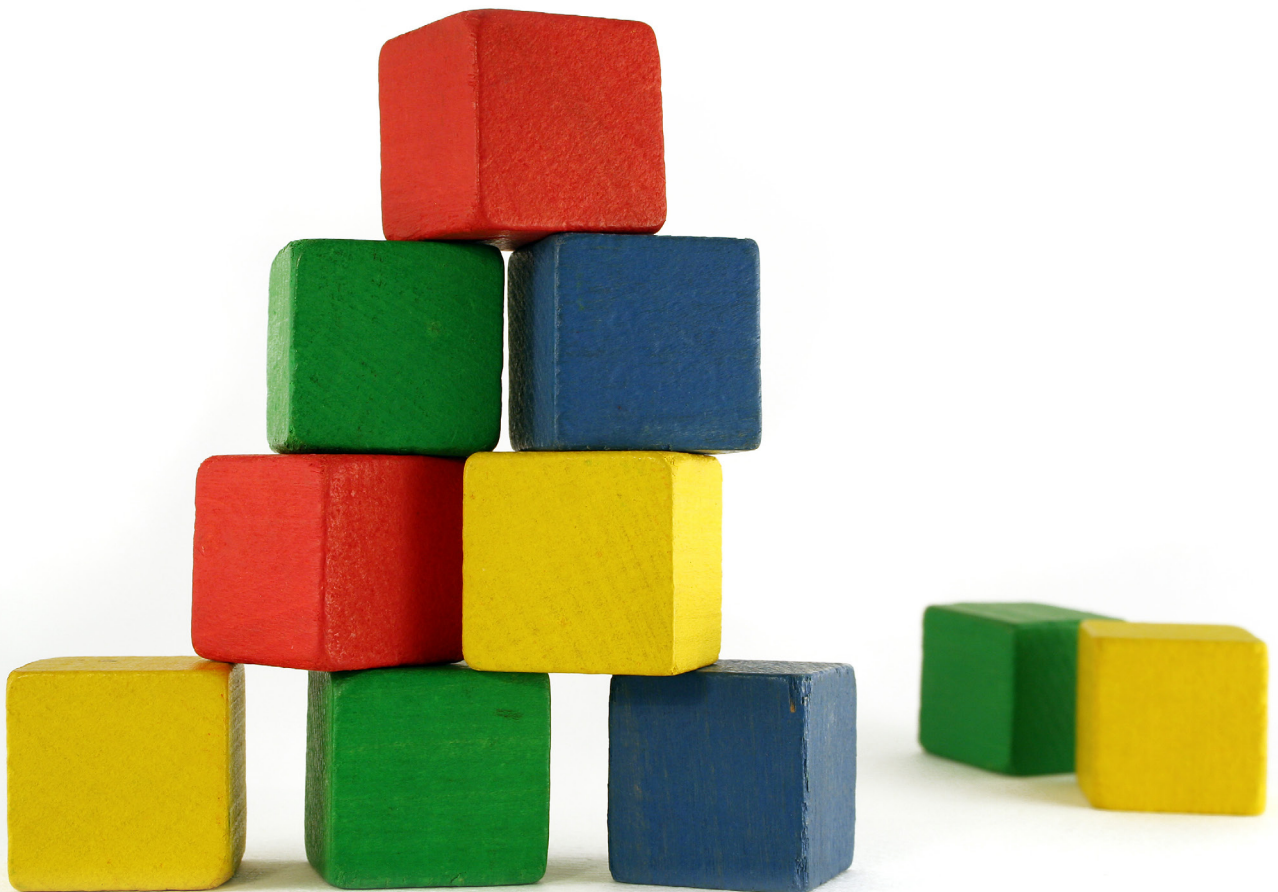# Organising for excellence

An international review of good
practice in organisational design and
governance of research funding bodies

Molly Morgan Jones, Louise Lepetit, Joachim Krapels,
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Preface

In November 2015, Sir Paul Nurse published his review of the research councils and the research and innovation funding system for the UK. The review highlighted the strengths of the UK funding system, but identified areas for improvement, notably in streamlining the research funding council functions. In response, the government's white paper in May 2016, 'Success as a Knowledge Economy', set out plans for a new body, UK Research and Innovation (UKRI). This will bring together the seven research councils, Innovate UK, and the research functions currently performed by the Higher Education Funding Council for England (HEFCE). UKRI will be a Non-Departmental Public Body acting as an overarching research funder.

A key consideration for this new funding body will be the design of its structures and governance, so as to best advance its ultimate objectives. To inform the structure and governance of such a body, the Department for Business, Energy and Industrial Strategy (formerly the Department for Business, Innovation and Skills when the report was commissioned), commissioned a study to answer the question: *What is the international evidence on best practice in organisational design and governance for a research funding body?*

This report summarises our findings. It synthesises the existing evidence relating to best practice in establishing strong and accountable organisations and governance structures; identifies lessons from the strengths and weaknesses of different organisational models for distributing research funding; and provides a UK context to the analysis.

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Table of Contents

Figures

Tables

Summary

Introduction

Following an independent review, the UK government has set out plans for a new body, UK Research and Innovation (UKRI), which would bring together what are currently the seven UK research councils, innovation funding body Innovate UK, and the research functions performed (in England) by the Higher Education Funding Council for England (HEFCE).[1]

To help inform the design of the structure and governance of UKRI, the UK's Department for Business, Energy & Industrial Strategy (BEIS)[2] commissioned this study to explore and review the international evidence on best practice in organisational design and governance for research and innovation funding bodies. The study covers i) evidence relating to good practice in establishing strong and accountable organisations and governance structures; and ii) lessons from the strengths and weaknesses of different organisational models for research and innovation. The initial search for evidence covered both research and innovation funding organisations, as well as organisations in public, private and third sectors that work in the field of research and innovation. The analysis has a UK context, but the study did not seek to make specific recommendations about the design and governance of UKRI.

Methods and Summary of the Evidence Base

The research was carried out during May–November 2016 and draws on three bodies of evidence:

1. **Short case studies** yielded information about the a selection of research and innovation funding organisations currently in existence around the world, how these bodies are organised, how they operate, and the content and formulation of their strategies. The case study review covered research and innovation funding organisations in seven countries (Australia, Germany, the Netherlands, Norway, South Korea, the UK and the USA). However, information regarding the theory underlying their organisational design was very limited, as was evidence linking such design to their performance.

2. **Semi-structured interviews** (27) with individuals with experience and expertise in research and innovation funding, policy, and governance. These interviews covered autonomy and flexibility, accountability, strategy and strategic decision making, organisational models, and supporting interdisciplinary research. The interviewees, who had diverse interests within governance topics, provided useful insights on the basis of their experience, from which several themes emerged. Of the interviewees, 20 were either currently or formerly part of national or international research funding organisations covered in our case studies. The remaining seven interviewees were either academics or private sector representatives with experience of issues related to governance of research and innovation and complex organisations.

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[1] UK Government 2016

[2] At the time this study was commissioned and until, it was known as the Department for Business, Innovation and Skills (BIS).

3. **A literature review** provided insights in topics that paralleled those covered in the interviews and case studies, though again it was difficult to identify *empirical* evidence linking organisational design to outcomes. Evidence specific to the governance of research and innovation funding bodies was found to be sparse, and this was confirmed in the interviews. The review covered academic and grey literature related to governance in research and innovation, as well as the third sector and industry.

Insights

Based on our integrated analysis of the evidence, which was guided both by the issues emerging from the case studies, interviews and literature and topics of specific interest to BEIS, four cross-cutting analytical themes emerged.

1. Strategy and portfolio management. Strategy describes the way an organisation or entity sets out to achieve its aims and objectives over a medium to long period of time. It is, essentially, a roadmap that can be turned into an implementation plan. The focus on strategy for this particular study was in part determined by BEIS, who had specific questions about evidence around the influences of strategy, the process of strategy development, its role in decision making and its content in the context of a research funding agency. Three core issues related to strategy emerged from our analysis: the process of strategy formulation, the content of the strategy, and the use of portfolio management to inform decision making and prioritisation. Our analysis revealed that:

- *Strategy formulation processes were consultative across multiple stakeholder groups, but vary in the extent to which these processes are internal or external, top-down or bottom-up.* Some organisations developed strategy in close consultation with their constituent stakeholder groups, while others consult on the strategy after it is developed.

- *Most strategies set out broad directions to be taken over a period of about five years.* They avoid prescriptive statements about specific research projects or topic areas in favour of highlighting cross-cutting, horizontal priorities. Some strategies explicitly align with government policy priorities, but not all take this approach.

- *Many strategies contained a set of overarching or guiding principles.* These generally cover some element of scientific excellence, but also openness, engagement, accountability and public benefit.

- *Mechanisms of flexibility and responsiveness support strategic decision making.* Bottom-up approaches and broad research and innovation capacity enable responsiveness to needs from the research community. As with strategy formulation, working from the bottom up can help with stakeholder engagement and in the design of programmes that are flexible and responsive to research needs, which could facilitate decision making.

- *Different strategies exist to support decision making, but portfolio management techniques were one area that stood out as being used by different funding bodies.* The exact nature of these techniques will vary, but all encompass a need for robust data, attention to the principles of a diverse portfolio, and the need to analyse the portfolio according to different analytical themes or needs.

2. Supporting collaboration and functional networks. Supporting collaboration and interdisciplinary research, alongside maintaining effective, functional networks within a research funding system are critical. Three issues are explored here: the need to foster and encourage interdisciplinary research; the

need to link effectively that external support function to an efficient internal organisational structure which encourages cross-functional collaboration; and the use of a networked governance approach. Our analysis revealed that:

- *It will be important to align external support for interdisciplinary research with internal organisational mechanisms.* Interdisciplinary research requires collaboration throughout and within the funding system. Good practice includes incentivising cooperation (e.g. through cross-divisional funding mechanisms) and awareness of internal organisational barriers (which may be physical, cultural or other).

- *Establishing effective internal cross-functional collaboration within an organisation relies on a careful balance between formalisation of rules about how to collaborate and the decentralisation of responsibility for the collaboration.* Many funding organisations have different approaches to incentivising this, varying from linking collaboration to staff performance management through to requiring that specified percentages of budgets be dedicated to cross-disciplinary work.

- *Maintaining a broad network of stakeholders through a networked governance approach is central to a funding body's effectiveness.* This is achieved through mutual trust, understanding the needs and challenges faced in research, and a deep connection to the societal challenges that research and innovation will need to help solve.

3. People and organisational culture are seen as more important than underlying structure, as good leaders and people can overcome poor structure and governance. Organisational culture is defined as the formal and informal norms and values that govern behaviour within the organisation. Culture is at the core of organisations and deemed one of the most important factors to take into account in organisational design and change. Three issues related to culture emerged from our analysis: leadership should seek to create transparency; to successfully change an organisation an understanding of the culture is necessary; and relatedly, a new organisational structure will only work if the leadership are perceived to be legitimate. Our analysis revealed that:

- *Leadership strongly influences culture.* Leaders affect areas such as transparency in decision making, which in turn strongly impacts morale.

- *Establishing the right mix of people skills and capabilities is widely acknowledged to be important for organisational efficiency and effectiveness.* There needs to be close alignment between the overall aims, functions and values of the organisation, and the skills. For example, the Defense Advanced Research Projects Agency (DARPA) explicitly hires staff in a way which aligns with its culture and working practices of funding 4–5 year boundary-spanning and cutting edge research projects.

- *In addition to the right people skills and capabilities, many agreed there is an organisational need for horizon scanning and evidence synthesis capabilities.* Many saw potential for a research funding body to bring system-wide benefits through the use of centralised evidence gathering and analysis to inform strategy making, priority setting, portfolio management, and other decisions.

- *A thorough understanding of organisational culture is required to successfully implement change.* Cultural differences can also be valuable.

- *Organisational structures will only work if they are perceived to be legitimate.* It is difficult for any organisation to operate without achieving legitimacy and acceptance.

4. Structure and organisational design principles like autonomy, trust and the relative nature of centralisation form the basic architecture of an organisation. While we are not able to link specific organisational structures to different outcomes, we did identify the features related to the nature of autonomy that a research funding body should have. These features include the organisational architecture and a degree of centralisation of decision making. Our analysis revealed that:

- *Autonomy of research funding organisations can be divided into two aspects: process and content.* Content refers to the topics or areas of research that will be funded, while process refers to the method by which high-quality research projects are selected (usually through peer review). Organisations need to ensure that they are attuned to the difference and that there is autonomy over both aspects.

- *Larger organisations (including research funders) tend to be more decentralised.* This enables larger organisations to ensure decisions make use of all available information.

- *Clarity over roles and responsibility is important, regardless of the level of centralisation.* This is particularly true during periods of organisational change.

Conclusion

Looking across these findings, it is clear that there is no single 'formula' or organisational design principle that prevails in all contexts. As one interviewee told us, in his experience after 25+ years in government funding bodies and departments, he had observed as many organisational models for funding agencies as there were funding agencies and departments themselves. Each one is context specific and has evolved for particular reasons related to the system it funds and works within. If there is one overarching message from our study then, it is that strategy development and organisational approach must reflect nationally specific goals and ambitions, existing or desired research cultures, and the size and scale of research base.

There is no 'one' model which can be lifted, but there are governing *principles* which held true across the evidence base. A framework which integrates these principles together should begin from a set of core operating values which support the overarching vision and mission for a complex organisation. Though it is not our role to prescribe a set of principles for UKRI, we can offer a set which emerged as central from our analysis of the evidence base:

- **The Haldane Principle** essentially calls for independence and autonomy of research decisions from political bodies or politicians and it is widely interpreted today, by the research community, to mean that decisions are best left to the research community itself. However, the full set of principles does introduce a notion of subsidiarity and a role of government departments when it comes to viewing the governance of research and its relationship with government in its entirety. Nevertheless, it is clearly viewed by stakeholders as a crucial pillar of the UK research and innovation system.

- **Agility and flexibility** refers to the need for any organisational design and system of governance to allow for flexibility and responsiveness to changing contexts and conditions. It featured in the literature on successful, complex organisations and emerged as important in interviews and case studies.

- **Openness and transparency** featured strongly throughout our review, in particular from the case studies and the interviews. Many interviewees spoke of its importance for gaining the trust of the research community. It was also seen as a means of achieving accountability.
- **Societal relevance** is a concept that has been present in research funding for many years, and featured in many case studies and interviews. As a principle, it affects an organisation's aims and how it funds research.

As shown in the Figure below (Figure ES-**1**-**1**), these four principles sit at the core of the organisational design framework. The four analytical themes and the insights which emerged from our analysis (summarised above and in Chapter 3) then sit in the outer rings of the framework. Taken together, these concepts can be used to help guide the design of a research and innovation funding body such as UKRI.

Figure ES-1-1: An integrated set of principles for our analysis. The inner ring consists of four principles with further details provided in the bulleted list above. The outer ring consists of the four main analytical themes of the report and the supporting evidence for each.

Overall, this study integrates the principles which could be considered in the design, structure and governance of research and innovation organisations. It is worth noting that over the course of our study, we found remarkably little literature which analysed research policy from this perspective. Yet, there is a wide body of literature which focuses on how to improve and establish the effectiveness of a research system. We believe this study shows that if we do not consider both the system and the organisational entity which governs the system together, then we risk missing a piece of the puzzle. We hope this report is one step towards addressing this risk.

Acknowledgements

Abbreviations

ARC	Australian Research Council
BEIS	Department for Business, Energy & Industrial Strategy
BHF	British Heart Foundation
BIS	Department for Business, Innovation and Skills
DARPA	The Defense Advanced Research Projects Agency
DFG	The German Research Foundation (Deutsche Forschungsgemeinschaft)
DOD	Department of Defense
DOE	Department of Energy
HEFCE	Higher Education Funding Council for England
HHS	Department of Health and Human Services
IC	Institute and Centre (NIH)
FY	Financial Year
GERD	Gross Domestic Expenditure on Research and Development
NEA	The National Endowment for the Arts
NHMRC	National Health and Medical Research Council
NIH	National Institutes of Health
NIHR	National Institute of Health Research
NRF	The National Research Foundation
NSF	National Science Foundation
NWO	The Netherlands Organisation for Scientific Research
RCN	The Research Council of Norway
REF	Research Excellence Framework
UKRI	UK Research and Innovation

1. Introduction

1.1. Background to the study

An effective system for supporting research and innovation is imperative in achieving high standards of research performance and a base for innovation which can lead to sustainable economic growth. The study of such systems, or the 'science of science', as it is has become known, is predicated on the ability to measure research, with the aim of improving the effectiveness and value for money of research funding.[3] Knowing 'what works' and 'why' will inform decisions about which areas of research to invest in, determining how and who should invest, and identifying the returns.

