the societal desirability criterion. However patient benefit and improvements to health and social care are only two aspects of 'societal desirability', which as a criterion extends far wider than this, and perhaps other components of societal desirability are less well addressed by the NIHR funding criteria. Nevertheless the remit of the NIHR is clearly stipulated, reflecting the fact that it is funded by the Department of Health, and it is therefore perhaps not reasonable to expect funding requirements to extend beyond the patient benefit and health and social care improvement aspects of societal desirability. Additionally, the NIHR's remit is clearly to improve health and social care through research on a national level. It therefore contributes to some aspects of national societal desirability but societal desirability at an international or global level appears to be beyond its remit.

In summary, the NIHR is relatively explicit in requiring applicants to justify the ways in which their proposed research will benefit one area of society (patients and health/social care), for one country.

The Wellcome Trust Funding Programme[69]

The Wellcome Trust was set up by Sir Henry Wellcome in 1936 and is a global charitable foundation that is independent of both political and commercial interests. The Wellcome Trust's **vision** is to achieve extraordinary improvements in human and animal health, and its **mission** is to

[69] Where paraphrasing information might have lost the precision of the original formulation from the research funder, the wording was kept.

support the brightest minds in biomedical research and the medical humanities. The Wellcome Trust has three focus areas:

1. Supporting outstanding researchers;
2. Accelerating the application of research;
3. Exploring medicine in historical and cultural contexts.

The Wellcome Trust has identified five strategic challenges, which it believes are some of the biggest challenges to human and animal health. Support is provided to projects within the UK and abroad in order to address these strategic challenges. The five strategic challenges are:

1. Maximising the health benefits of genetics and genomics;
2. Understanding the brain;
3. Combating infectious disease;
4. Investigating development, ageing and chronic disease;
5. Connecting environment, nutrition and health.

Funding for the Wellcome Trust started with a substantial investment from Sir Henry Wellcome's company in 1936. Since then, income has been generated through investments in property, public and private equities, hedge funds, and cash. The current Invested Endowment is about £15bn. Expenditure on charitable activities totals about £700 million per year.

The Wellcome Trust funds work in six key areas:

- Biomedical Science – Biomedical Science funding is categorised as follows:
    - Personal support for outstanding researchers – e.g. Investigator Awards, Fellowships;
    - Large-scale collaborative multi-disciplinary projects – e.g. strategic awards;
    - Equipment and resources – e.g. biomedical resources, multi-user equipment grants;
    - Clinical trials in Low and Middle Income countries.

- Technology Transfer – this includes the following:
    - Stimulating development of new products and technologies;
    - Encouraging the commercial application of research to meet medical needs by facilitating their route to market.

- International
    - International funding is provided to Low and Middle Income country applicants within the remit of Public Health (including communicable and chronic diseases) and / or Tropical Medicine (including clinical and biomedical work). The aim of this is to support research and strengthen research capacity in these countries, as stipulated in the Wellcome Trust's International Strategy;
    - Funding is also provided to support a range of internationally collaborative projects, including major international partnerships between higher-income countries (e.g. the International HapMap Project and the Structural Genomics Consortium).

- Public Engagement
    - The Wellcome Trust seeks for people from all walks of life to consider, question and debate the key issues in science and society;
    - Up to £10 million is therefore offered annually to support projects that will promote public engagement;
    - Examples of projects support by the Public Engagement funding stream include 'People and Society Awards' and 'Arts Awards'.

- Medical Humanities
    - This funding stream supports research that considers important questions relating to the interface between medicine, health-related science and the wider humanities;
    - This type of research is important to illuminate perceptions of health and illness in the past and present, and to shape the practice of medicine in the future;
    - Medical Humanities research projects are funded within a wide range of disciplines including, for example, anthropology, classics, the creative arts, English, history, medicine, philosophy, psychology and sociology.

- Society and Ethics – this funding stream supports research that explores the social and ethical aspects of biomedical research and health. More details will be provided about this funding stream later in the report.

Given the wide range of research projects supported by the Wellcome Trust, it is not surprising that research output is substantial. The Wellcome Trust advocate an Open Access Publishing principle, in which outputs from research that they have funded should be made freely available in order for knowledge to be used in a way that maximises benefit to health and to the public. The Wellcome Trust also ensures that it monitors the outcomes and impacts of projects that it has funded, to inform future strategy and demonstrate the importance of biomedical research to the economy and to society.

The Wellcome Trust's Society and Ethics programme

In order to explore ways in which the Wellcome Trust seeks to fund research that will lead to societal desirability, one particular programme (the 'Society and Ethics' programme) is now be examined in greater detail.

The Society and Ethics programme seeks to support research that explores the social and ethical aspects of biomedical research and health. The overall aim of any research supported must be in keeping with the Wellcome Trust's vision of achieving extraordinary improvements in human and animal health. Ideally research should link to the Wellcome Trust's five strategic challenges and should address tractable, real-world problems. There are two key funding strands within the Society and Ethics programme, and they aim to fund research that:

1. Seeks to consider social, economic and cultural factors that influence health, biomedical or health research, the development and implementation of healthcare practices, and health interventions.

2. Sets out to inform answers to questions about resolving ethical dilemmas arising from biomedical or health research, the development and implementation of healthcare practices, and health interventions.

The Society and Ethics funding programme incorporates a number of different grant schemes, including: Investigator Awards, Research Fellowships, University Awards, Research Fellowships for Health Professionals, Strategic Awards in Medical Humanities, Wellcome Trust-POST Fellowship in Society and Ethics, Small Grants, Society and Ethics Doctoral Studentships and the Hub Award[70].

The application form for one grant scheme, the Society and Ethics Doctoral Studentships, was scrutinised in order to ascertain the applicant requirements. Broadly speaking, most of the requirements for the application form fall into six areas:

- Applicant requirements: including demographic details, curriculum vitae, reasons for applying, intended career path and publications;
- Research environment: including supervisor details and sponsor details;
- Recommendations: including from the applicant's supervisor, an academic referee and any project supervisors;
- Research project: including the research question, a description of why the research is important, details of the project plan and an outline of the research's relevance to policy and practice;
- Output: including public engagement plans and plans for dissemination of research findings;
- Financial aspects.

Whilst the application form for the Society and Ethics Doctoral Studentships does not require the applicant to state explicitly the ways in which their proposed research will lead to benefit for society, there are certain aspects of the form that allude to this. Firstly, the applicant is required to justify the importance of their research, and, given the overarching vision of the Wellcome Trust, it seems reasonable to assume that this justification would be in relation to the anticipated benefits to human and animal health. Secondly, the applicant is required to state the relevance of the project (if any) to policy and practice. This suggests that it is important for the research to have reach beyond academia, to other parts of society. Finally, the applicant is asked to provide an outline of their public engagement plans and plans for dissemination of the research findings. This fits with the Wellcome Trust's Open Access Publishing policy, and suggests that the Wellcome

[70] http://www.wellcome.ac.uk/Funding/Public-engagement/Funding-schemes/Hub-Award/index.htm

Trust deems it important for findings to be made as widely available as possible, providing opportunity for individuals and institutions to benefit from the new knowledge generated.

The Wellcome Trust and the Societal Desirability of Research

Upon reading the Wellcome Trust's webpages and an example of one funding application form, there do not appear to be explicit references to a need for research to fulfil a criterion of societal desirability. However, there are key ways in which the Wellcome Trust funding programme does nevertheless seek to achieve this criterion. The Wellcome Trust's vision, to achieve extraordinary improvements in human and animal health, underpins all its funding provisions, and this vision is fully concordant with the criterion of societal desirability: improvements in human and animal health are of course extremely beneficial to society.

The five strategic challenges identified have been chosen because they are believed to be the biggest challenges currently facing human and animal health: these challenges therefore are consistent with both the Trust's overall vision and with a funding criterion of social desirability. In smaller ways too, the Wellcome Trust indirectly works to provide societal benefit. It advocates an Open Access Publishing policy, in order that new knowledge may lead to maximum benefit for health and for the public – wide dissemination of new knowledge is desirable for our society, both nationally and internationally. The Wellcome Trust monitors the outcomes and impacts of projects that it funds, and this reflects the Trust's commitment to demonstrating the importance of its research to the economy and to society.

One can therefore conclude that, whilst the Wellcome Trust does not appear to incorporate an explicit requirement for societal desirability to be demonstrated by research that it funds, its overall vision and ethos are in keeping with the 'societal desirability' criterion of RRI.