In response to Sir Paul Nurse's review of the research councils, the Higher Education and Research Bill have set out plans for a new body, UK Research and Innovation (UKRI).[4] This will bring together the seven research councils, Innovate UK, and the research functions currently performed (in England) by the Higher Education Funding Council for England (HEFCE). UKRI will be a Non-Departmental Public Body acting as an overarching research funder.

A key consideration for this new funding body will be the design of its structures and governance, so as to best advance its ultimate objectives. To inform the structure and governance of UKRI, the Department for Business, Innovation and Skills (BIS) commissioned a study to explore and review the international evidence on best practice in organisational design and governance for a research funding body.[5] With a UK context to the analysis, the study covers:

- Evidence relating to good practice in establishing strong and accountable organisations and governance structures.
- Lessons from the strengths and weaknesses of different (international) organisational models for distributing research funding.
- Lessons from the wider public and private sector about the strengths and weaknesses of different governance approaches.

Our analysis and synthesis of the evidence cuts across the three areas identified above, and in particular will focus on understanding strengths and weaknesses within the context of the UK research and innovation sector and the associated regulatory and policy frameworks in which it operates. The research

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[3] Grant & Wooding 2010

[4] UK Government 2016

[5] At the time this study was commissioned, this was the name of the government department. After the change in government in June 2016, the department was renamed to be the Department for Business, Energy and Industrial Strategy (BEIS).

draws on three main bodies of evidence: academic and grey literature; case studies of international research and innovation funding models; and interviews with national and international leaders with expertise in the areas of research and innovation funding and corporate governance. This report unpacks the synergies between different bodies of evidence and provides an analytical framework for understanding how this evidence can be used to inform the design and governance arrangements within UKRI.

1.2. The current research and innovation context in the UK

Research and development in the UK is funded by the government, by companies, and by charitable organisations.[6] Within the government, research funding is provided by various ministries, for example the Department of Health, the Ministry of Defence, and the Department for Business, Energy and Industrial Strategy (BEIS)[7], as well as bodies within these ministries including the UK's seven research councils[8] and the higher education funding councils for each of the devolved regions.[9] Such funded research is carried out mainly in universities and research institutes. Other funders of research are government departments, local authorities and other public agencies.[10] Government also plays a role supporting innovation in private companies, through initiatives such as technology transfer mechanisms, public-private partnerships, research and development tax credits, and other public policy initiatives.[11]

The organisation of UK government research funding relies on a dual support system, comprising two research funding streams. The first stream, known as formula-based quality-related research funding, flows through UK funding bodies[12] and is based on peer review and research quality assessment of retrospective performance. The most recent example is the Research Excellence Framework (REF) 2014.[13,14] The second stream of funding relates to project funding, which flows through the seven councils which, together, comprise the UK research councils. It is forward-looking and based on peer-reviewed grant applications.[15] The two streams are interconnected and interdependent.

1.3. Methodology

There were three main data collection tasks to the study. The first task involved a detailed review of organisational design and funding models of different research and innovation funding bodies in a

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[6] Nurse 2015

[7] At the time this study was commissioned, this was the Department for Business, Innovation and Skills (BIS).

[8] The seven research councils are the: Arts and Humanities Research Council (AHRC); Biotechnology and Biological Sciences Research Council (BBSRC); Engineering and Physical Sciences Research Council (EPSRC); Economic and Social Research Council (ESRC); Medical Research Council (MRC); Natural Environment Research Council (NERC); and Science and Technology Facilities Council (STFC).

[9] Krapels. et al. *forthcoming*

[10] Nurse 2015

[11] ibid.

[12] Under funding bodies we list: Higher Education Funding Council for England (HEFCE), Higher Education Funding Council for Wales (HEFCW) and the Scottish Funding Council (SFC) and for the Department for Employment and Learning (DEL).

[13] POST 1997

[14] BIS 2015b

[15] BIS 2013

selection of case study countries. The second task focused on gathering and synthesising evidence from a literature review of available academic and grey literature on different aspects of organisational design and corporate governance. In the third task we conducted a series of interviews with a selection of experts who either worked in large and complex research-based organisations and/or research and innovation funding bodies, or academics who studied the field. The purpose of the interviews was to gather evidence that would not necessarily be present in the wider literature, to test ideas and hypotheses from the synthesis of the literature, and to identify additional literature we may not have come across in our searches. While all three tasks proceeded in parallel, the first two commenced before the interviews in order to give us time to understand some of the themes from the case studies and literature so we could explore them further in the interviews.

Together, the three tasks allowed us to identify strengths and weaknesses of different models and associated organisational design principles. Individual methods for each phase are summarised in turn and, where appropriate, reference is given to Annexes for further detail.

1.3.1. Case studies

The case studies provided an overview of the research funding systems, and funding bodies within them, in a selection of countries. In consultation with BEIS, we initially focused on six countries: the UK, the USA, South Korea, Germany, the Netherlands and Australia. These countries were selected because they either: had funding systems of a similar size and scale to the UK; had recently undergone a transition or organisational change within their system; were supporting similarly high quality research and innovation systems; or represented a different organisational approach from the UK. Once the countries were selected, we then focused on a representative group of funding agencies per country. In this we sought to not only represent major public research funding organisations within each country (e.g. the National Institutes of Health (NIH) and the National Science Foundation (NSF) for the United States), but also to provide a cross-section of different disciplines and funding models, for example those from the third sector. Finally, through our desk research we found the case of the Research Council of Norway (RCN) to be particularly important for the current study due to the fact they underwent reorganisation several years ago and there was a readily available set of evaluations of that process for us to review.[16] Table 1-1 below provides a summary of the organisations within each country which were selected for review.

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[16] Arnold & Mahieu 2012

Table 1-1: Summary of research funding organisations by country

Country	Research funding organisation (names in bold indicate an interview was conducted with this organisation)
UK	**British Heart Foundation (BHF)**
	Cancer Research UK
	Arthritis UK
	Wellcome Trust
	Leverhulme Trust
	National Institute of Health Research (NIHR)
USA	**National Institutes of Health (NIH)**
	National Science Foundation (NSF)
	Bill and Melinda Gates Foundation
	The National Endowment for the Arts
	The Defense Advanced Research Projects Agency (DARPA)
	Carnegie Corporation
	National Nanotech Initiative
Australia	**Australian Research Council (ARC)**
	National Health and Medical Research Council
South Korea	**The National Research Foundation (NRF)**
	Korea Institute for Advancement of Technology
	Korea Institute of Energy Technology Evaluation and Planning
	Korea Institute of Industrial Technology
The Netherlands	**The Netherlands Organisation for Scientific Research (NWO)**
Germany	**The German Research Foundation (DFG)**
Norway	**The Research Council of Norway (RCN)**

Once these organisations were selected, we conducted a rapid evidence review to identify the following key descriptive features: the different types of research funding organisations and organisational models; the defining characteristics of different funding organisations and models; the main ways they deliver their objectives; how decisions about funding are made; and any available evidence for the effectiveness of the organisational model relative to organisational success (success being measured by various indicators of

research productivity). In addition, for the organisations highlighted in bold, we also conducted interviews with one or more representatives of the senior leadership.

1.3.2. Literature review

We conducted a large and extensive literature review through three different pathways. First, we conducted a systematic literature review to identify empirical evidence about how different research funding models and corporate governance principles related to improved performance (of either an organisation or a research system). The guiding research questions for each area of literature were:

- Research funding systems: *what empirical evidence is there about different research funding models and their relationship to different measures of 'successful' research in the research system?*
- Corporate governance: *what empirical evidence is there about different characteristics or principles of research-oriented organisations which can be linked to different measures of 'successful' research or organisational performance?*

For each question, our focus was to identify *empirical* evidence which linked our research question to different outcome measures of 'success'. 'Success', in this context, is not necessarily a straightforward concept to unpack and there are many different metrics and measures one could look to.[17] For example, one could look at publications as a measure of productivity in a research system, patents, GDP, number of researchers trained, etc. It was outside the scope of this study to determine an appropriate measure of success for the research system, and in any case this could risk limiting the study too much. Therefore, we initially focused on any measure of success as defined within the scope of the study being considered in the review.

Two systematic reviews were conducted simultaneously to explore each component of our research questions. The search strategy for each is detailed in Annex 1. Retrieved papers were screened and a master database of the literature searches was constructed by amalgamation of all the citations from various databases and sources. The citations were scrutinised by two reviewers for inclusion. Disagreements were resolved by consensus and/or arbitration involving a third, more senior reviewer. From this a full set of included studies was produced. Figure ES-**1-1**Figure 1-1 presents the number of papers at each stage of the systematic review.

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[17] Krapels et al. *forthcoming*

	Research funding	Corporate governance
Records identified through database searching	1658	1314
Number of records screened	180	113
Full text articles assessed for eligibility	18	25
Data extraction	14	15
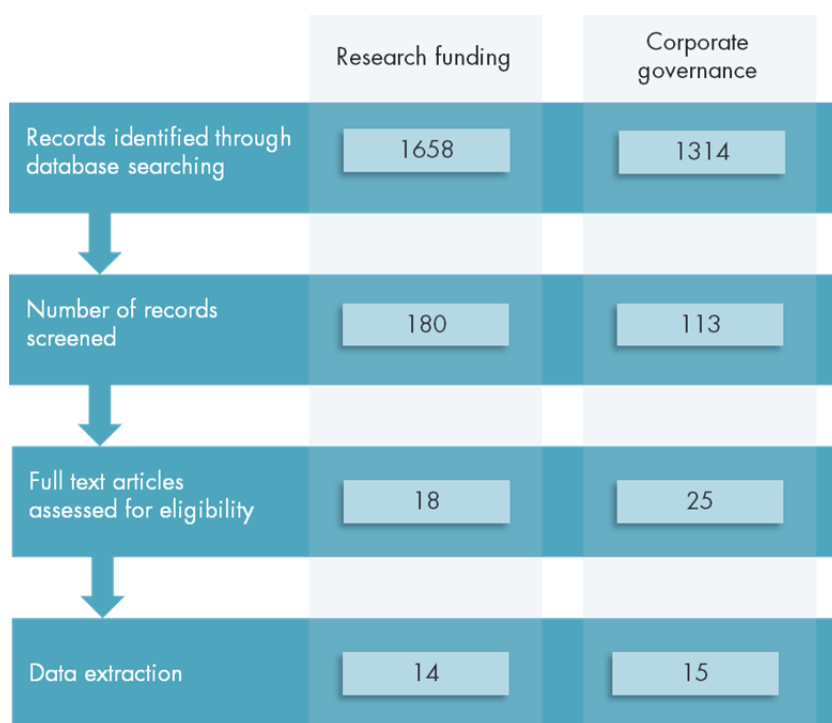
Figure 1-1 Systematic searches flow diagram showing the number of papers identified during the four steps of the literature search for research funding systems and corporate governance

As we found only a small number of papers of real interest for the study which provided empirical evidence, we conducted a series of targeted searches on several themes. These themes were chosen in discussion with the client based on twelve leading academic journals.[18] They included autonomy, strategic decision making, accountability, coordination models, organisational structure (incl. 'hub and spoke') in research funding or public organisations (targeted search 1). The search strategy was then enlarged to include searches about organisational design within large and complex organisations, including in R&D-intensive firms (targeted search 2). This brought a large number of results. Figure 1-2 below summarises the review process and the number of papers at each stage.

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[18] We identified these journals through a team discussion and consultation with some of the academics in our study and our senior QA reviewer. The journals were: *Academy of Management Review, Academy of Management Journal, Journal of Management, Journal of Management Studies, American Political Science Review, Strategic Management Journal, Administrative Science Quarterly, American Journal of Political Science, British Journal of Management, Harvard Business Review, Research Policy, MIT Sloan Management Review*.

	Targeted search 1	Targeted search 2	Additional searches
Records identified through database searching	798	976	206
Number of records screened	77	43	22
Data extraction	12	5	13

Figure 1-2 Targeted searches flow diagram showing the number of papers identified during the three steps of two targeted searches and additional literature searches

Finally, some literature was brought to our attention through 'snowballing' searches where relevant literature was identified from those papers which we had found in our searches and were useful for the study. This included some literature about network governance, innovation, collaboration models or R&D portfolio management, books and reports about organisational design and funding models, and some grey literature.

Quality assessment was then performed on the selected studies in order to ensure all papers were of sufficient quality as appropriate to the study design. An Excel spreadsheet was then used to record relevant data from each paper, to provide an overview of existing insight from the literature and to assign relevant analytical categories for synthesis of the findings. Figure 1-3 represents the countries covered by the selected studies. Studies included a variety of methodologies, interventions and outcomes, which did not allow the team to perform a meta-analysis.
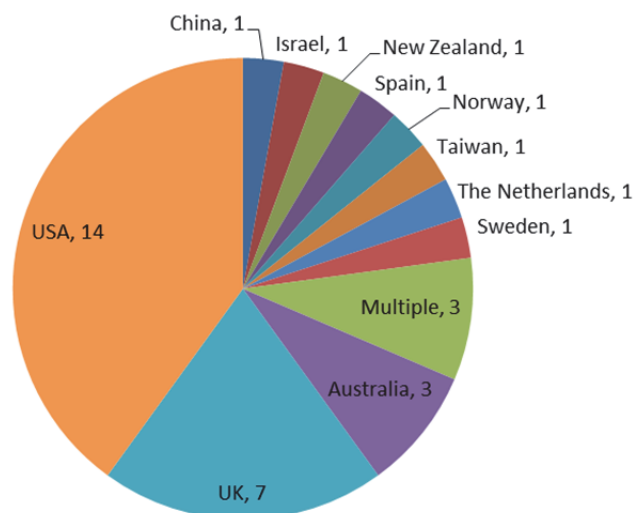
Figure 1-3 Pie chart showing countries represented in the literature review with the number of papers for each. It consists of 12 wedges: China, Israel, New Zealand, Spain, Norway, Taiwan, The Netherlands and Sweden-all 1, Multiple-3, Australia-3, UK-7, USA-14.

1.3.3. Interviews

Thirty-two interviews with 27 individuals were conducted for this study.[19] Interviewees were selected with the aim of obtaining representation from multiple countries and across disciplines and types of expertise – including individuals who study governance, research and innovation policy,[20] as well as those who have professional experience from working in these areas. Specifically, interviewees either had leadership roles in funding bodies (15 interviewees), experience in government (4 interviewees), or significant expertise in research and innovation activities (8 interviewees).[21] Furthermore, an effort was made to include individuals who work in systems that have or are currently undergoing significant structural changes and a number of the interviews were part of the case studies described below. Interviewee codes are presented by group in Table 1-2. The interviews were carried out from 19 May to 5 August 2016. Most were telephone interviews, but three were face-to-face and one was by email. Interviews lasted 35–70 minutes, with most around 50–60 minutes.

Two researchers analysed the interviews, with each leading the identification of emerging themes related to two broad areas and then reviewing and revising the analysis from two other broad areas. The four areas covered were strategy, collaboration and interaction, organisational design, and the role of people.

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[19] As the table below shows, interviews were conducted with 27 individuals, but five interviewees were followed up with for a more detailed discussion about their organisations strategy, horizon scanning, interdisciplinary funding practices and portfolio management approach. In some cases, two individuals were present for the interview. These are still counted as one interview.

[20] Three interviewees had specific expertise in innovation.

[21] Where interviewees currently or previously held roles covering different categories, they were assigned to the one category which had brought experience that seemed most relevant to what was discussed during the interview.

Table 1-2 Interviewees by category

Category (number of interviewees)	Interviewee codes
Research and innovation funding bodies (14)	Int 01, Int 02, Int 03, Int 05, Int 06, Int 07, Int 10, Int 11, Int 14, Int 17, Int 18, Int 19, Int 21, Int 23, Int 27
Government (4)	Int 04, Int 15, Int 20, Int 25
Active in research into governance and/or research and innovation policy, or in innovation (9)	Int 08, Int 09, Int 12, Int 13, Int 16, Int 22, Int 24, Int 26
Public research and innovation funding bodies (11)	Int 02, Int 03, Int 05, Int 06, Int 10, Int 11, Int 17, Int 18, Int 19, Int 21, Int 23, Int 27
Private and third sector research and innovation funding bodies (3)	Int 01, Int 07, Int 14
Government (4)	Int 04, Int 15, Int 20, Int 25
Active in research into governance and/or research and innovation policy, or in innovation (9)	Int 08, Int 09, Int 12, Int 13, Int 16, Int 22, Int 24, Int 26

Overall, interviewees represented seven countries; just over half were based in the UK (Figure 1-4).
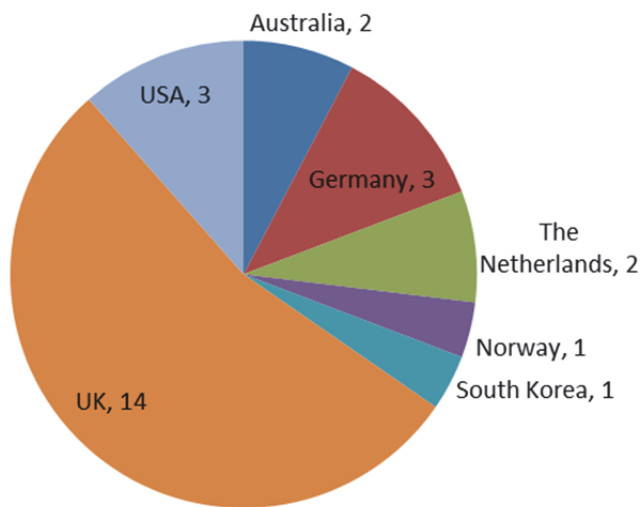
Figure 1-4 Pie chart showing countries represented by interviewees and the number of interviewees for each country. It consists of seven wedges: USA-3, Australia-2, Germany-3, The Netherlands-2, Norway-1, South Korea-1, UK-14.