United States

The U.S. FY2013 federal budget provides $140.8 billion (approximately €104 billion) for "research and development (R&D)" (only slightly changed from preceding years). This funding is highly concentrated. Seven federal agencies receive 95.8% of total federal R&D funding. The largest recipients are the Department of Defense (50.6%), the Department of Health and Human Services (22.3%, primarily for the National Institutes of Health), and the National Science Foundation (5.2%).

This section of the report focuses on the National Science Foundation (NSF) because, though the smallest of the "big three", its experience with the criterion of "broader impact" relates most closely to efforts to drive research towards societally desirable goals. In addition, if briefly, analogous criteria used at the National Institutes of Health (NIH) and at several smaller federal funding agencies, such as National Aeronautics and Space Agency, are described.

The National Science Foundation and Broader Impacts

The National Science Foundation (NSF) is an agency of the US federal government that supports fundamental research and education in all *non-medical* fields of science and engineering.[71] Its medical counterpart is the National Institutes of Health (NIH). With an annual budget of about $7 billion (€5.2 billion) (fiscal year 2012), the NSF supports approximately a fifth of all federally supported *basic* research conducted in US institutions of higher learning.[72] In some fields, such as mathematics, computer science, economics, and the social sciences, the NSF is the major source of federal funds. Although many other federal research agencies, including the NIH, operate their own laboratories, the NSF does not. Instead, it fulfils its mission almost entirely by distributing competitive, limited-term grants in response to specific proposals from researchers (NSF 2012).

The NSF received about 50,000 such proposals in 2012, funding about 11,000 of them. Funded proposals are typically those ranked highest by "peer reviewers", though NSF's own program officers make the final selection. The peer reviewers are NSF-recruited independent scientists, engineers, and educators who are experts in the relevant field. Reviewers cannot work at the NSF or for an institution that employs those proposing research on which the reviewer must pass. All evaluations of proposals are confidential. While reviewers see the names, institutions, credentials, and budgets of those proposing research, those proposing do not see the names of reviewers (but can see the evaluations). Both peer reviewers and program officers are supposed to base their decisions on NSF's published criteria (NSF 2012).

Between 1981 and 1997, the NSF had four funding criteria: *research competence*; *merit of the research*; *utility*; and *effect on infrastructure* (NSF 1995). In 1997, the NSF replaced these four criteria with two: *intellectual merit* and *broader impacts* (Diagram 12). This change may reasonably

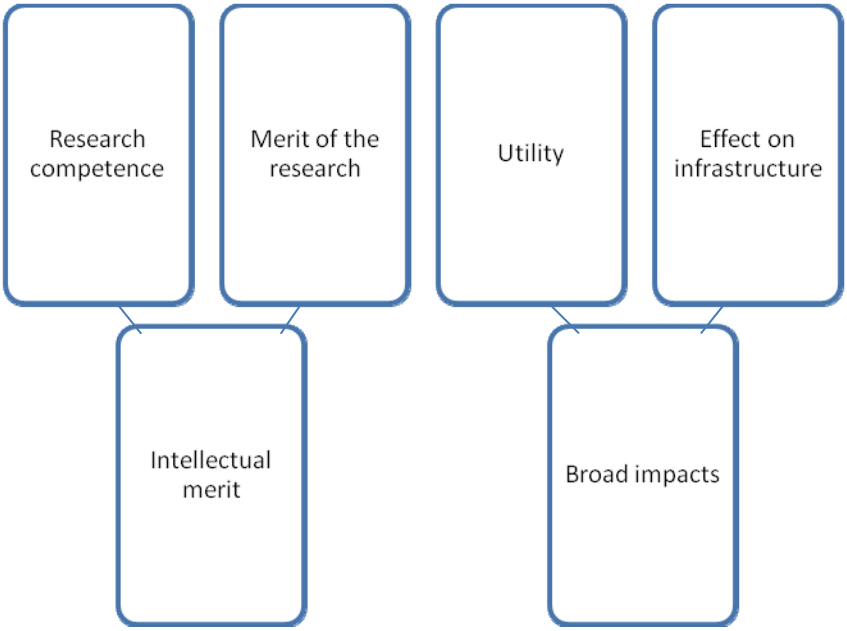
[71] Actually, this is not quite right—or is quite right only given a certain understanding of "science". For example, NSF does not typically fund research in criminal justice science, library science (except digital libraries), or animal husbandry, but does fund work in philosophy and history of science.

[72] This amount, though large, is small compared to the overall federal spending on research. NIH alone spends about $30 billion a year on medical research. (NIH 2012)

be judged to have achieved two purposes. The first was simplification, reducing the first two of the old criteria (competence and merit) to one (intellectual merit) and reducing the second two (utility and effect on infrastructure) to one (broader impacts) (Rothenberg 2010). But the change could also be judged to have broadened the utility-infrastructure criteria considerably (depending on how "utility" and "infrastructure" had been interpreted before).

There was good reason for changing the criteria. Surveys of NSF reviewers conducted in 1991 and of NSF program officers in 1995 showed that most reviewers ignored at least one of the four criteria, with the third and fourth (utility and infrastructure) being the ones most likely to be ignored. The chief reason offered for ignoring those two was that they were not clear. The new term "broader impacts" was to provide the missing clarity (Rothenberg 2010). Starting in 1997, the second criterion was:

Diagram 12
NSF change in funding criteria, 1981-1996 → 1997 - present.



What are the broader impacts of the proposed activity?

- How well does the activity advance discovery and understanding while promoting teaching, training, and learning?
- How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?
- To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks and partnerships?
- Will the results be disseminated broadly to enhance scientific and technological understanding?
- What may be the benefits of the proposed activity to society?

Criticism of Broader Impacts

If this new criterion achieved more clarity than its predecessors, it certainly did not achieve enough. When the NSF reviewed the new criterion after 14 years of experience, it found both

reviewers and program officers critical of it.[73] There seemed to be two lines of ideological criticism.

One line, originating within the research community, especially among mathematicians, emphasized the need for science to follow its own internal logic:

The broader impact of science is (it was argued) unpredictable in detail but certain in gross. Too close a connection between what politicians want and what gets funded will actually defeat the purpose of funding fundamental research, that purpose being to benefit from the unpredictability of such research. The United States (US) might as well close the NSF and give its funding to the agencies of applied research and seek to direct the NFS's research into economically productive channels itself. The US has many agencies of applied research—the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), the Office of Nuclear Regulatory Research, the Defense Advanced Research Projects Agency (DARPA), and so on. The NSF is supposed to be different from these, to be the only federal agency supporting fundamental (non-medical) scientific and engineering research because that research advances the "frontiers of knowledge" (Holbrook 2012). *Indeed, for the first three decades of its existence, the NSF did not fund engineering research, deeming it not fundamental enough. This discrimination against engineering research may now surprise even those unaware that the leader in efforts to establish the NSF as the agency of "basic research" was Vannevar Bush, an engineer rather than a scientist (Rothenberg 2010).*

The other line of ideological criticism, originating in Congress, emphasized the need for fundamental research to repay the public investment. Not only was the NSF established in 1950 to "promote the progress of science" but also "to advance the national health, prosperity, and welfare; and to secure the national defense"; this remains its official mission (NSF 2012). Thus, the NSF's mission has always included certain broader impacts: advancing the national health, prosperity, and welfare; and securing the national defence. The controversy, if there is one, must be over how best to achieve those broader impacts (Hellström and Jacob 2012). Merely letting science follow its own internal logic was a strategy abandoned by 1981, if not long before, though (it seems) without any evidence that the strategy had failed (Rothenberg 2010).

In addition to these two lines of ideological criticism, there were several more practical criticisms. The most important of these was that both applicants and reviewers tended to interpret the bulleted items under the general question as requirements ("a check list"), all of which must be satisfied rather than as five examples of broader impacts. Interpreting the bulleted items as requirements achieved clarity at the expense of research that the NSF might want to fund, for example, in mathematics or astrophysics (NSF 2011, 8).

[73] The data appear in Appendix C of NSF 2011, a report of over 300 pages (providing many insights into the entire process of re-formulating the broader-impacts criterion).