1.4. Summary of report

This report presents our integrated synthesis of the evidence collected and our analysis of it in a way which matches the aims of the study. In Chapter 2 we provide a summary of the evidence from which we

conducted our analysis.[22] Chapter 3 then provides the main insights from our analysis and Chapter 4 summarises our conclusions. We focus primarily in Chapters 3 and 4 where we draw the evidence together which can be used both to understand the evidence synthesised to date, and to inform in a dynamic fashion the different components of UKRI for the future.

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[22] There is an Addendum containing detailed case studies and a summary of the literature, which contain the main material from which this analysis was drawn. This Addendum may be made available from the researchers on request.

2. Summary of the evidence base

2.1. Introduction

The evidence base for this study includes three interconnected components: a wide-ranging and targeted search of the literature, including grey literature; interviews with 27 leading academics and representatives of research and innovation funding bodies and companies in the UK and internationally; and descriptive case study reviews of a selection of research funding agencies in each country. Each component sought to answer a different element of the overarching research questions. The literature review aimed to help us identify not only best practice in research funding within the UK and other countries, but also across other sectors, including the third sector and industry. This enabled us to understand, and provide insight into, how elements of organisational design and corporate governance in complex organisations can lead to the achievement of successful outcomes. The interviews enabled us to grasp the nuances and facets of organisational design and strategy which are 'unwritten' and descriptive in nature. By understanding the perspectives of those who work within and have been a core part of building and designing research funding organisations for many years, we were able to gain unique insights. Finally, the case studies complemented both the literature search and the interviews by providing a clear descriptive grounding of the many different design features and organisational approaches that are used in different countries around the world.

While the insights from across the entire evidence base are integrated into the whole report, we provide in this chapter an overview of the main points from each source of evidence. We start with a summary of the case studies, and then move to an overview of the literature and interviews.

2.2. Introduction to the case studies

These case studies provide a short overview of the research funding system and a selection of research funding organisations in six countries. For each country and set of organisations we sought information on the core questions below, aiming to capture those outside the government funding system to see if there were any approaches to governance and organisational design which stood out.

- What are the different types of research funding organisations and models in the UK and comparable countries?
- What are the defining characteristics of different funding organisations and models? How are they organised?
- How do different research funding organisations deliver their objectives?

- How are strategies formulated and what is the content of that strategy?[23]
- How are decisions about funding made in different research funding organisations?
- What underlying theories have been proposed for their effect/s?

Though we identified information on all these for many of the organisations, we found very little evidence for the final question about the theories for different levels of organisational effectiveness, nor was there any systematic or readily available evidence evaluating the effectiveness of different funding organisations and linking that to any features of organisational design. This is comparable to other studies we have done of a similar nature[24], but is still worth highlighting as it seems to be an important and notable gap in the literature.[25] In the following sections we provide a short summary of each funding system at the country level and a table summarising the organisations within each country.

2.2.1. United Kingdom

Overview of the UK's research funding system

Research and science in the UK have historically been financed by considerable contributions from both industry and government. In the last 10 years, gross domestic expenditure on R&D (GERD) as a percentage of GDP has been around 1.7 per cent, out of which business-funded R&D covered approximately two thirds of overall R&D spend and government-funded R&D ranged between 0.47 per cent and 0.57 per cent of GDP.

Public investment in research is the primary responsibility of the Minister of State for Universities, Science, Research and Innovation with the Department for Business, Energy & Industrial Strategy (BEIS) being the governmental department responsible for science and research policy and funding. In the 2016–17 science and research budget, the UK has committed to public investment of £5.9bn in research. However, there are other departments with responsibilities for research policy and funding, including the Departments of Health; Environment, Food and Rural Affairs; International Development; Transport; the Home Office; and the Ministry of Defence.

BEIS delivers public science and research funding through a 'dual support system', (historically) consisting of the research councils and the devolved higher education funding bodies, including HEFCE and its equivalents in Scotland, Wales, and Northern Ireland. While the research councils provide competitive project funding to institutions for projects, programmes, fellowships and studentships on the basis of prospective applications, HEFCE and its equivalents in Scotland, Wales and Northern Ireland provide block grants to institutions on the basis of past performance which is invested by higher education institutions at their own discretion to maintain their research capacity.

Through the science and research budget, the UK also supports other research organisations, including the UK Space Agency (£225m in 2016–17), National Physical Laboratory and the UK Atomic Energy Authority. The UK has also four independent National Academies, the Royal Society, the British

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[23] This was a specific request by BEIS late in the study, so a review of strategy was only done for a selection of organisations. A detailed review or organisational strategies is provided in Section 3.2.

[24] See, for example, Pollitt et al. 2016.

[25] A full write-up of each case study is provided in a separate case study Addendum.

Academy, the Royal Academy of Engineering and the Academy of Medical Sciences, which aim to provide leadership and promote excellence across their fields of UK research. They receive BEIS-sponsored grant funding for key programmes that help deliver government priorities. Collectively, they will be allocated £98m in research funding in 2016–17.

Aside from research funding through the science and research budget, the UK government funds and supports research through other governmental departments, their specialist governmental research agencies, such as the Department of Health supported National Institute for Health Research (NIHR) or the Ministry of Defence's Defence Science and Technology Laboratory (Dstl), and networks of specialist public sector research establishments, such as the Met Office and the Health and Safety Laboratory.

In the UK, there are also significant non-profit research funders, particularly in the biomedical sector. The most significant large non-profit research funders are the Wellcome Trust and Cancer Research UK, which invest around £900m and £400m a year respectively in research-related activities. There are other smaller, yet significant research funders, including the Nuffield Foundation, the Leverhulme Trust, and a considerable number of other research charities.

Aside from the research councils and HEFCE, BEIS also provides R&D funding to businesses through Innovate UK (formerly known as the Technology Strategy Board), the governmental innovation agency responsible for supporting business-led technological research and innovation. Innovate UK is the government's innovation agency promoting and investing in business-led innovation across the UK, particularly to small and medium businesses, through four broad sector groups (and an open programme). With a budget of around £561m for 2016–17, Innovate UK provides competitive R&D funding through two competitions in each sector group. In addition Innovate UK supports the national network of Catapult Centres to strengthen the way it connects business with knowledge, partners and opportunities.

Summary of a selection of UK funding organisations

The National Institute for Health Research (NIHR) was established in April 2006 and is funded through the UK Department of Health. NIHR's vision is to improve the health and wealth of the nation through research, and their mission is to provide 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. It acts in effect as the research arm of the NHS, conducting research in and for the NHS and its patients. NIHR's total annual spend is in the region of £1bn. In 2014–15, it spent a total of £1,034m across four strands (Infrastructure, Faculty, Research, Systems), with a total of £237.6m spent on research,[26] with the largest programme being the Health Technology Assessment programme, which received funding of £74.2m.

The Wellcome Trust is an independent, charitable UK research funder dedicated to improving health. The Trust was established on the basis of Henry Wellcome's will of 1936 and endowment to be used to 'advance human health'. The research income comes from a £18.3bn investment portfolio (as of FY2015), allowing the organisation to set out longer-term objectives, while having the independence to act flexibly and responsively. The core governance mechanisms are the Trustee's directors (known as

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[26] NIHR 2015

Governors), the Company Secretary of the Trustee, and the Executive Board. The Board of Governors comprises experts in the fields of medicine, science, business and policy who are 'independent in character and judgement and that there are no relationships or circumstances that are likely to affect, or could appear to affect, the Governors' judgement'.[27] Funding decisions are made with the help of external experts across Wellcome's funding remit. External experts provide the Trust with written peer reviews and act as members of numerous advisory committees across key areas of research funding support.

Cancer Research UK is the UK's largest charitable funder of cancer research. The charity support research into all types of cancer, from understanding the biology and causes of cancer to investigating how to prevent, diagnose and treat the disease. Cancer Research UK invested £393m in cancer research through in-house research institutes and research grants to external scientists (including universities and hospitals). Recent total spend of research has increased from £325m in 2011 to £393m in 2015. The majority of Cancer Research UK's investments in research go to supporting five institutes across the UK. Its research strategy is driven by three core principles of:

- *People*, supporting the best scientists and giving them autonomy and flexibility to tackle important research questions.
- *Partnership*, developing effective partnerships across sectors to accelerate research progress, influence policy and inform the public.
- *Collaboration*, investing in long-term infrastructure and capacity building to support integration and strong networks across the research base.

Arthritis Research UK supports research into the cause, treatment and cure of arthritis and musculoskeletal diseases. The charity supports both investigator-led research and specifically targeted research to key areas of strategic interests. In 2014–15, the charity invested £23m into research activities. The research encompasses a broad range of research areas, including molecular and cellular biology, immunology and inflammation research, pain, biomechanics and bioengineering, preventative medicine, orthopaedics, genetics and epidemiology and regenerative medicine. The research also has a focus on the translational opportunities and supports experimental medicine and clinical trials.

The British Heart Foundation (**BHF**) is the UK's largest independent charity funding that funds cardiovascular research. The charity has operated since 1961 and is dedicated to research, but also to prevention and campaigning activities. The BHF invested over £81m in cardiovascular research in 2014–15.

The Leverhulme Trust is one of the largest philanthropic research funders in the UK. In 2015, the Trust distributed approximately £110m on supporting research through funding research centres (36%) and individual research project grants (29%), as well as providing research fellowships (16%), and other activities and prizes. The research is provided via the responsive mode of funding, i.e. the choice of topic and research design is left with applicants. The Trust does not have strategic priorities for research; its goal is to fund curiosity-driven research with demonstrable quality, significance, and originality.

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[27] Wellcome Trust 2015a

2.2.2. United States

Overview of the US research funding system

The USA has considerable R&D spending compared to other OECD countries, spending $136bn on R&D in FY2014, with the budget expected to rise to $145bn on R&D in FY2016. The US research system relies primarily on an R&D-intensive business sector (2.04 per cent of GDP in 2012) which accounts for 70 per cent of total gross domestic expenditure on R&D (GERD).[28] The public research funding system in the USA is not under the responsibility of a specific government body; there are many bodies which fund research across a range of areas, as well as a range of intermediate research funding organisations providing funding to other organisations.[29] Most publicly funded research is conducted in universities, although some government agencies perform research themselves. This includes, most notably, the National Institutes of Health (NIH), which both funds and conducts research, as well as several federal departments, including the Department of Defense, the Department of Energy, the Environment Agency, the Food and Drug Administration, the Department of Health and Human Services (HHS), the Center for Disease Control, and the Department of Veteran's Affairs, many of which also have networks of laboratories.[30] The other major national funder of research is the National Science Foundation (NSF), however it has no research institutions of its own.[31]

The US research system is mainly administered at the federal level, although many states also support research through various commissioning mechanisms. Approximately 30 agencies receive research budgets, with the top five being (in terms of the 2015 Federal Science & Technology budget listing):[32]

1. The Department of Defense (DOD): $64.4bn budget for FY2015
2. The National Institutes of Health (NIH): $29.5bn budget for FY2015
3. The Department of Energy (DOE): $12.2bn budget for FY2015, including USD 4.7bn for its science programmes.
4. National Aeronautics and Space Administration (NASA), $11.5bn budget for FY 2015.
5. The National Science Foundation (NSF): $5.6bn budget for FY2015.

In addition, major foundations also provide significant funds for research institutions.[33] Some of the long established ones include the Carnegie Foundation, the Hewlett Foundation, the Rockefeller Foundation and the Bill and Melinda Gates Foundation.[34]

Summary of a selection of US funding organisations

The National Science Foundation is an example of a public agency supporting all fields of fundamental science and engineering, except for biomedical sciences (as this is covered by the NIH). The NSF provides

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[28] OECD 2012

[29] Steering and Funding of Research Institutions N.d.

[30] ibid.

[31] ibid.

[32] R&D in the 2015 Budget (revised).

[33] Steering and Funding of Research Institutions N.d.

[34] ibid.

grants to higher education institutions, businesses and research organisations in the USA. It notably provides one quarter (24 per cent) of federal funds for basic research in higher education. The majority of grants go to individuals or small groups of investigators. The organisation is divided into seven discipline-based directorates.[35] Each of these is headed by an Assistant Director who is a specialist in each particular field and reports directly to the NSF Director. Overall, the NSF has a decentralised structure, with each directorate being responsible for their individual funding decisions, despite being tied up to strategic orientations and decisions being taken by the leadership entities (i.e. the Office of the Director and the National Science Board). Each division within a directorate is responsible for managing a portfolio of grants and proposal competitions within a broad area of research and education.

The National Institutes of Health represents the largest source of funding for medical research in the world and is the most important source of funding for biomedical research from the federal government. The organisation supports both disease-related and basic research projects with over half of their funding awarded regardless of applicability to a specific disease. The NIH is both a funder and provider of research; its intramural and extramural research programmes provide funding in accordance with scientific merit and strategic priorities. The NIH is comprised of 27 institutes and centres (ICs), which are diverse in terms of mission, scope of activity and size, but similar in their organisational structure and the way they fund research. While there is an overall NIH director, each IC also has its own agenda and director, each of whom are appointed by the Secretary of the DHHS. Additionally, each IC has an Advisory Council tasked with advising the IC director on policies and priorities. All but three of the institutes receive their funding directly from Congress, and administer their own budgets.[36]

The NIH Director, with support from the six NIH Deputy Directors, provides central leadership to individual ICs, as well as across the organisation. The director is advised by the Council of Councils, which is made up of representatives from the IC Advisory Councils, lay representatives and others, and through discussion with the federal government's Department of HHS and Congress. The Director, in turn, advises the President on research priorities and strategic direction through the annual NIH budget request to Congress.[37] The Director, with a unique NIH-wide perspective, guides the agency's overall activities and outlook. The Office of the Director is responsible for setting policy for NIH and for planning, managing, and coordinating the programs and activities of all the NIH components.

The Bill and Melinda Gates Foundation provides competitive grant funding to various research actors, including private companies, governments, non-profits, faith-based groups, and academic institutions to undertake research in the fields of: clinical medicine; public health; health services and primary care; biological sciences; agriculture, veterinary and food science; anthropology and development studies; education; and social work and social policy. The Gates Foundation decides upon its research areas and strategic priorities through internal and some external consultation with researchers and policy makers. The foundation has adopted a specific focus on providing incentives to private companies to undertake actions achieving a social impact. The foundation usually invites proposals by directly contacting

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[35] These include: Biological Sciences; Computer and Information Science and Engineering; Engineering; Geosciences; Mathematical and Physical Sciences; Social, Behavioural and Economic Sciences and Education and Human Resources.

[36] NIH 2017b

[37] NIH 2017a

organisations, but occasionally grants funding through published requests for proposals or letters of inquiry. They notably provide grants through 'Grand Challenges', a family of initiatives fostering innovation to solve key global health and development problems. The decision making process for awarding these grants involves internal and external reviewers. The final decision is taken by a member of the Foundation's executive board.

The Carnegie Corporation of New York aims 'to strive for international peace and the advancement of education and knowledge' and 'to promote the advancement and diffusion of knowledge and understanding'. The foundation is governed by a Board of Trustees responsible for defining the strategy for the grant making programmes. The board is composed of 21 trustees including the President of Carnegie and various representatives of universities, and two honorary trustees. The foundation currently supports four key programme areas: Education, Democracy, International Peace and Security, and Higher Education and Research in Africa. Those strategic orientations revolve around the two aims stated above, which were defined by the founder of the corporation, the steel manufacturer and philanthropist, Andrew Carnegie.

The National Endowment for the Arts (NEA) is an independent federal agency, which aims 'to strengthen the creative capacity of [American] communities by providing all Americans with diverse opportunities for arts participation'. The foundation relies on principles of transparency and openness as part of the 'Open Government' strategy. The agency has established a strategy to interact with the field in an in-depth way, and provides research grants to non-profit organisations and individuals through its Research Art works programme. The NEA Office of Research and Analysis is responsible for awarding grants for research on the value and impact of the arts in the United States. Despite its small size the agency is rather decentralised with 14 field directors overseeing the grant making decisions in their respective fields. Additionally, the National Council on the Arts provides advice to the organisation and its chairman.