Acknowledging the force of these criticisms, the NSF initially proposed the compromise discussed below. The purpose of the criterion of "broader impacts" is to: "ensure the consideration of how the proposed project advances a national goal(s)".[74] Elements to consider in the review are:

1. Which national goal(s) are addressed in this proposal? Has the PI presented a compelling description of how the project or the PI will advance the goal(s)?
2. Is there a well-reasoned plan for the proposed activities, including, if appropriate, department-level or institutional engagement?
3. Is the rationale for choosing the approach well-justified? Have any innovations been incorporated?
4. How well qualified is the individual, team, or institution to carry out the proposed broader impacts activities?
5. Are there adequate resources available to the PI or institution to carry out the proposed activities? (NSF 2011, 264-265)

The NSF hoped this list of questions (combined with its deflationary preamble "elements to consider") would avoid the impression both of requirements and of any supposition that the NSF expected reviewers or program officers to predict the broader impacts of fundamental research in detail. The list supposed only that reviewers and program officers could evaluate ("consider") whether a proposal's choice of broader impact was designed to serve a national goal, whether the resources available seemed adequate to carry out the design, how well-justified the design was, and whether the qualifications of those involved were sufficient. Such evaluations required little knowledge beyond what is required for evaluating intellectual merit (which had a list of questions almost identical) (NSF 2011, 13).

This compromise statement received considerable criticism, but mostly of detail, leading to several revisions. Among the revisions was the substitution of the more general "societal goals" for "national goals".[75] Effective on 14 January 2013, the NSF implemented revised merit review

[74] The first version of the proposed revised merit criterion (NSF 2011, 264) provided the following information about "national goals":

> Collectively, NSF projects should help to advance a broad set of important national goals, including:
> - Increased economic competitiveness of the United States.
> - Development of a globally competitive STEM workforce.
> - Increased participation of women, persons with disabilities, and underrepresented minorities in STEM.
> - Increased partnerships between academia and industry.
> - Improved pre-K–12 STEM education and teacher development.
> - Improved undergraduate STEM education.
> - Increased public scientific literacy and public engagement with science and technology.
> - Increased national security.
> - Enhanced infrastructure for research and education, including facilities, instrumentation, networks and partnerships.

Note that even this long list is not exhaustive. The nation's goals simply "include" these. Note too that NSF projects are to advance these goals "collectively". There is no requirement that any particular project advance any of these goals. The list is much the same as the "goals" in the America COMPETES Reauthorization Act of 2010 (H.R. 5116), Sec. 526.

[75] The substitution of "societal" for "national" seems to have been a way to provide more free-play in the choice of impacts to pursue (since there was no Congressional definition of "societal goals" as there was of "national goals"). For those with an ear for language, the question might arise: Why "societal" rather than the shorter and older "social"?

guidelines based on a recent National Science Board (NSB) report (NSF 2011).[76] While the merit review criteria remained unchanged from those established in 1997 (intellectual merit and broader impacts), the guidelines sought to clarify and improve the way they function. Relevant here are changes in the guidelines for "broader impacts".

After making it clear (as before) that broader impacts may be accomplished through the research itself as well through auxiliary activities, the instructions add that the "NSF values the advancement of scientific knowledge *and* activities that contribute to the achievement of societally relevant outcomes" (NSF 2013, italics ours). Since this sentence appears in the paragraph explaining what is meant by "broader impacts", we must read it as stating two independent propositions: first, that the NSF values the advancement of scientific *knowledge* that contributes to the achievement of societally relevant outcomes, one sort of broader impact, and second, that the NSF values *activities* that contribute to the achievement of societally relevant outcomes (even if the activities in question do not themselves advance scientific knowledge), another sort of broader impact. This reading is partially confirmed by the list of examples that follow immediately (the successor to "national goals"):

> Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education (NSF 2013, 14).

Of the nine examples given, all (or, at least, most) seem independent of any advance in scientific knowledge that a particular project might achieve. Thus, full participation of women, persons with disabilities, and underrepresented minorities might be achieved through a project that only improves scientific literacy or only enhances infrastructure for research or education. It is the first criterion (intellectual merit), not the second, that assures that a project is likely to advance scientific or technical knowledge. The problem that the would-be principal investigator faces when drafting a proposal is how to combine an activity having enough intellectual merit with one or more activities or outcomes having enough broader impact. Both criteria must be satisfied but

There is no official answer. The best guess is that "societal" suggests "society" while "social" also suggests "socialize", "sociable", "socialism", and other ideas slightly less appropriate.

[76] The NSB consists of the NSF director and twenty-four ordinary members appointed by the President of the United States and confirmed by the United States Senate. The NSB meets six times a year to establish NSF's overall policies within the framework of applicable national policies set by the President and the Congress. The Board also serves as an independent policy advisory body to the President and Congress on science and engineering research and education and has a statutory obligation to "render to the President and to the Congress reports on specific, individual policy matters related to science and engineering and education in science engineering, as the Board, the President, or the Congress determines the need for such reports," and to "render to the President and the Congress no later than January 15 of each even numbered year, a report on indicators of the state of science and engineering in the United States." (42 U.S.C. Section 1863, Sec.4.(j)(1-2)) The NSF's director is also responsible for administration, planning, budgeting, and day-to-day operations of the foundation.

fulfilling one to a high level may help towards win funding for a proposal that does not satisfy the other criteria as much. The NSF continues to struggle with providing adequate guidance to would-be grant recipients concerning what counts as the right sort of Broader Impact. For the latest effort, see the "Toolkit" available at http://www.nsf.gov/news/news_summ.jsp?cntn_id=131813.

RRI and Broader Impacts

Given the above, we may identify three important similarities between RRI as defined by von Schomberg and the criterion of broader impacts:

1. **Socially desirable** - The NSF apparently has a conception of science, technology, engineering, and mathematics as working to achieve "societally relevant outcomes"—presumably outcomes "relevant" in a positive way, that is, outcomes society should desire (even if it does not). Both RRI and broader impacts seek science and innovation that serve society.

2. **Process** - There is in both criteria the idea of a process by which researchers in academia (and other research institutions) might work with industry and others to achieve societally desirable outcomes. Admittedly, the part played by process in the NSF criterion ("partnerships" and "participation") seems far less central than in RRI.

3. **Specific Goals**. The list of socially desirable outcomes that the broader impacts criterion aims at is at least partially the same as that which Europe has or might be expected to put together. For example, Europe wants its research and innovation to increase its economic competitiveness just as the US wants its research and innovation to do.

Though these similarities between RRI and broader impacts are significant, the differences between the two criteria seem more significant, as the following section will show.

RRI is (primarily) about process; broader impacts is (primarily) about outcomes. In broader impacts, the only references to process are the optional involvement in partnerships with "industry and others" and the greater participation of women, persons with disabilities, and underrepresented minorities. And even these two process outcomes may be achieved without extensive collaboration. For example, an NSF-style partnership between academia and industry might amount to no more than an agreement to pass on useful discoveries to a particular company well before publication in exchange for the use of some equipment or patents; it need not involve bringing representatives of industry into the planning of research.[77]

RRI seeks to make the process of research and innovation transparent. The closest the broader impacts' list of desirable aims comes to transparency is a) improved education in science, technology, engineering, and mathematics and b) increased public scientific literacy and public

[77] Indeed, having had more than three decades of experience with academic-industry partnerships, Americans have become cautious about allowing partnerships to be too close. See, for example, Davis (1991), Krimsky (2004), or Institutes (2009). NSF now requires academic institutions to have conflict of interest policies to keep university-industry relations from becoming too close (NSF 2013, 6-7). RRI seems to risk similar problems.

engagement with science and technology. There does not seem to be any explicit conception of designing the research (or innovation) so that the public can be involved in research as such. Even "public engagement with science and technology" seems in fact to be largely engagement with science and technology after it has been produced.[78]

The concluding paragraph in the explanation of broader impacts does, however, include requirements relevant to transparency:

> Plans for data management and sharing of the products of research, including preservation, documentation, and sharing of data, samples, physical collections, curriculum materials and other related research and education products should be described in the Special Information and Supplementary Documentation section of the proposal (see GPG Chapter II.C.2.j for additional instructions for preparation of this section) (NSF 2013, 14).

Two items in the Grant Proposal Guide (GPG) Chapter II.C.2.j seem clearly relevant to RRI. A data management plan "may" include: "policies for access and sharing including provisions for appropriate protection of privacy, confidentiality, security, intellectual property, or other rights or requirements" and "policies and provisions for re-use, re-distribution, and the production of derivatives" (NSF 2013, 29-30). These are, however, options, not requirements. They may also be interpreted as concerned with transparency within the scientific and technological community rather than with public transparency.

Broader Impacts and Ethical Acceptability and Sustainability

Nothing in the broader impacts section, or anywhere else in the instructions to applicants, suggests any interest in sustainability. The instructions do, however, include a section separate from broader impacts concerned with the ethical acceptability of research.

> The AOR [Authorized Organizational Representative] is required to complete a certification that the institution has a plan to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students, and postdoctoral researchers who will be supported by NSF to conduct research (NSF 2013, 8).