The Defense Advanced Research Projects Agency (DARPA) is a federal agency created in 1957 in response to the Soviet launch of Sputnik. Its main purpose is 'to make the pivotal early technology investments that create or prevent strategic surprise for US national security.' DARPA is under the responsibility of the US Department of Defense's assistant secretary of Defense for Research and Engineering. DARPA is well renowned for its support to radical transformational technologies. DARPA supports an approach 'to fostering and implementing radically new technology concepts recognised as transformational', characterised by 'high-risk, high-payoff' research programmes. DARPA does not own any research facilities on its own but rather contracts research to other organisations. Furthermore, the organisation does not have any 'entitled constituencies' and funds research either in academia, industry or national research institutions. DARPA has developed a bottom-up approach to create their portfolio of programmes. Research programmes are developed entirely by DARPA's programme managers, who engage intensively with military leaders and with the research community to identify technological areas. Proposals are evaluated by the programme managers supported by the Source Selection Board composed of government experts following a rigorous approval process. The agency has developed a set of questions called the 'Heilmeier Catechism' to help the officials determine which risks are worth taking and evaluate proposed research proposals. The Heilmeier Catechism guides the programme manager in thinking

through the programme goals and objectives. Answers validate the impact and technical feasibility of the programme, and help to identify the hard challenges the programme will address:

1. What are you trying to do? Articulate your objectives using absolutely no jargon.
2. How is it done today, and what are the limits of current practice?
3. What's new in your approach and why do you think it will be successful?
4. Who cares?
5. If you're successful, what difference will it make?
6. What are the risks and the payoffs?
7. How much will it cost?
8. How long will it take?
9. What are the midterm and final 'exams' to check for success?[38]

DARPA's budget accounts for one quarter of the DoD's science and technology budget (approximately $3bn annually). DARPA's specific strategic orientation to support unconventional high-risk research translates into various organisational practices, including a relatively small size, a flat, non-bureaucratic structure, a focus on potentially change-state technologies and highly flexible and adaptive research programme.

2.2.3. Australia

Overview of Australia's research funding system

Australia relies on a 'dual funding' model for research funding which is aimed at satisfying the principles of selectivity and concentration leading to a concentrated amount of selected projects receiving research funding. As with the UK, the first stream of funding relies on a performance-based funding system to allocate block grants based on quality assessment. Research block grants are provided through the Department of Innovation, Industry and Science. The second stream of funding relies on the allocation of competitive research grants provided by the main research councils: the Australian Research Council (ARC) and the National Health and Medical Research Council (NHMRC).

Summary of a selection of Australian funding organisations

The Australian Research Council (ARC) is the main public funding organisation in Australia. The ARC is responsible for funding research and research training, evaluating the quality of research and providing policy advice on research matters.[39] The ARC provides funding for basic and applied research in the fields of Agriculture and Food Science, Earth Systems and Environmental Sciences, Geography, Environmental Studies and Transport, Cybersecurity, Energy, Resources, Advanced manufacturing and Health. The Council supports research projects through the National Competitive Grants Programme. The programme supports individual research projects through two streams (ARC Discovery Programme and ARC Linkage Programme), which provides funding for basic and applied research, research training, research collaboration and infrastructure.

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[38] DARPA N.d.

[39] ARC 2015.

The National Health and Medical Research Council (NHMRC) is the Australian government's main funding body for clinical and medical research, having provided just over AUS\$8.8bn (£5.2bn) between 2000 and 2015.[40] Among its primary responsibilities, NHMRC manages research support and funding through a variety of mechanisms, including grants for individuals, specific research projects and broad programmes of research. NHMRC also provides advice to the Australian government on health and medical research, ethical practice in healthcare and in research and is responsible for developing evidence-based health advice.

2.2.4. South Korea

Overview of South Korea's research funding system

The South Korean research funding system consists of multiple ministries and public agencies as depicted in below.[41] Seventy per cent of public research funds in South Korea are awarded to specific projects through competitive grants.[42]

The Korea Institute of S&T Evaluation and Planning is involved in the evaluation of overall national R&D programmes. However, the Institute does not evaluate individual R&D projects. It is in charge of establishing standards for ministries' evaluation of their own R&D programmes, and monitoring the quality of the evaluations conducted by the ministries.[43] Within the Ministry of Science, ICT and Future Planning (MSIP), the research funding is overseen by the National Research Foundation (NRF). MSIP is responsible for basic science research, while NRF oversees industrial technology research. Both councils evaluate and manage the Government Research Institutes under their responsibility, perform annual evaluations aimed at assessing managerial performance and undertake three-year evaluations of research performance.[44]

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[40] NHMRC 2017

[41] OECD 2014.

[42] Rabesandratana 2014

[43] OECD 2014.

[44] OECD 2014.

Summary of a selection of South Korea's funding organisations

The National Research Foundation (NRF) provides funding for basic science R&D projects as well as for operating academic research organisations. The NRF's main objectives are: to improve research quality; to maximise the utilisation and dissemination of research results; and to establish the world's leading research support system.[45] The NRF plays a key role as advisor in the government's R&D policy making process. The NRF's research programmes are divided between R&D and non-R&D programmes, which received respectively 50.8 per cent and 49.2 per cent of the budget in 2011. R&D programmes are divided between basic research; academic research capacity enhancement; fundamental technology; nuclear energy and safety; big sciences; and international cooperation in science and technology in accordance with governmental priorities.[46] Basic research receives the largest proportion of R&D funding (48.5 per cent of the R&D budget in 2011). The NRF is divided into two field-based directorates and six function-based directorates. The field-based directorates are Basic Research in Science and Engineering, and Humanities and Social Sciences. All directorates are overseen by the Director General who reports to the President. The President, in turn, runs the NRF in conjunction with the Board of directors as well as the Director General.

The Korea Institute for Advancement of Technology is a quasi-government-public organisation under the Ministry of Trade, Industry and Energy. It conducts research and analysis on issues related to industrial technology and innovation, and supports the Ministry in designing the industrial technology policy. The Institute also supports the Ministry in the evaluation of regional R&D projects.

The Korea Institute of Energy Technology Evaluation and Planning is the national funding agency dedicated to innovative energy R&D. The institute's main objective is to help the Korean government to plan and implement effective national R&D programmes that support domestic as well as international researchers, universities, and private companies to bring innovative energy technology to life. The Institute's main functions include: R&D planning; project evaluation & management; international cooperation; and human resource development.

The Korea Evaluation Institute of Industrial Technology is a government-affiliated organisation in charge of the manufacturing sector. It supports the Ministry of Trade, Industry and Energy's industrial R&D project planning, and evaluation and management. It is also in charge of undertaking technology demand surveys and technology forecasting in manufacturing. One of its goals includes supporting researchers' participation in R&D projects as well as technological cooperation between large companies and small and medium businesses.

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[45] OECD 2014

[46] NRF 2017

2.2.5. The Netherlands

Overview of the Netherlands' research funding system

The Netherlands government distributes public money for research funding through different channels. It provides direct institutional funding for universities from the Ministry of Education, Culture and Science and indirect funding based on competitive grants, which flows through various funding bodies, the most important one being the Netherlands Organisation for Scientific Research (NWO). Funding of research also occurs via knowledge institutes at other ministries, for example at the Ministry of Justice and the Ministry of Health, Welfare and Sport, and finally there is a fourth stream of direct funding for policy-oriented research.

These different mechanisms are referred to as funding 'streams'. The Ministry of Education, Culture and Science is the main funder of research activities across all disciplines and infrastructure at universities. It administers the so-called 'first money stream', which is a direct budget for universities' education and research infrastructure without intervention of intermediaries.

The intermediary funding organisations, the NWO and the Netherlands Royal Academy of Arts and Sciences are responsible for the distribution of funds for basic research made available by Ministry of Education, Culture and Science. A large share of this budget is allocated for research at universities. This research funding, called the 'second money stream', is distributed to individual researchers. These grants can be directed by the NWO according to its themes and areas, which are reviewed every four years. It is worth noting, as discussed in the analysis below, that the NWO was undergoing a significant reorganisation at the time of this study and insights from this are captured throughout our report.

The remaining portion of each university's budget (approximately one third) consists of a 'third money stream' – contract research – funded by other public or private sources (e.g. foundations, the European Commission or industry). The proportion of money which comes from each stream varies by discipline. For example, for health-related disciplines, about a third of all funding comes from the first money stream. Medical research also receives a high proportion of funding from the third money stream, primarily from the Ministry of Public Health, Welfare and Sports. This Ministry also funds R&D through contract research at non-profit research institutes, hospitals and other healthcare services. In all, there are around 150 knowledge institutions which are part of the ministries' research network.

Summary of one of The Netherlands' funding organisations

The Netherlands Organisation for Scientific Research (NWO) is the most important provider of research funding in the Netherlands. It focuses on all scientific disciplines and fields of research, apart from biomedical research, and provides competitive grants to universities and research based on peer-review assessment and selection procedures. Another part of this budget is spent on the eight NWO research institutes and on programme funding for research facilities. The NWO has also a dedicated budget to strengthen open science. It is constituted by various divisions and foundations, which organise research funding.

As the main national research organisation contributing to the national science and innovation policy, the NWO takes on several roles; besides acting as a major public funding body, the organisation is also in

charge of research programming; it promotes collaboration in science at various levels, supports Open Science policy and contributes by various means to the national and European science policy.[47] The 2015-2018 strategy published by the NWO states the organisation's objectives and the various funding instruments to achieve them. The strategy follows the Dutch Cabinet's 2025 Science Vision.[48] The strategy is developed around three main areas: encouraging collaboration within the sciences, consolidating scientific strengths for the benefit of societal challenges and supporting the organisation of researchers.

The NWO uses a range of funding instruments to support fundamental and applied public research at universities and research institutes, including large-scale, long-term research programmes focussed on a specific target or theme, collaboration between researchers, individual researchers programmes, large-scale infrastructure, non-programmed research, international collaboration, for knowledge dissemination and open access publication of research results.

2.2.6. Germany

Overview of Germany's research funding system

The research landscape in Germany is characterised by a variety of research funding organisations. The public sector provides one third of R&D spending but industry is the largest funder of R&D. Additionally, a large share of the over 20,000 foundations in Germany provide funding for research.[49]

The federal structure of Germany, divided into 16 Länder, implies differences between the states and the federal government in the way research is funded and organised as they act independently from each other. The federal government and the states support research through (1) institutional funding, (2) direct project funding and (3) 'departmental research'. The last refers to funding received from Germany's federal ministries, which fund 40 federal R&D institutions and German states, and municipalities which also fund departmental level research at over 160 Länder research institutions.[50]

The main non-university research organisations supporting projects of national significance are financed jointly between the federal and the states governments such as the German Research Foundation, which represents Germany's main research funding organisation.[51]

Summary of a selection of Germany's research funding organisations

The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) is a self-governing organisation and the main research funding organisation in Germany. It is constituted in the form of an association under private law. Its members are drawn from German research universities, non-university research institutions, scientific associations and the Academies of Science and the Humanities. It provides financial support for research in higher education and public research institutions, but does not perform

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[47] NWO 2017a

[48] NWO 2017b

[49] Research in Germany 2016a

[50] ibid.

[51] Research in Germany 2016b

any research activity itself. The DFG provides funding in all disciplines of science, engineering and the humanities. It focuses mainly on fundamental rather than applied research.[52] The DFG provides funds only on the basis of research proposals. The foundation adopts a bottom-up approach to research funding, which means that researchers can submit applications without any subject restrictions. The DFG's operational entity, the DFG Head Office, is divided into three departments (Central Administration, Scientific Affairs, Coordinated Programmes and Infrastructure) and six administrative divisions. DFG's departments differ in their nature; Department I (Central Administration) is divided into function-based units (i.e. international affairs, information management, and quality and programme management), whereas Department II is discipline based. Department III administers the coordinated programmes fostering cross-disciplinary research and infrastructure investments and is divided according to the various components of those programmes (i.e. Research Careers; Research Centres; Scientific Instrumentation and Information Technology; Scientific Library services and information systems). The DFG Head Office is supervised by the Executive Board formed by the President and Secretary General.

The Alexander von Humboldt Foundation is funded by the Federal Foreign Office, the Federal Ministry of Education and Research, the Federal Ministry for Economic Cooperation and Development, the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety as well as other national and international partners.[53] The Foundation funds research at multiple universities and non-university research institutions such as the Max Planck Society, Fraunhofer Gesellschaft, Hermann von Helmholtz Association of German Research Centres and the Gottfried Wilhelm Leibniz Scientific Community, known as the Leibniz Association.

2.2.7. Norway

Overview of Norway's research funding system

The Research Council of Norway (RCN) is the main research funding body in Norway. It was created in 1993 by the Norwegian government with the aim of reducing fragmentation and increasing coordination in the research and innovation funding system. It was originally formed by bringing together five research councils and one innovation agency under one single council. The RCN therefore combines the functions of a research council and an innovation agency.[54]

Summary of one of Norway's research funding organisations

The Research Council Norway (RCN) not only provides funding to universities and research institutions but also supports innovation in business. Industry funding is for user-directed R&D projects, which is allocated mainly through research institutes. Since its reorganisation the Council has focused on a small number of large programmes relevant to national priorities and has increased its share of funding spent on

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[52] DFG 2015

[53] Alexander von Humboldt-Stiftung/Foundation N.d.

[54] Norway has two additional agencies supporting innovation: the Industrial Development Corporation of Norway (SIVA) and Innovation Norway. SIVA supports innovation through investment in physical and virtual infrastructure across the country, while Innovation Norway provides mainly loans (as opposed to grants) to support business development and innovation. The division of labour and responsibilities across these organisations is seen to be appropriate and understood (Arnold & Mahieu 2012).

non-programmatic funding schemes. Additionally, its share of competitive research funding has increased from 70 per cent in 2001 to 80 per cent in 2012.[55] The 2011–2012 evaluation of the RCN found that this system has improved the rate and quality of publications from the funded research organisations. The RCN currently manages about a quarter of the state's spending on R&D from sixteen different ministries.[56] However about half of RCN's budget is granted by two ministries: the Ministry of Education and Research (28 per cent of Ministry funding in 2010) and the Ministry of Industry and Trade (23 per cent in 2010).[57]

In terms of its organisation, a restructuring in 2010 created a combination of two priority-focused divisions (for Energy, Resources and Environment; and for Society and Health) and two divisions reflecting RCN's function as a research council and innovation agency (for Science, and for Innovation). However, the organisation remains complex as it responds to the need to coordinate national priorities internally in the absence of a high-level entity in charge of coordinating national research strategy. There are many internal coordination groups and the RCN is governed by three levels of hierarchy: the Director General associated with the Executive Board; the Division Directors supported by Division Boards; and the Programme Boards.

2.2.8. Cross-cutting case study features

Overall it should be noted that there is no 'one size-fits-all' model and that governance arrangements made by the research funding bodies are adapted to their overall strategic goals and missions as well as to the external context within which they fall. Nevertheless, we can draw out some points across the organisations studied with respect to organisational structure, governance and leadership, and the nature of funding provided. Key features of research strategies are covered in Section 3.2.

Organisational structure

Overall it can be observed that large governmental research funding bodies we studied are organised along broadly discipline-specific lines (e.g. the National Science Foundation, the National Institutes of Health, the Netherlands Organisation for Scientific Research, the National Research Foundation), however there are some notable exceptions (e.g. the Australian Research Council, the German Research Foundation and the Defense Advanced Research Projects Agency) which have either been organised along more functional lines (in the case of the Australian Research Council and the German Research Foundation) or cross-cutting areas (the Defense Advanced Research Projects Agency). Smaller independent research funding bodies (e.g. Cancer Research UK, Arthritis Research UK, British Heart Foundation, the Wellcome Trust) also tend to have a function-based organisational structure. The Research Council Norway is different in that it has adopted a matrix configuration. This is due to the fact that it has 16 different ministries which it works across, and so its matrix organisation reflects the need to respond flexibly to different needs.