This is conventional RCR (responsible conduct of research) training. A typical curriculum might include Research Misconduct, Data Management, Conflict of Interest, Collaborative Science, Human Subjects, Lab Animals, Mentoring, Peer Review, Responsible Authorship, and Safety (CITI 2013). There is nothing specific in RCR about the ethical acceptability of the outcome of the research. Indeed, this requirement is limited to undergraduates, graduates, and postdocs. There is

[78] One exception to this general separation of research and the public is what has come to be known as "citizen science", that is, projects that recruit members of the public to help gather research data. So, for example, a recent NSF-funded project at Cornell University included volunteers living in areas affected by the Deepwater Horizon oil spill surveying birds on beaches and in marshes along the Gulf coast. The volunteers shared what they learned through a website which automatically built interactive maps showing locations of reported birds in relation to current and forecast oil-slick locations, allowing for quick response of conservation efforts (NSF 2010).

nothing about similar training for the chief researchers (the faculty overseeing the work of the undergraduates, graduates, and postdocs).

In addition to this RCR training, there is a requirement that any research on human subjects have the approval of the organization's ethical review committee (NSF 2013, 30). Such a committee typically includes at least one member of the public (HHS, 2013). A similar committee must pass on research involving animal subjects.

We will now examine some other US examples of funding criteria. Our investigation seems to show that no other US agency has adopted a criterion similar to the NSF's broader impacts, though some requests for proposals, subsidiary programs, general standards, or parts of a review process do have similar goals (or, at least, likely effects), for example a requirement that funded projects include some public outreach. We therefore only introduce one other public agency and one private one. These seem to be a fair sample of how the majority of US funders seek to accomplish something resembling RRI.

The National Institutes of Health

The National Institutes of Health (NIH) is the primary federal agency charged with conducting and supporting medical research in the US. Consisting of 27 "institutes" and "centers", its mission is to "seek fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to enhance health, lengthen life, and reduce the burdens of illness and disability" (NIH 2011). The agency received over $30 billion in funding for the fiscal year 2012, 80% of which was awarded in competitive grants (NIH 2012). The NIH funds both basic and applied biomedical research and, like the NSF, has, especially in the last few years, tried to justify its funding of basic research by its possible social impact.

Like the NSF, the NIH uses review panels to distribute most of its funds. Unlike the NSF, the NIH has a two-tier process of review. The first tier employs experts organized into "Scientific Review Groups" to judge the scientific and technical merits of a proposal. These groups are much like the NSF's peer review panels (both in membership and procedure). In reviewing proposals, the NIH uses five criteria:

1. the significance of the proposal to medicine;
2. the experience of the investigators;
3. the innovation of the proposal;
4. the reasonableness of the approach;
5. the environment in which the research will be conducted.

The significance of the proposal to medicine seems to include potential impact on society as well as on science, since the following questions are suggested as being relevant:

- Does the project address an important problem or a critical barrier to progress in the field?
- If the aims of the project are achieved, how will scientific knowledge, technical capability, and/or clinical practice be improved?

- How will successful completion of the aims change the concepts, methods, technologies, treatments, services, or preventative interventions that drive this field?

The NIH's "Funding Opportunity Announcements" will sometimes include additional criteria, including criteria concerned with education, recruitment, and retention to enhance diversity (NIH 2013a). Once the NIH's first-tier review is complete, the proposal is handed off to the "advisory council" (or "advisory board") of the appropriate institute or centre for a second review. The purpose of this second review is to determine the relevance of the proposed research to that institute or centre, including its potential impact on health. Each advisory council is composed of scientific experts and laypersons (in a ratio of two scientists to one layperson) in order to "ensure that the NIH receives advice from a cross-section of the US population in the process of its deliberation and decisions"[79] (Holbrook 2010).

The standards of relevance and impact vary somewhat from one institute or centre to another, but one example may serve for all. The advisory council of the National Institute of Mental Health (NIMH) evaluates proposals against two goals: will the project "transform the understanding and treatment of mental illnesses through basic and clinical research, paving the way for prevention, recovery and cure?" and is the project proposed likely to help "bridge the gap between the development of new, research-tested interventions and their widespread use by people in need?" (NIMH 2008).

The NIH also requires projects receiving direct funding to make resulting peer-reviewed publications available to the public through NIH's PubMed Central, a publically available database it maintains (NIH 2013d). Finally, the NIH has two large programs to reduce the time between the discoveries of basic research and their application in ordinary medical practice. One of these, "Clinical and Translational Science Awards", has provided about sixty academic institutions with funding to set up research centres whose goal is to work together to improve the way in which clinical and translational research is conducted across the country (NIH 2012, NIH 2013c).