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[55] Arnold & Mahieu 2012

[56] RCN 2015

[57] Arnold & Mahieu 2012

Governance and leadership

Independent foundations and charities we studied are governed by an independent boards of trustees supported by advisory committees (e.g. Cancer Research UK, Arthritis Research UK, British Heart Foundation, the Leverhulme, Trust, von Humboldt Foundation) with day-to-day management delegated to executive teams. Some of the large research funding bodies we analysed are also governed by a board of trustees associated with an executive team (e.g. the Netherlands Organisation for Scientific Research, the National Science Foundation, the National Research Foundation), Boards in those organisations have an important decision making role in terms of priority settings. Other organisations are governed by a CEO supported by advisory committees (Australian Research Council, the National Health and Medical Research Council). DARPA does not have any governing board. The German Research Foundation also constitutes an exception as it has a complex governance system aimed at including the research community in its decision making process and to provide strong checks and balances. The Research Council of Norway also represents a particular governance structure as it is governed by three levels of hierarchy: the Executive Board in coordination with the Director General the Division Boards and the Programme Boards.

Nature of funding provided

Most of the research funding organisations we analysed provide funding to a wide range of areas (e.g. the National Science Foundation, Australian Research Council, the National Research Foundation, the Netherlands Organisation for Scientific Research, the German Research Foundation, the Research Council of Norway, von Humboldt Foundation), while others have been created with the aim to support a specific area of research (e.g the National Institutes of Health, the National Health and Medical Research Council, the Korea Institute for Advancement of Technology, the Korea Institute of Energy Technology Evaluation and Planning).

Cross-functional collaboration and interdisciplinary research

Most of the organisations we studied have interdisciplinary research integrated into their strategic goals (e.g. Cancer Research UK, Arthritis Research UK, the Leverhulme Trust, the National Institutes of Health, the National Science Foundation, the Australian Research Council, the Research Council Norway, the German Research Foundation). Some of them have built large programmes to support interdisciplinary research (e.g. the National Science Foundation, the National Institutes of Health, the Defense Advanced Research Projects Agency), while others (e.g. the Netherlands Organisation for Scientific Research, the National Science Foundation, National Institutes of Health, the Research Council Norway) have developed internal mechanisms for cross-functional collaborations. The Defense Advanced Research Projects Agency (DARPA) constitutes an example of networked governance.

2.3. Literature

We systematically searched a range of literature as described in the methodology section above and detailed in Annex 1. Out of 4,952 papers initially retrieved in our searches, we screened a total of 435 papers and comprehensively reviewed 59. Due to the extensive and far-reaching topic areas that could be explored, particularly under the corporate governance and organisational design literature, we had

discussions with the client about the core areas in which they would like more information. This resulted in our efforts to focus on identifying literature under the following specific areas: strategic decision making, autonomy, accountability and responsibilities within the organisation, collaboration processes, and organisational structure in research funding or other public organisations, as well as in large and complex organisations and in R&D-intensive companies.

Overall we found it difficult to identify papers with *empirical* findings which linked organisational design to outcomes an organisation might be hoping to achieve (e.g. measures of success). Additionally, because the topics themselves were so broad, it was difficult to identify coherent bodies of literature around each topic unless we drilled down to micro levels of detail. Furthermore, we found very little literature evaluating the impact of different elements of organisational design within research funding organisations. Indeed, the papers we did find recognised this to be a significant gap in the literature.[58]

Despite these challenges, from across this literature we did identify a series of topics which were relevant to the broader question about the features of organisational design and practice which are important to consider. These themes helped to organise and coalesce our findings around the four main insights highlighted in the next chapter: strategy and strategic decision making, supporting collaboration and interdisciplinary research, people and organisational culture, and structure and organisational functions. However, there are two overarching points which should be kept in mind:

- *Organisational design is context-specific.* Above-mentioned themes and organisational elements are context-specific. Organisational design derives from strategy design and planning, which is influenced by both the internal (e.g. organisational culture, leadership interpretation of the environment) and external (e.g. degree of environmental uncertainty and complexity) organisational context as well as by the overarching mission of the organisation.
- *There is a mutual influence of organisational elements on each other.* Designing an organisation should be envisaged in a holistic manner with the elements being carefully balanced and analysed against each other.

The next chapter brings the insights from across the three sources of evidence summarised in this chapter together and draws out four areas of insight relevant to the organisational design and governance of a research funding body.

2.4. Interviews

Interviewees represent three different groups: leadership in funding bodies, experience in government, and academics in the areas of research and innovation activities (see Section 1.3.2). They were asked for their insights (based on their academic or professional work) in multiple aspects of funding body governance: autonomy and flexibility, accountability, strategy and strategic decision making, organisational models, and supporting interdisciplinary research (see protocol in Annex 2). They were also asked for their views on the strength of the existing evidence base in this area (and suggestions of useful sources) and given an opportunity to comment directly on the UK context and proposed changes. The interviews were semi-

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[58] See for example, Colatat 2015.

structured and, in practice, there was wide variation in the content covered because the interviewees had a wide range of backgrounds, and of areas of interest and expertise.

The general message from the interviews was that there is a weak evidence base about governance of public bodies responsible for research and innovation funding. Interviewees involved in the study of governance and/or science and technology policy studies said the literature is limited for multiple reasons, including publication bias (among commissioned evaluations in particular), and big differences in context making it difficult to draw on insights from different countries and sectors. Interviewees involved in running funding initiatives also were unsure what literature may be available and felt there was probably not a strong evidence base. One commented that she made a point of always looking for evidence like this that their funding body might have commissioned so they could draw on what they were funding, but none had ever come up or been brought to her attention.

In addition to this, the following general themes emerged from the interviews:

- *There is a need for a bottom-up approach to research funding systems.* Achieving this involves building trust, open communication and showing that inputs provided are valued and taken into account.

- *People and culture are often more important than an organisation's structure.* While there are many ways to design a funding organisation, what matters is that the design matches the country context and is accepted by the community it serves.

- *Organisational change takes time.* Initiatives to introduce change should include a detailed planning phase, which should be given adequate time to be well thought through, and then implementation follows from that and can take several years to bed down.

- *Research and innovation itself also takes time and requires a long-term funding perspective.* These include the development of research capacity in multidisciplinary areas, and the emergence of impacts from research and innovation investment.

- *Autonomy from government is a multi-faceted concept and thought about in many ways.* Overall, there were at least two aspects to autonomy which emerged: process (e.g. how decisions are made about which grants to award) and content (e.g. selection of priority areas to create calls for proposals). Both elements of autonomy should be respected in a funding organisation.

- *Respect disciplinary differences.* As the system becomes more centralised, it is important to respect disciplinary differences and maintain some disciplinary autonomy.

- *Avoid internal competition.* Different divisions (e.g. representing different disciplines) will tend to work better together if they do not feel they are competing for resources.

- *Avoid political interference as it undermines the system.* Political interference (where decisions are taken that are not in line with what the sector feels makes sense) is seen as often having the potential to undermine research and innovation funding efforts.

These themes are integrated into our final synthesis in Chapter 3.

3. Insights from an integrated evidence base

3.1. Four interrelated areas of focus emerge from across the evidence base

The evidence that we have collected for this study included conducting 32 interviews with leaders of research funding bodies or experts in the field of corporate governance and organisational design or research funding systems,[59] analysing case studies of funding agencies within six different countries, and systematically reviewing a large amount of literature in various areas related to the insights that were coming out of the case studies, interviews and discussions with BEIS. Within and across each of these sources of evidence there have been an array of cross-cutting themes and issues which have emerged. Some of these issues are at a micro-level within organisations and refer, for example, to the capabilities and skills that will be required in order to successfully run a funding organisation. Other issues sit at a higher level, and relate to strategy, strategic context and guiding principles.

As this study has called for an integrated perspective on issues of organisational design and governance for research funding bodies, based on the best available evidence across a range of sources, both our gathering of this evidence and its synthesis has proceeded in an iterative fashion. We have continually reflected on information from the literature, interviews, case studies, and feedback from BEIS about what is of most interest to them, in a reflexive manner, and used this approach to interrogate and strengthen our findings in key areas as they emerged over the course of the study.

Using this approach, four interrelated concepts for deeper analysis have emerged. The four concepts, and supporting issues related to each, are:

- *Strategy*, including issues around: the process of strategy formulation; the content of strategy; and mechanisms of strategic decision making in dynamic environments.
- *Supporting collaboration within and across the organisation*, including issues related to cross-functional collaboration; interdisciplinary research; and networked governance.
- *People and organisational culture*, including issues of: leadership; capabilities and skills; and organisational culture and identity.
- *Structure and organisational design principles*, including issues related to: autonomy and decentralised versus centralised design features.

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[59] Interviews were conducted with 27 individuals, but follow-up interviews exploring the topics specifically addressed in this chapter in more depth were conducted with 5 of the interviewees.

Insights across each of these are now discussed in turn.

3.2. Strategy and strategic decision making

Box 3-1: Overview of findings regarding strategy

Strategy is how an organisation sets out to achieve its aims and objectives over a medium to long period of time. It is, essentially, a plan of action. Three core issues related to strategy emerged from our analysis: the process of strategy formulation, the content of the strategy, and features and characteristics of strategic decision making.

Process

- *Most strategy formulation processes are consultative across multiple stakeholder groups, internal and external to the organisation.* The case studies and interviews are all strongly in agreement that this type of open approach is essential.
- *The role of the strategy in setting the internal and external tone should not be overlooked.* The evidence also points to the idea that context is highly important in strategic planning, and that establishing the culture and values of the organisation by setting out a shared vision and mission are a critical part of the strategy process.

Content

- *Most strategies set out broad directions to be taken over periods of about five years*, and they avoid prescriptive statements about specific research projects or topic areas in favour of setting out broad horizontal areas of focus.
- *Strategies vary in the extent they follow directly from governmental priorities, or are simply broadly aligned with them.* The evidence suggests that organisations take different approaches to establishing the guiding principles and priorities for their strategy. There is no evidence about effectiveness of different approaches.
- *Many strategies contained a set of overarching or guiding principles.* These generally cover some element of scientific excellence, but also openness, engagement, accountability, and public benefit.

Strategic decision making

- *Building in mechanisms and modes of flexibility and responsiveness are seen as important for establishing a solid foundation for strategic decision making.* As with strategy formulation, working from the bottom up can help with stakeholder engagement and in the design of programmes that are flexible and responsive to research needs, which could facilitate decision making.
- *Portfolio management techniques were noted by many interviewees as an effective way to manage a research portfolio.* Though it was not possible to ascertain specific details of the exact mechanisms used, the broad principles of effective portfolio management techniques included recognition of the diversity of a portfolio, the need to collect robust data across the portfolio, and the need to establish effective analytical capabilities to analyse and assess the data.

Strategy describes the way an organisation or entity sets out to achieve its aims and objectives over a medium to long period of time. It is, essentially, a roadmap that can be turned into an implementation plan. The focus on strategy for this particular study was in part determined by BEIS, who had specific questions about evidence around the influences of strategy, its development, its role in decision making

and its content in the context of a research funding agency. We therefore asked specific questions about strategy in our interviews and explicitly explored the strategies of a number of the funding organisations we reviewed. Equally, it is also an area on which the literature has much to say and there is a wide body of management literature that explores the issues around strategy and how it can contribute to a successful organisation, including the interplay between strategy and organisational culture.[60] In the following section we will discuss: 1) the process of strategy formulation; 2) the content of strategies; and 3) how strategies are used to inform decision making.

3.2.1. Process of strategy formulation

Strategy development and strategic planning is recognised to be a process which should be highly context-specific, but is nevertheless important and various studies have linked the interplay between organisational strategy, organisational design and organisational context to overall organisational performance.[61] Moreover, both internal and external context will have an influence on the process of developing a strategy. For instance, an organisation's strategy is likely to be affected by the degree of environmental uncertainty and complexity, but also by the interpretations of this environment made by the top management, which are likely to be subjective.[62]

As it was not always possible to ascertain from desk research what the *process* for formulating strategy was in our case studies, we asked in all our interviews for insights and information about how people developed strategy in their own organisations and any good practice which emerged from their experience. Nearly all interviewees told us that the processes for designing strategy involved varying forms of consultation with internal and external stakeholders – largely through the use of workshops, working groups and open consultations. As one interviewee put it, 'if it's done behind closed doors, people won't buy into it.[63] We also reviewed the timing of strategy formulation: most organisations used a 4–5 year time horizon for their strategies, with some of them also incorporating mid-term reviews halfway through this cycle. The exception to this from the organisations we reviewed in more depth was the NIHR in the UK and DARPA in the USA. The NIHR's strategy *Best Research for Best Health* was written in 2006 and a new strategy has not been produced since. However, there are detailed implementation plans that sit alongside the strategy, and these implementation plans are updated every six months and have been since 2006. DARPA rewrites its Strategic Plan every two years (the most recent one being published in March 2015).

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[60] See for example, Schein 1999; Schein 1985; Coleman. 2013; and Mintzberg & Lampel 1999.

[61] See for instance; Hailey & Balogun 2002; Jarzabkowski & Wilson 2002; and Roberts 2007.

[62] Burton et al. 2015

[63] Int 10

Box 3-2: Examples of strategy processes

In the USA, the NIH, across its institutes and centres, uses a fairly standardised approach for formulating strategy. It begins with initial drafting and input from working groups on specific topics (e.g. big data) that involve both institute staff and external experts. After being revised in consultation with the institute's advisory council, the draft objectives are published and feedback is invited from the public (including researchers in academia and industry; healthcare professionals; patient, scientific, professional and advocacy organisations; federal agencies; and members of the general public). On the basis of this feedback and further advisory council input, the strategy is further revised and then finally published.

The NSF has a similar process which begins internally, before sending a draft out for wider consultation once an extensive initial drafting process has taken place. However, whatever is done, it is done openly and transparently. Individual divisions were left to develop strategies as was appropriate for their work.

DARPA has a more top-down approach to its strategy development. The Director puts together and writes the entire strategy on the basis of discussions with internal office directors, previous office Directors, universities, researchers, industry and various divisions of the US military. She finds out what the trends and technology trajectories are outside the organisation, and then synthesises all of this to identify the areas of focus for the organisation. The Strategic Plan is rewritten every two years.

In the UK, when the NIHR was developing its strategy, *Best Research for Best Health*, the strategy process involved consulting informally one-on-one with people across the health and social care research community for a year in order to understand the main issues. An official government strategy was then published, consulted on, and responded to. This latter stage was thought to be important to stakeholders as the NIHR officials made it explicit where comments from stakeholders had been taken on board, down to being specific about page numbers and numbers of times a word was changed from one version to another.

For the RCN in Norway, the strategy development process began with an environmental scanning process, like a horizon scanning activity, which provided the knowledge base for the new strategic framework. The entire organisation then contributed to the first draft, a process which involved working across all four divisional research boards within the RCN. Then, when a first draft was ready, it was sent out to 148 entities across the research system in Norway for public comment, as well as making it available on the Internet. Feedback was then incorporated before a final draft was published.

In addition to the process itself, interviewees discussed specific factors which should be considered when developing strategy. Four interviewees emphasised that designing effective strategies would require establishing what the overarching aims of research and innovation investment are and developing research priorities from that, but they acknowledged this is not straightforward to do.[64] Another noted it involved considering questions such as the extent to which governments need to see economic returns from research investment and how direct those returns should be. One interviewee noted that the strategy literature, broadly speaking, was useful for testing thinking and 'hanging ideas on' – in particular specific tools like a PEST analysis, McKinsey's Seven Ss, and a SWOT (Strengths, Weaknesses, Opportunities

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[64] These insights came from a range of interviews, including Int 16; Int 24; and Int 26.

and Threats) analysis were all useful in different ways – but that this was only one part of the process.[65] Another pointed out that,

> *[These are] huge ideological questions to resolve at a high level in government, but they have a big effect on how you evaluate funding bodies, what they're accountable for, and how you incentivise different parts of the system.*[66]

An additional contextual factor which could be considered in the process of strategy development is the balance of expectations and resources provided. Three interviewees, discussing the UK context, emphasised that expectations must be in line with resources – in terms of pay for funding body staff (which impacts recruitment quality),[67] the information staff can access (which impacts decision making quality),[68] and the funding available.[69] In some cases, developing strategy can serve an explicit purpose of negotiation. One interviewee explained that though the government sets high-level priorities, the funding body uses its annual budget request as a means to engage in a dialogue about the situation in different fields of research and this, in turn, is part of their strategic process.[70]

Despite using broadly similar processes to formulate strategy, organisations may still be perceived as being more 'bottom-up' or 'top-down' in the way they develop strategy, depending on the extent to which the stakeholders feel engaged in the process and listened to. Most interviewees felt that transparent engagement was important in all actions of a funding body, whether it was about developing strategy or not, a point to which we will return below in Chapter 4.