Translational research is scientific research that helps to turn the innovations of basic research into artefacts, processes, or procedures that enhance human health and well-being. Translational research is a response to the compartmentalization of most research; it is necessarily multidisciplinary, sometimes including psychologists, social scientists, engineers, and even lawyers along with the more typical biomedical scientists and physicians.[80]

Translational research is important in biomedical research, especially as a way to shorten the time between finding a promising drug or therapy and proving its safety and efficacy in humans (Coller, 2009). In the past fifty years, there has, it seems, been an increasing disconnect between basic and clinical research, with highly specialized PhDs (and MDs) doing much of the basic research and practicing physicians doing much of the clinical research. Pharmaceutical companies are also

[79] Members of an advisory council are chosen by the respective institute or centre and approved by the Department of Health and Human Services. For certain committees, members are appointed by the President of the United States.
[80] The terms "translative research" and "translational science" are (more or less) equivalent to "translational research".

spending more money on their own research and so have a diminished interest in pursuing academic discoveries (Butler 2009).

The NIH's other translational program "Bench to Bedside" funds specific research teams seeking to move a basic scientific discovery into therapeutic interventions (NIH 2013b). Ordinarily, scientists have little incentive to get involved in the complex process needed to move a potentially useful discovery to the bedside. Indeed, given the cost and difficulty of the regulative process, they have considerable incentive not to get involved. To overcome that barrier, Bench to Bedside pays basic and clinical researchers to collaborate, and provides training, research, and infrastructure to help researchers guide their discoveries or inventions to approval for medical use. Thus, Bench to Bedside initiatives seem designed to drive research towards societally desirable goals, since - if successful - discoveries will benefit those needing health interventions faster than they otherwise would.

The NIH and Ethical Acceptability and Sustainability

Apart from the two tiers of "external review" that proposals have to go through before being funded by the NIH, there is an internal review to make sure that proposals meet legal requirements for ethical acceptability for research on humans and animals.[81] Proposers must include a justification for any involvement of human subjects in their proposed project and a plan to protect those subjects from any risk arising from participation in the research. No mention is made of sustainability in the proposal documentation.

The Bill and Melinda Gates Foundation

In 2012, the Gates Foundation distributed about $3.4 billion in domestic and international grants in public health, global development, and improving the US educational system. The Foundation's board (half the members of which are Bill Gates, Melinda Gates, and Bill Gates' father) sets the funding strategy. The Foundation solicits proposals both by inviting organizations to submit a letter of inquiry and also by putting out private or public calls for proposals. The Foundation's executives review the proposals. Review criteria vary greatly depending on the call but are usually drawn from the strategic goals of the "section" issuing the call. The sectional goals typically include broader impact. For example, the Foundation's agricultural development section has the overall goal of reducing "hunger and poverty for millions of farming families in Sub-Saharan Africa and South Asia but increasing agricultural productivity in a sustainable way" (Gates 2013).

The Gates Foundation has been praised by many, especially for supporting research into global health that has had a major impact on government policy (Anderson 2011). The *Lancet* (2009) even praised it for how it had "inaugurated an important new era of scientific commitment to global health predicaments." However, the funding process remains rather opaque, and appears to be largely managed through informal networks rather than through a more transparent review by independent and technical experts. There also seems to be evidence that some organizations

[81] For human subjects in research, the relevant laws are 45 CFR Part 46 (HHS) and 45 CFR Part 690 (NSF) Federal Policy for the Protection of Human Subjects; for animals, 7 USC. 2131 et seq., 9 CFR 1.1-4.11.

are favoured over others. A study published in the *Lancet* in 2009 reported that over 82% of the Foundation's funding went to US-based recipients from 1998-2007. During that same period, 659 grants were awarded to non-governmental or non-profit organizations. Of these, most (560) were organizations in high-income countries. Of the remainder, only 37 went to non-governmental, non-for-profit organisations in middle- or low-income countries. The article concludes that "…this raises the question as to whether some organizations might be better characterized as agents of the foundation rather than as independent grantees" (McCoy 2009). In 2012, a committee established by the Foundation itself reported that investigators who had received funding through the Foundation wanted more transparency in the grant review process (Gates 2012).

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