3.2.2. Content of the strategies for research funding organisations

In addition to considering the process of strategy development, we also drew out evidence on the content of strategies of research funding bodies. The strategies of many bodies set out very broad strategic objectives they will work on over a period of about five years.[71] They tend to emphasise general aspirational concepts that guide how the funder will support research, but they avoid being prescriptive about specific topic areas that will be funded. One interviewee said that the strategy is kept at a high level to prevent it becoming a means for the government to intervene on the direction being taken by the funder.[72]

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[65] Int 06. A PEST framework (also known as 'STEEP' or 'PESTLE') is a commonly used analytical tool for identifying and categorising basic trends and information about a range of different contextual issues which will influence any future situation. See for example, Shoemaker 1995 and Henry 2008

[66] Int 16

[67] Int 26

[68] Int 24

[69] Int 27

[70] Int 17

[71] E.g. BHF, Cancer Research UK, the Leverhulme Trust, the NIH (at the level of institutes and centres as well as the NIH overall), the NNI, the Norwegian Research Council, the NSF and the Wellcome Trust.

[72] Int 17

Looking across the case studies, though, some common themes about the content of organisational funding strategies do emerge. Specifically, we looked at the following areas:

- Features of strategic aims and principles: are there any shared features or common principles across strategies?
- Setting of priorities and priority areas: do these come from the top down (e.g. government) or bottom up (e.g. through researcher proposals)?
- Focus of the strategy on:
  - Sectors or disciplines: is the strategy organised or focused on sectors or disciplines?
  - Areas of research: is the strategy focused on specific technologies, disease areas, or specific parts of the innovation or research pathway?
  - Societal themes: is the strategy focused on societal themes or 'grand challenges'? (A grand challenge usually brings together a number of research areas).
  - External engagement: interactions with industry, the public or other stakeholders.
- How and where are investments made: what is the balance between different kinds of funding approaches (projects, programmes, fellowships, etc.)?

Across these areas several insights emerged and we sum them up in the following sections.

Features of strategic aims and principles

Many strategies contained a set of overarching or guiding principles which help to determine research priorities. These generally cover some element of scientific excellence, but also openness, engagement, accountability and public benefit. The following bullets offer some examples:

- Cancer Research UK has four research objectives. It seeks to fund research which: *prevents cancer*, by reducing people's risk of developing cancer; *diagnoses cancer*, by diagnosing more cancers earlier; *treats cancer*, by developing new cancer treatments; and *optimises treatments*, by making treatments more effective for each patient (emphasis our own).[73]
- The NIHR is governed by the principles of transparency, open competition, quality, cost effectiveness and delivery. The organisation is structured around the architecture of a health research system, with patients and the public at the heart of what they do.[74]
- The NSF has the following core values: scientific excellence, organisational excellence, learning, inclusiveness, and accountability for public benefit.[75]
- The ARC has the following core principles: excellence in achieving its mission; engagement with government, universities, research agencies, businesses and the wider community, nationally and internationally; benefit to the community through economic and social return on investment, engaged and informed decision making and efficiency of operations; and

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[73] CRUK 2014

[74] Interview with former senior figure at NIHR, as well as information available at http://www.nihr.ac.uk/about-us/how-we-are-managed/our-structure/.

[75] NSF 2014

accountability through adherence to ethical standards and government policy using transparent, efficient and effective processes.[76]

- The National Health and Medical Research Council in Australia has the following themes which guide its strategy: invest in high quality health and medical research and build research capability, supporting the best research and researchers; support for the translation of health and medical research into clinical practice, policy and health systems and the effective commercialisation of research discoveries; maintain a strong integrity framework for research and guideline development, underpinning rigorous research and relevant and accurate guidelines and promoting community trust.[77]
- The DFG in Germany has the following principles: strategy, flexibility, transparency, excellence.[78]

Priority setting

While it was not always possible to ascertain how priorities were set, there seemed to be a few main approaches. Some strategies relied on following wider government priorities, notably the ARC and NHMRC in Australia and the RCN, while others involve a consultative process between stakeholders and/or a board. For example, as outlined above, the UK's NIHR engaged in a series of one-to-one meetings across the health and social care research community in order to determine the primary issues that needed to be addressed, however as noted below it did align with broader government priorities of improving health and wealth. The NSF in the US engages in a series of internal processes and discussions with its staff and board members to decide which ideas from the previous strategy are working, and which are not. This is reviewed and discussed iteratively at different levels throughout the organisation before a full draft is sent to the external research community for consultation.

In Norway, the RCN strategy for 2015–2020, *Research for Innovation and Sustainability,* is aligned with the government's *Long-term plan for research and higher education 2015–2024*[79] and states that it 'is the product of active collaboration within the RCN's governing bodies and incorporates input from an extensive external consultation process.[80] Thus, the RCN explicitly aims to ensure that its strategy serves a purpose of operationalising the government's long-term plans. The government's *Long-term plan* for research and education contains policy and research areas including: seas and oceans; climate, environment and clean energy; more effective public sector services; enabling technologies; innovative and adaptable industry; and world-leading academic groups. The activities the RCN develops in its own strategic plan follow directly from these areas and are operationalised through a series of primary and

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[76] These are paraphrased here. The full version can be found in the ARC corporate plan:
http://www.arc.gov.au/sites/default/files/filedepot/Public/ARC/corporate_plan/ARC_Corporate_Plan_2016to17_to_2019to20.pdf.

[77] Emphasis in original. https://www.nhmrc.gov.au/about/nhmrcs-mission-and-functions/nhmrc-strategic-direction.

[78] From an interviewee familiar with the DFG

[79] Norwegian Ministry of Education and Research 2014

[80] RCN 2015, 2

secondary objectives under each main heading. The Wellcome Trust, on the other hand, has an emerging framework with no fixed time frame.[81]

Strategy focus

Few strategies were organised around specific sectors, areas of research or disciplines. Most highlighted cross-cutting themes, be this across a disease pathway as in the case of Cancer Research UK and the BHF, or broader themes which cut across the research base, such as those identified by the Wellcome Trust (emphasis added):

- *Advancing ideas*, by funding great ideas and inspired thinking that address the fundamental health challenges of our time.
- *Seizing opportunities*, by identifying a new need, setting ambitious goals and new directions, and pursuing those opportunities through varies channels.
- *Driving reform*, by leading by example and campaigning for wider reform.[82]

Or by the NSF (emphasis added):

- *Transform* the frontiers of science and engineering
- *Stimulate* innovation and address societal needs through research and education
- *Excel* as a federal science agency.[83]

The NIHR in the UK deliberately states that it does not usually set strategic priorities in terms of disease areas (with some exceptions like dementia), but rather funds in terms of a strategic approach. It argues this allows it to address all areas of disease and clinical need, all professions and all areas of health and care. However, it does align itself with government priorities of improving health, and wealth, and this latter area was viewed by an interviewee to be an important area to emphasise in order to make the case for investing in health research (that is, that it could contribute to economic growth as well as improved health of the country).

Overall, most strategies focus on high-level 'horizontal' elements which can help to stimulate an entire research base, but some then refer to specific aims or objectives in the content of the strategy. For example, the RCN strategy says the council will work to 'strengthen research for the development of resource-based industries, particularly industries based on marine resources'[84] and refine the R&D tax incentive scheme, among other areas. The NHMRC discusses national health priority areas, which include dementia, obesity and arthritis, and the Dutch NWO defines 'top-sectors', which are areas of high national economic importance (e.g. food chemicals). One interviewee from a research funding council observed that if you look back over many years of strategies, one might see that the main areas of research which were highlighted had not changed very much and that topics like information technology, security, and climate change were a constant which had been there for many years.[85]

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[81] Wellcome Trust 2016

[82] Wellcome Trust 2016

[83] NSF 2014b

[84] RCN 2015, 22

[85] Int 10.

Investment strategy

Few strategies make investment strategies explicit, but to the extent we were able to glean this information we can determine that in the first instance all funders take peer review very seriously and base funding decisions on that. Secondly, many also seem to have a diverse portfolio of investments across institutes, centres, individual researchers and partnerships. Only Cancer Research UK explicitly makes mention of its philosophy that by funding institutes and centres it brings minds together in a co-located and synergistic fashion.

External engagement

In general, there was no uniform approach to how strategies addressed industry, the public, patients, and other external stakeholders as this depends on the nature of the organisation itself. However, most strategies did explicitly refer to aspects of external engagement. For instance, the ARC strategy emphasises wider engagement and refers to the Linkage Programme, which is about engaging with organisations outside academia, the NWO reserves nearly half of its funding for 'top-sectors' for public-private partnerships, and the National Institute for Mental Health (part of the NIH) expresses an interest in building on opportunities in citizen-driven science.[86]

In addition to these factors that we looked for systematically within the strategies themselves, some interviewees commented on the content of strategy and points which should be considered. One interviewee stressed that it is important to consider the timeline for a return on investment, and that it may be long, especially for innovation:

> *Economic growth is one aim, but using that on its own would steer you to a very particular set of interventions which may be less generating of innovation in the longer term… Research itself takes a long time to pay out. For innovation it's difficult to even set a timeline.[87]*

Another interview presented a more mixed picture of how strategy should be focused, balancing pre-defined topics with blue-skies research.

> *You need some efforts concentrated around… priorities like climate change, but you also need a reservoir of the more unfettered basic or blue-skies research [to act as an insurance policy so you can address new problems that arise]. A country like Britain has to have a healthy balance between the two.[88]*

When we consider whether and how strategy has influenced organisational design of funding agencies, there is very little evidence linking the two. The only evidence we did find was in the case of the DARPA.[89] Colatat showed that DARPA's specific strategy of 'fostering and implementing radically new technology concepts recognized as transformational' has translated into specific organisational elements to allow the agency to support unconventional research, such as a relatively small size, a decentralised, non-

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[86] NIMH 2015

[87] Int 16

[88] Int 13

[89] e.g. Colatat 2015; Bonvillian & Van Atta 2011; and Kates 2005.

bureaucratic structure, and a highly flexible and adaptive configuration facilitating cross-functional and interdisciplinary collaborations.[90]

3.2.3. Using the strategy to inform decision making: remaining responsive to the needs of stakeholders and portfolio analysis techniques

Another element of strategy which we explored was how strategies are used to inform decision making. Such strategic decision making involves 'gathering intelligence, setting directions, uncovering alternatives, selecting a course of action, and implementation'.[91] In other words, it is how strategies are actually implemented. Two areas emerged here which we explore further in this section: the first was the importance of remaining flexible and responsive to changing organisational and external dynamics; the second was the use of project portfolio management techniques as a means of monitoring the portfolio of projects against the strategic objectives.

Stakeholder responsiveness and flexibility

Several interviewees who represent funding bodies described their organisations' approaches to high-level decision making more generally and, in so doing, they often discussed the extent to which they incorporated consultation and bottom-up input from their stakeholder communities. For agencies with innovation policy in their remit, there was recognition that innovation tends to involve more government input about priority areas, but still there was emphasis on the need to ensure that the business voice (and that of small businesses in particular) is heard.[92]

Discussing why bottom-up approaches are effective, interviewees referred to the people 'on the ground' (in or connected to the research community) as being best-informed about where there are research opportunities and needs,[93] something also echoed in the literature in a paper reviewing the strategic approach of the RELU programme.[94] Many interviewees also said that funding bodies play an important role in linking the government with the community, and that that bottom-up input is important for responsiveness to needs. As one person told us, 'unless you keep an eye on the ground, you can lose flexibility.'[95] In addition, consultation with the community serves the broader purpose of openness and transparency. One interviewee explicitly commented that as a general principle, 'whenever you can be open and transparent, you should be.'[96]

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[90] Colatat 2015, 875

[91] Nutt 2000

[92] Int 16

[93] Int 02–04; Int 06; Int 07; Int 11; Int 16; Int 18; Int 19; Int 22; Int 24

[94] Lowe & Phillipson 2006

[95] Int 02

[96] Int 06

Box 3-3: The DFG as an example of a responsive-mode approach to decision making

From our case studies, we can see that the DFG in Germany is just one example of a funder which places a strong emphasis on taking a response-mode approach, in both its researcher-led funding calls and when establishing strategic initiatives. DFG president Peter Strohschneider has written:

Researchers themselves must continue to drive research and research developments. And it is this aspect which defines the special role of the DFG within the German research system… Research performance, which plays an essential role in today's knowledge society, is not possible without academic and research freedom. [97]

At the DFG, strategic initiatives tend to come from the community, not exchanges among the DFG Senate, Executive and Board (although decisions will need to be made at this level). To ensure a voice for the research community at high level, the DFG senate includes 36 elected representatives from the scientific and academic communities who serve four-year terms.

At the ARC in Australia, the strategy sets out broad objectives linked to the funding programs and policy functions of the body, but the funding strategy, per se, is to let the merits of the scientific ideas and proposals speak for themselves. The peer review and panel structure enables them to fund the best research ideas; there is no predetermined notion that one discipline or field has more money available to it than others. In the Netherlands, the NWO ran a national consultation in which all scientists and the general population could offer ideas for research, which has resulted in the national science agenda. While this agenda does not directly translate into the work streams of the NWO, it does serve as a source of input to the development of the strategy.

Finally, as part of strategic decision making, many interviewees commented on how they ensured that research and innovation funding systems remained flexible and responsive to research and innovation needs. Generally interviewees agreed that maintaining such flexibility is important for various reasons, including avoiding the country's research system becoming 'locked in' to certain areas, and preventing individuals from dominating in a way that stifles new ideas. Leadership and autonomy were highlighted as important by a few interviewees as one way to allow for the freedom to make decisions and establish collaborations. One commented that 'flexibility and agility is not about structure, but it's about leaders being willing to collaborate and compromise',[98] while others[99] noted that the people making funding decisions need autonomy and need to be able to speak openly amongst one other.

Trust was seen as very important in this regard,[100] as was having open and flexible calls.[101] There are multiple examples of situations where funders built in some degree of 'impermanence' or 'dynamism' into their programmes or processes. One interviewee[102] recommended piloting programmes first for 3–5 years and then evaluating them to see how they are working – this enables learning and gradual change, and

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[97] Strohschneider 2013

[98] Int 02

[99] Int 06; Int 19; Int 26

[100] Sentiments along this line were discussed by multiple interviewees in various ways, but were most notable from Int 06; Int 07; Int 19; and Int 26. Int 01 also stressed the importance of gaining the trust of the community.

[101] Int 03; Int 27

[102] Int 10

avoids protest about major changes being made. This interviewee said 'no programmes should be for life', but admitted that shutting down facilities can be a challenge. The NIH does this in its Common Fund, where projects can run for a maximum of ten years and have set milestones that must be achieved. When some projects end and others begin, the agency has the opportunity to change direction and focus on new problems. As another example, the NRC has designed a system whereby the funding for established priorities is cut by 10 per cent each year to free up funding for new areas (see below for more information on this process). Some representatives of funding bodies furthermore described mechanisms for responding to emergencies, e.g. by setting aside a kind of 'agility pot' – funds to use if unanticipated needs arise[103] – though it should be noted this is different from an interdisciplinary 'common fund'. These representatives said that agreement would need to be reached about how much should go into this pot and the rationale for that decision.

Project portfolio management techniques

Put simply, project portfolio management is the simultaneous management of a whole collection of projects[104] and is recognised as being an important part of strategic management.[105] When we initially asked interviewees how they managed their project portfolios within their funding bodies, many said there was no single tool or technique. It was a balance and a mix of many things which enabled them to balance and manage their portfolio across disciplines, project sizes, sector needs, strategic priorities, national policy needs, etc. One interviewee commented that 'portfolio management is an intelligent questioning approach' but that 'the challenge of managing any portfolio is that there are multiple cuts through it, multiple lens'.[106]

A few interviewees provided us with lists of factors which fed into their decisions, but which always needed to be kept in a delicate balance. These factors included: long-term versus short-term needs, opportunities to be seized versus threats to be deflected, partnerships versus single actions, flexibility and stability, and funding for infrastructure versus strategic initiatives. The factors are numerous, and will differ slightly for each organisation, but the point is more that there are many issues to be balanced and no one had single tools that they used.

Due to the fact that this was an area that emerged primarily from the interviews and was of interest to BEIS, we did not explore the literature on the topic extensively, but rather went back to interviewees to determine what, exactly, they did to manage their portfolios.[107] We received information about the kind of information they collected and data sources for that information, how the data was managed, what analysis was done on the data, and how the data and analysis were ultimately used.

There were multiple aspects to the kinds of information that interviewees collected across their portfolio. All made efforts to track defining characteristics of research projects across the portfolio, including

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[103] Int 01; Int 14

[104] Meskendahl 2010

[105] Morris & Jamieson 2005; Shenhar et al. 2001

[106] Int 06

[107] All of the information in this section, unless otherwise noted, came from interviewees from these organisations. However, in the interests of protecting anonymity of respondents throughout the report, we have not cited the information by interviewee as was done in other sections.

features such as public versus private bodies, gender of researchers, disciplines, type of research questions being asked, type of industry/sector, geography, etc. A few interviewees explicitly stated that they did not do enough to track the impact of their projects over time, but that they would like to be better at this. Most data were sourced from internal financial and project tracking mechanisms, as well as using external data such as bibliometric or patent information.

A few organisations (e.g. the NSF and NIH) had a central office that managed the data and conducted regular analysis of that data. For example, in the US at the NIH, they perform analyses using various kinds of scientometric (bibliometrics, patents, value of data, etc.) data to give them a picture of how their portfolio is performing against different areas. For example, bibliometric data can be used to compare outcomes across different funding streams and they have used that analysis to help inform future funding decisions and guide grant decisions. One example given by an interviewee was of how their review of Pioneer Awards versus R01 grants led them to adopt a more 'person-oriented approach' versus a project-based approach. They also use these internal analytics to look at what kind of internal processes work well in managing programmes. Some of this is done by individual divisions or institutes, but most is done through a central coordinating office within the Office of the Director where institutes can ask for specific pieces of analysis to be done.

The RCN in Norway primarily use allocation data and publication data, together with recruitment data, for its portfolio analysis and will perform analyses according to sector the funding recipients are in (e.g. universities for academics, versus industry data for those in industry receiving funding). The RCN performs many types of analyses on this data for use in different contexts, such as evaluations, reports to the ministries, input for the national budget proposal, etc. Some divisions, it was noted, also collect longer-term data about the performance and impact of different projects, but this is not done systematically across the organisation. Overall, evaluations and analyses play an important role in strategic decision making with regard to the RCNs priorities, and data and statistics on grant awards and results over time provide important information for decision making. In addition, it was noted that new priority areas are often identified through larger-scale national strategy processes. To this extent, the RCN's data and national statistics are an integral part of the knowledge base for these processes.

The NIHR has a central performance management dashboard which is aligned with its organisational structure and so can be used to provide different lens on the organisational portfolio depending on what one wants to know.[108] The dashboard has a particular use in allowing for them to analyse data about the inputs, processes, outputs and outcomes of different funding streams at a granular level.[109] Importantly, the dashboard allows the institute to look at the data in different ways, which reflects the needs of a funder to analyse what they are funding and for what purpose from the perspective of multiple stakeholders and angles. For example, they might view their portfolio by disease area, by patient group, by geography, by funding recipients, etc.

DARPA, on the other hand, does not have an internal analytics function, per se, but its overall model relies on constant and continuous interactions with their research communities in order to monitor the

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[108] NIHR N.d.

[109] El Turabi et al. 2011

external environment and to help inform whether the portfolio is meeting strategic needs. Each programme manager has a travel and project development budget and is constantly interacting with the research communities relevant to different topics they are responsible for. This ensures they know what research is needed, what calls for funding might look like, and how their projects are performing.

Finally, the data and analysis collected by different organisations were reportedly used in different ways across the various organisations we spoke with. Some used it to directly inform strategic direction, whereas others used their analyses to see at a macro level how their performance compared to other countries. When it came to deciding which parts of the portfolio to phase out, or not, most interviewees said that the decision often starts much earlier on with setting limits on how long things are funded for in the first place.

> *The model is very important- you do not want to invest the rest of your life in something you funded 10 years ago.*[110]

However, this does not mean you want to abandon things you have invested in, either. At the NIH, for example, a few years before a major funding programme might be coming to an end they try to encourage demonstration projects for the final few years so that the outputs begin to be noticed and taken up by the wider research and industrial communities. At the NSF, for longer-term programmes they do an evaluation about halfway through programmes and as part of the evaluation they look at how the programme can be sustained beyond the period of the funding as a continuing resource for the research community. In both instances, organisations noted the need to be attune to the longer-term sustainability of the resources that were created and how these can continue to be used by the research community.

At DARPA, no project is longer than 4–5 years in duration and that is a deliberate feature of their organisational funding model. There are also clear milestones built into the projects so that it is clear when a barrier is reached and the project may need to be stopped. Importantly, project failure is embraced at DARPA, and even celebrated: 'Openness, to new ideas, risk-taking and tolerance of failure are essential elements of DAPRA innovation.'[111]

However, some did speak to us about the potential utility of project portfolio management techniques, particularly ones which explicitly incorporate and celebrate a diverse portfolio. This suggests a need to incorporate thinking about the diversity of the portfolio, and there is important work here in the literature that could be further explored in future studies.[112] One such approach was first introduced by Stirling, and as he points out in the article, one of the reasons to explore and account for diversity is that 'in research strategy, diverse portfolios offer flexibility in the face of uncertain future progress and promote learning across programmes.'[113] More broadly, technological diversity can be seen as a stimulus for innovation[114] and productivity,[115] so it is in the interest of funding bodies to promote it.

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[110] Int 10

[111] DARPA 2016

[112] See for example Stirling 2007

[113] Stirling 2007, 707, drawing on Rosenberg 1996 in relation to the point on future progress and David & Rothwell 1996 for the point on promoting learning across programmes.

[114] See for example, Rosenberg 1982.

[115] Aoki 1996

While there are likely many approaches to managing diversity within a portfolio, it was not within the scope of this study to fully explore them here. One that was brought to our attention by an interviewee, though, draws on Stirling's work where he calls attention to three general attributes of diversity summarised in the literature.[116] These include:

- *Variety:* referring to the number of categories into which the elements of a system is divided. It allows us to answer the strategic portfolio management question: how many types of things do we have? In the case of strategic research portfolio management, 'things' could refer to projects or programmes being funded, types of researchers, units supported, etc.
- *Balance:* referring to the pattern of distribution of the system elements. It answers the question: how much of each type of thing do we have?
- *Disparity:* referring to the ways and extent to which we distinguish between the elements within the system. It answers the question: how different from each other are the things we have?

The relevance of these points for portfolio management is to draw attention to the need to explore different elements of portfolio diversity. From here, various tools can be developed which would help one manage the system. Such tools could take the form of translating various attributes of research projects funded by a funding body, including type of project, discipline, researchers, funding amount, etc., and plotting these against performance scores (peer review) and other criteria deemed appropriate for strategic management.[117] Although developing such a system may require additional work, exploration of these areas may be merited.

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[116] Stirling 2007

[117] One such approach is outlined in Stirling 2012

3.3. Supporting collaboration and interdisciplinary research

Box 3-4: Overview of insights regarding collaboration and interdisciplinary research

Supporting collaboration and interdisciplinary research, alongside maintaining effective, functional networks within a research funding system is critical. Three core issues are explored here: the need to foster and encourage interdisciplinary research; relatedly, the need to link effectively that external support function to an efficient internal organisational structure which encourages cross-functional collaboration; and the use of a networked governance approach.

- *Fostering interdisciplinary research will rely, in part on effective support for cross-functional collaboration and so these two elements are linked. There is strong evidence of this from both the literature and interviews.* In any complex organisation, cross-functional collaboration can be an important means of achieving success, but in a funding body which aims to support research across a funding system it becomes even more important. The literature and interviewees provide insights into good practice, including providing incentives at a divisional level for cross-group working, paying attention to both physical and organisational barriers, working outside disciplinary boundaries, and creating dedicated pools of cross-disciplinary funding.
- *Related, establishing effective cross-functional collaboration relies on a careful balance between coordination and control mechanisms within the organisation.* Evidence suggests that building effective cross-functional collaboration rests on a careful balance between formalisation of rules about how to collaborate and the relative degree of centralisation/decentralisation of coordination and responsibility for the collaboration.
- *Many interviewees discussed the idea that establishing and maintaining a broad network of stakeholders across a research and innovation community was central to an effective research and funding body.* The purposes were multiple and include elements touched on throughout this synthesis including maintaining the trust of the research community, understanding the needs and challenges faced in the research sphere, providing a knowledge brokering function between the research base and policy, and maintaining a deep connection to the emerging societal trends, issues and grand challenges that research and innovation will need to help solve.

This topic covers issues ranging from the importance of cross-functional working in complex organisations, to insights from the interviews which related to how to support people working together, sharing ideas and knowledge, and supporting the flow of information and ideas which enable collaborative working.

3.3.1. Fostering interdisciplinary research

In today's global and interconnected research and innovation environments, fostering interdisciplinary research is seen as increasingly important,[118] despite that fact it has generally been recognised as underfunded and difficult to support.[119] In the UK, the importance of interdisciplinary research has been recognised in the higher education sector as a way of addressing the pressing societal problems (often

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[118] Int 24 noted that it is important to distinguish interdisciplinarity itself from the challenges that will change over time and be tackled by researchers from multiple disciplines.

[119] See e.g. Sharp et al. 2016; Wellcome Trust 2015b; and Bromham et al. 2016.

referred to as 'grand challenges'), accelerating scientific developments which can open up new opportunities, but also ensuring higher value for public funds.[120] The critical importance of interdisciplinary research and the need to foster higher levels of collaboration between disciplines was also acknowledged in the UK government's Science and Innovation Strategy (2014).[121] The recent quantitative review of the performance and intensity of interdisciplinary research in the UK confirmed this importance and identified a number of defining features of interdisciplinary research in the UK, including that most interdisciplinary research was highly concentrated in the social sciences and humanities. However, overall, interdisciplinary research had a lower citation impact than that of other publications, though the UK's top 10 per cent of interdisciplinary research publications are highly international, collaborative (both with other academics and with industry), and are of high quality as indicated by citation impact.[122]

Interviewees for this study identified a range of challenges and risks that affect interdisciplinary research, including cultural and linguistic differences across disciplines, and a discipline-based education system.[123] They also mentioned more systemic and structural challenges, such as a lack of incentives for researchers to do interdisciplinary work due to discipline-structured hiring and publishing structures, difficulties in assessing multidisciplinary funding applications, a lack of sustained funding to build interdisciplinary research capacity, and difficulties in getting different funders or different divisions within a single funding body to collaborate.

In response to the perceived value and importance of interdisciplinary research, many research funders have begun to create supporting mechanisms to facilitate interdisciplinary research and it was an area that we focused on in our review of the evidence. In the UK, the Cross-Council Funding Agreement of the research councils is applied to 'responsive-mode' research grant proposals with an aim to ensure that 'no gaps develop between the councils' subject domains and to ensure equality of opportunity for proposals at the interface between traditional disciplines, where many of the major research challenges of our time are located'.[124] A number of the research councils also support interdisciplinary research collaborations with consortia of UK universities. The commitment to interdisciplinary research from non-government research funders is also evident, with major funders, such as the Wellcome Trust, proactively supporting interdisciplinary research proposals.

Similar efforts to support interdisciplinary research can be seen internationally and indeed emerged from our case studies. For example, the NSF runs a number of programmes designed explicitly to fund interdisciplinary research and has a special review process for unsolicited interdisciplinary proposals.[125] Similarly, the DFG reviewed its research funding portfolio to adapt to interdisciplinary research.[126]

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[120] BIS 2015a

[121] BIS 2014

[122] Pan & Katrenko 2015

[123] Int 13 and Int 24 commented that in the UK there have been contradictory policies in that interdisciplinarity work has been encouraged, but research assessment processes disadvantage interdisciplinary researchers.

[124] RCUK 2016

[125] NSF N.d.

[126] DFG 2013

Some interviewees emphasised the need for a bottom-up approach in the context of interdisciplinary research funding (though generally comments indicated that selection of priority areas requires a more directed approach). One interviewee said that 'if researchers buy in to [cross-disciplinary grand challenges], then the research councils will follow. [You] need to communicate the opportunities to researchers clearly and get them to work together.'[127] In line with this idea, another said that 'policy-driven interdisciplinarity… is mostly wishful thinking [and] not truly interdisciplinary,'[128] explaining how their organisation is developing assessment processes involving interdisciplinary panels. Notably, interdisciplinary assessment panels were suggested as being a useful tool by six interviewees from five countries.[129] One interviewee from a research funding body commented that:

> *What is most important is to organise the peer review in a manner that promotes identification and funding of good, interdisciplinary grant proposals. Research in this field shows that peer review serves to preserve the status quo, shies away from risk, and tends to prioritise well-established research themes within well-established research disciplines rather than interdisciplinary research of a more experimental nature.*[130]

However, much of this discussion is at a macro level about how to launch and support research funding programmes, and less about how to organise the funding body to more effectively support interdisciplinary research.[131] While the challenges of supporting interdisciplinary research cannot be addressed through changes to the governance and organisation of a research and innovation funding body alone, as it also depends on researcher behaviours, interviewees did make specific suggestions of interventions involving funding bodies. Several ideas related to encouraging staff from different divisions or bodies to interact. Some were simple but easy to overlook, but our interviewees told us that in many of their funding bodies efforts are made to help staff from different organisations or divisions spend time together informally and 'share coffee,' as this can lead to exchange of ideas and getting to know one another.[132] (The same idea was also suggested by one interviewee in the context of interdisciplinary review panels).[133]

Several interviewees discussed the importance of how funding is distributed. They said that collaborative programmes can degenerate into 'turf wars' if staff from different divisions or bodies feel they are in competition with one another (e.g. to ensure 'their' discipline gets its fair share of proposals funded).[134] Interviewees said that to mitigate this issue, money should be set aside separately as an independent pool devoted to interdisciplinary research and/or strategic priorities.[135] A few examples of this can be drawn out.

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[127] Int 15

[128] Int 03

[129] Int 03; Int 07; Int 10; Int 14; Int 18; Int 23

[130] Int 23

[131] See Kates 2005 and Corley et al. 2006.

[132] Int 10; Int 11

[133] Int 07

[134] Int 01; Int 05; Int 10; Int 13; Int 15; Int 17; Int 23

[135] Int 01; Int 10

One funding organisation is planning to develop a model whereby divisions within the organisation are allocated a budget in two parts.[136] The first part can be spent wholly within their divisional remit, but the second part, referred to as 'coloured money', is earmarked for cross-disciplinary research. Divisions can suggest and participate in cross-disciplinary initiatives, but can only spend their 'coloured money' if a certain minimum number of other divisions joins the initiative.[137]

Another example of this kind of approach can be found at the RCN in Norway. Here, there is also an explicit budget mechanism to help facilitate the ministry's coordinating role in research policy, but also to overcome the weaknesses inherent in a sector-based funding system. In their view, these weaknesses are related to the fact that each individual stakeholder gives little consideration to and knows little about the actions of the others. The mechanism is then used to fund research areas that fail to receive adequate support because they, for instance, fall under the remit of multiple stakeholders and do not receive enough support from any of them, or are not clearly the responsibility of any stakeholder. As a way to make sure these funds can be continuously freed up for use in other areas, programmes under this mechanism that are funded must reduce their budgets by 10 per cent annually. The funding freed up is then distributed among both new and established initiatives, allowing priorities to be re-defined and cross-sector efforts better coordinated.

The NIH as well as the NSF have also integrated ways to support interdisciplinarity within their organisational structures. From our case studies and interviews we found that in both organisations, dedicated mechanisms to support and fund interdisciplinary working across divisions and institutes were important. NIH efforts include the Common Fund and large-scale endeavours like the BRAIN and Precision Medicines Initiatives.[138] The NIH Common Fund receives its own budget appropriation from Congress (as do the NIH institutes and centres), is housed centrally within the Office of the Director, and aims to run cross-cutting programmes that capitalise on emerging opportunities and address major research roadblocks.[139] It was noted as being a useful way to enable interaction and collaboration among investigators from across institutes and centres – many of whom would otherwise stay linked to a single institute for their entire career.[140]

One interviewee added that it is essential to also have top-level coordination to encourage different bodies/divisions to talk together about how to use the funds. Another said that, in addition to operational changes, strong leadership is needed to foster a culture of cooperation and working for the greater good.[141] It was stressed that conflict is not necessarily problematic; rather it can be productive and can help in solving complex problems.[142] A few interviewees said it is important to recognise and capitalise on the

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[136] In order to preserve anonymity we have not named this funding organisation.

[137] Int 21

[138] The BRAIN (Brain Research through Advancing Innovative Neurotechnologies) initiative is a large-scale project to better understand the structure and function of the human brain, and it involves the NIH, NSF and other public and private partners. The Precision Medicines Initiative is a research effort aiming to gather longitudinal data on the lifestyle, environment and genetics of 1 million US participants.

[139] NIH 2017c

[140] Int 17

[141] Int 02

[142] Int 12

cultural differences and different ways of working and thinking about problems that exist across disciplines.[143]

> *Big differences in how hypotheses and ideas are generated need to be appreciated and somehow brought together in a way which is synergistic rather than counteractive.[144]*

Here, the literature provides additional insight to that gained from the interviews and it highlights where strategies to foster interdisciplinary research can be found at various levels of the research funding process. For example, interdisciplinarity can be integrated within the intrinsic missions and objectives of the research funding organisation. This is notably the case with DARPA, recognised as a 'global model for interdisciplinarity effectiveness'[145] and whose mission of 'fostering and implementing radically new technology concepts is recognized as transformational'.[146] In developing unconventional higher-risk research projects, DARPA explicitly promotes organisational flexibility and mechanisms that lower barriers to collaboration. This can be seen in a number of ways, from recruitment to the way it runs its administrative functions. Internally, DARPA recruits programme managers from diverse disciplines and has deliberately not organised the offices around disciplines.[147] There is a deliberately short hierarchy (only two levels exist in practice) as it is thought that this leads to the free and rapid flow of information and ideas. Programmes are also problem-based: they are designed to focus on hard problems or emerging scientific and technical opportunities, but not on disciplines.[148]

Furthermore research programmes are developed entirely by DARPA's programme managers which generally call for a combination of technology and a breadth of expertise that can only be achieved through interdisciplinary research teams. This encourages novel collaborations by creating opportunities for researchers to meet and create interpersonal relationships by organising programme-specific workshops. Programme managers spend a significant amount of their time travelling the country and the world talking to a huge variety of people. They explicitly encourage their managers to spend time in industries or research environments far removed from the problem they are working on (e.g., someone designing a programme on aerospace would be encouraged to spend a day in a pharmaceutical company). They encourage looking outside one's home area to gain insight on difficult problems. The combination of incentives for collaboration at the programme level, with structures actively fostering the exchange of tacit knowledge, can explain the fact that novel collaborations more common on projects funded by DARPA than other agencies and that those novel collaborations are more likely to be repeated than novel collaborations at control agencies.[149]

Finally, once interdisciplinary programmes are up and running, the issue of sustaining support for interdisciplinary work was raised. One interviewee, who had run an interdisciplinary programme, said:

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[143] Int 01; Int 13

[144] Int 01

[145] Kates 2005

[146] Bonvillian & Van Atta 2011

[147] Kates 2005

[148] Kates 2005

[149] Colatat 2015

> *What was interesting is for the really creative research to come in took about three years because unless [researchers are] already working together, it takes one or two years to really understand the language, the way you address the research, the way you do the research, and break down those barriers.[150]*

Another emphasised that interdisciplinary research programmes in the UK have tended to be run for short periods, leaving the researchers involved at a disadvantage when the funding ends and they must obtain support under standard responsive mode calls, which the interviewee felt were biased against interdisciplinary research.[151]

3.3.2. Supporting cross-functional collaboration

Many of the ideas above about fostering interdisciplinary research point to a need to support cross-functional collaboration within an organisation. Cross-functional collaboration characterises the degree of linkages between the various organisational components of the organisation (i.e. the degree of information sharing and collaborative projects). One of the pieces of evidence to come from our interviews and literature was that in complex organisations, finding appropriate ways of enabling and supporting cross-functional collaboration is critical.

According to studies, in complex organisations cross-functional collaboration can enable a high degree of quality and efficiency of information sharing among the various units and sub-units of the organisation.[152] Burton et al argue that cross-functional collaboration relies on so-called coordination and control mechanisms.[153] Control systems relate to how performance measurement is embedded at the level of the unit and individual, and how budgets are attributed. Coordination mechanisms are especially relevant in distributed organisations to ensure not only a vertical but also a lateral sharing of information. They include mechanisms like cross-functional teams and committees or project management systems and smaller mechanisms such as liaison roles, committees, formal and informal rules, job descriptions, statements of procedures, codes of ethics, employee or customer survey systems, etc.[154]

Evidence also suggests that building effective cross-functional collaboration rests on a careful balance between formalisation of rules about how to collaborate and the relative degree of centralisation/decentralisation of coordination and responsibility for the collaboration.[155] For example, Gerybadze and Reger[156] analysed organisational practices of intra-corporate innovation in 21 large R&D-intensive multinational corporations and found that the degree of cross-functional integration depends on the type of innovation strategy pursued by the firm. For example, a firm with geographically distributed innovation capabilities might set up a network of multiple learning centres when thinking about how to support cross-functional collaboration, and should ensure efforts are aligned with corporate strategy and cultures. Other elements that have been found to foster high-performing, cross-unit collaboration include:

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[150] Int 10

[151] Int 26

[152] Burton et al. 2015

[153] ibid.

[154] ibid.

[155] See, for example, Martin & Eisenhardt 2010; Gerybadze & Reger 1999; Waterhouse et al. 2008; and Raynor & Bower 2001.

[156] Gerybadze & Reger 1999

- Ensuring incentives are in place at the unit level and that there is an environment conducive to collaboration. This may include setting targets for the local divisions or physical office arrangements to remove barriers between divisions.
- When appropriate, establishing a 'reconfigured' team with a new structure, task and reporting mechanism so as to distinguish the new collaboration from existing units.[157]

From the interviews, we found that overall there was a consensus that transparency and open communication are important and should be encouraged, particularly when people may be expected to work across areas. Some stressed the need to ensure good communication within the organisation, such as through mechanisms for open communication between funding body leaders and the staff involved in programme implementation,[158] while others discussed the need for transparency in the context of funding evaluation procedures and the use of consultation.[159] Other approaches suggested as ways to encourage collaboration across divisions included rotating funding body employees to different disciplines[160] and creating horizontal groups to tackle cross-cutting issues.[161]

Despite general positivity about cross-functional working, one interviewee stressed the need to respect disciplinary differences, particularly when it comes to assessment, as the UK's system becomes more centralised.[162] The interviewee said that when assessment approaches are meant to work across fields and institutions, 'in many cases that ends up doing violence to what you're trying to get to grips with, and... with perverse incentives being built into the system. If you have a more decentralised system that recognises that sciences are different from social sciences which are different from arts and humanities, then you may end up with overall a better-functioning system.'[163]

3.3.3. Networked governance

There has been a limited, but rather important, literature describing *'networked governance'* in the case of research and innovation policy which has relevance to the need to support and create networked communities within the research funding system in order to have effective collaboration. This is particularly the case when there is a need to keep different stakeholders involved, not just informed or consulted, in order to deliver effective research and innovation.[164]

The idea of networked governance arises from a concern with traditional governance structures which are often characterised by 'top-down' processes. In the face of growing interdependency and complexity of policy problems, there is a proliferation of interactive forms of governance through networks and partnerships.[165] The central premise of networked governance is that when governance problems attain a

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[157] Martin & Eisenhardt 2010

[158] Int 10

[159] Int 06; Int 20

[160] Int 21

[161] Int 14

[162] See also Guthrie et al. 2013 for a discussion of this issue in relation to research assessment.

[163] Int 13

[164] Boekhol & Arnold 2002

[165] Arundel et al. 2015

certain level of complexity, a variety of actors, both inside and outside government, can interact to create solutions that governments or other centralised governance authorities would otherwise been unable to generate by themselves.[166] Networked forms of governance therefore help to integrate distributed knowledge and capacities for problem solving amongst different stakeholders. In this way, governance networks composed of diverse participants from all scales and sectors do not merely aggregate resources but take advantage of each participant's knowledge and capacities to bring about more efficient and effective outcomes.

Many interviewees discussed the idea that establishing and maintaining a broad network of stakeholders across a research and innovation community was central to an effective research and funding body. Although the concept of networked governance was not referred to explicitly by interviewees, multiple relevant aspects were discussed. These include elements touched on throughout this synthesis such as maintaining the trust of the research community, understanding the needs and challenges faced in the research sphere, providing a knowledge brokering function between the research base and policy, and maintaining a deep connection to the emerging societal trends, issues and grand challenges that research and innovation will need to help solve. Another relevant aspect discussed was the potential to create synergy by involving actors from across the research and innovation system,[167] and looking beyond improvements in efficiency to see what else could be achieved (e.g. different types of impact).[168] Bringing together people and groups with different interests was however acknowledged to be a challenge. As one interviewee explained,

> *We've tried to… be relevant in different areas but still have constant attention on the synergies of being one organisation. I think that's something we have been quite successful with… but this is really a challenge and will be in the years to come.*[169]

Another described an approach to encourage buy-in from a diverse group based around ambitious goals and the idea that 'if it's compelling, others will want to join in,' and generate a community-driven approach to problem solving.[170]

There are numerous examples cited as networked forms of governance research and innovation which come out of our case studies and the literature. According to some authors,[171,172] the decision of Finland, Sweden and Netherlands to develop National Innovation Councils is one example of creating more networked organisations to govern research and innovation problems. The high level councils not only provide strategic intelligence but also attempt to break with the traditional departmentalisation and ministerial silos, providing better vertical integration and promote inclusion of user and stakeholders in the policy process.

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[166] Huppé et al. 2012

[167] Int 01; Int 17; Int 20; Int 23

[168] Int 14

[169] Int 23

[170] Int 20

[171] Edler et al. 2003

[172] Perkonen 2006

There are also examples of distributed forms of research, particularly from DARPA. Fuchs[173] describes DARPA's research program managers as 'network architects' who identify fruitful research directions and serve as a conduit between researchers who would normally neither communicate nor collaborate with one another. As Bonvillian[174] shows, an important part of DARPA's success can be attributed to its highly diverse, yet networked teams and organisational structure that effectively aggregates distributed knowledge and skills of individuals in a particular direction towards solving a defined challenge.

Despite the renewed interested in networked governance organisations, there is little empirical evidence on the effectiveness of networked governance structures. As Huppé et al[175] (2012) claim, achieving networked governance is a difficult process. Collaboration is an underlying principle of networked structures, but collaboration, however, is not a given. An effective networked governance process requires a certain level of social trust. Trust has to be fostered and maintained, but when there is a high level of trust within a governance network, more autonomy and self-organisation results from the stakeholders, resulting in an environment where people feel more empowered to solve problems and achieve positive outcomes for the network.

There is however a wider literature on 'networked polity' that could provide a useful insight into what makes a networked structure successful. As Ansell argued, public officials must have 'embedded autonomy', i.e. they must be 'embedded in a concrete set of social ties that binds the state to society and provides institutionalized channels for the continued negotiation and renegotiation of goals or policies'. [176] In this case, Ansell describes that the government can operate as a 'liaison' or 'broker' in creating networks and empowering non-governmental actors, especially when state actors occupy a central position in these networks.[177] This central position is often occupied by government in the case of providing support to research and science. Acting as a network broker, there are examples in the literature of how the public sector has played a role in linking research organisations, firms or individuals to facilitate dissemination of knowledge or collaborative learning,[178,179,180] or linking different actors to build communities.[181] Indeed, many interviewees discussed this element as an important part of either their own role at a research funding organisation or something they viewed as important for a research funding organisation to maintain. For example, a former high-ranking civil servant in the UK pointed out that there had been a continual drive to embed a networked knowledge brokering function within the department as this would lead to a more robust ability to know what evidence was needed for policy development, and when.[182] However, robust empirical evidence and case studies remain limited.

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[173] Fuchs 2010

[174] Bonvillian 2014

[175] Huppé et al. 2012

[176] Ansell 2000

[177] ibid., 310

[178] ibid.

[179] Amsden 2003

[180] Whitford 2005

[181] Breznitz 2005

[182] Int 04

3.4. People and organisational culture

Box 3-5: Overview of insights from the evidence on people and organisational culture

People and the organisational culture they uphold (defined as the formal and informal norms and values that govern behaviour within the organisation), are at the core of organisations and deemed one of the most important factors to take into account in organisational design and change. Three core issues emerged from our analysis: leadership should seek to create transparency; to successfully change an organisation an understanding of the culture is necessary; and, relatedly, a new organisational structure will only work is they are perceived to be legitimate.

- *Leadership needs to create transparency.* The interviews in particular emphasised the importance of leadership in creating transparency over decision making. A lack of transparency, interviewees observed, can have negative consequences such as a drop in morale.
- *Establishing the right mix of people skills and capabilities are widely acknowledged to be important for organisational efficiency and effectiveness.* There will need to be close alignment between the overall aims, functions and values of the organisation, and the skills. For example, DARPA explicitly hires staff in a way which aligns with its culture and working practices of funding 4–5 year boundary-spanning and cutting edge research projects.
- *In addition to the right people skills and capabilities, many agreed there is an organisational need for horizon scanning and evidence synthesis capabilities.* Many saw potential for a research funding body to bring system-wide benefits through the use of centralised evidence gathering and analysis to inform strategy making, priority setting, portfolio management, and other decisions.
- *A thorough understanding of the organisational culture is required to successfully design and implement organisational change.* Especially in the case of organisational changes, such as mergers or reconfigurations, it is necessary to understand what the existing organisational culture and cultural differences are. Based on this understanding a pathway for change and a new structure can be designed that either aligns with, or integrates, existing cultures.
- *New organisational structures will only work if they are perceived to be legitimate.* Legitimacy refers to the perceived validity of phenomena, such as organisational structures. Without legitimacy, it will be difficult for an organisation to operate. Legitimacy is often the result of socialisation.

Many interviewees, after talking to us about the different design features, mechanisms and governance processes in their organisations, ultimately said that 'success' all came back to the people and the organisational culture. There are multiple strands of this which emerge as supporting people and building an organisational culture, including leadership, skills and capabilities, and roles and responsibilities.

3.4.1. Leadership

Leadership and management relates to the provision of strong, committed direction which embodies the corporate mission, motivates and guides people within the organisation, and makes and delivers on long-term strategy to meet emerging needs. The case studies show that funding organisations often rely on a similar structure of leadership consisting of a supervisory board or council to help develop the strategy and vision of the organisation, or an executive board which manages the daily activities of the organisation.

This configuration is used both within government funded organisations such as the NSF in the USA or the BHF in the UK. For example, the BHF is governed by a Board of Trustees composed of 14 members,

comprising a mix of medically-qualified and lay members. The Trustees have full legal responsibility for the actions of the organisation. They are appointed for a renewable term of three years. The Board meets six times per year and delegates specific responsibilities to various sub-committees. All Trustees are also members of the Council, an advisory body compromising up to 30 members.

The RCN is another example that has a formal Executive Board which is the Council's highest authority and represents the Council externally. It is formally regulated under the governing statutes of the Council and is set up as both an autonomous research policy body that is obligated to follow up government research policy but one that also has the right to provide research policy advice independent of the government's policy. As in the BHF, the Executive Board delegates tasks and allocates responsibility within the RCN, and assesses whether the institution's internal organisation is optimal, including whether the number of division research boards and the distribution of spheres of responsibility within these boards is appropriate. The division research boards provide oversight within each research division. While members of the Executive Board are appointed by the King and consist of persons with broad insight into research, business and industry as well as overall social issues, the members of the division research boards are appointed by the Executive Board following a comprehensive stakeholder consultation process.

Most other organisations we studied through our case studies have at least advisory boards of some capacity which serve to provide advice and guidance on issues of strategy and high-level focus for the organisation. The NIH has advisory boards for every institute which provide advice and guidance, but they also convene expert workshops on topics on a regular basis in order to gain specific expertise.

The ARC does not work with a supervisory board but instead reports to, and liaises with, the government minister directly. The ARC's internal structure and decision making process is largely centralised in the hands of the CEO and Executive Directors. Externally, the Council depends on the Australian government to set research priorities and Council funding schemes aim to support those priorities. The Minister for Education and Training is responsible for the ARC. The Minister has the following responsibilities:

- Approval of the corporate plan, funding rules and proposals for expenditure under the National Competitive Grants Programme.
- Establishment of designated committees to assist in carrying out the functions of the Chief Executive Officer.
- Provides direction to the Chief Executive Officer about the performance of the Council functions, and notifies him about general policies of the Australian government that apply to the Council or its committees and staff.[183]

The literature recognises leadership as one crucial element of organisational success.[184] This literature covers more topics than could be reviewed for this study, but studies we did review highlight, variously, the impact of leadership on mergers and acquisition success,[185] change management,[186] the effect of

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[183] ARC 2015, 92

[184] Barney 1991; Castanias & Helfat 1991; Finkelstein & Hambrick 1996; Hambrick & Mason 1984; Katz 1974; Norburn & Birley 1988; and Penrose 1959

[185] Dunbar 2014

different leadership behaviours on trust in an organisation,[187,188] and the need to embed leadership within an organisation as too much top down leadership can lead to uneven employee commitment and change ownership. Ryan et al[189] argued in favour of a combination of top-down, centre-down and bottom-up approaches, which would translate into involving the middle management of the organisation in ways which could strengthen the internal change and delegate a certain amount of decision making authority to staff members to make decisions about local goals, team structure and task allocation.

From the interviews it emerged that good leadership is characterised by internal transparency as to who makes decisions and how these decisions are made.[190] Generally, greater transparency is therefore encouraged with the exception of more sensitive issues such as personnel.[191] There is a risk, according to one interviewee, that if leaders of an organisation do not provide transparency and clarity, morale will drop among the rest of the organisation.[192] While greater transparency was mentioned as desirable by the interviewees, it was also observed that too much information can distract people, creating a need to balance the level of information provided and ensure that relevant information reaches those who need it. To ensure information was being cascaded, one interviewee had, while holding a leadership position, held lengthy quarterly meetings with more junior staff to check their awareness of the organisation's initiatives as well as to hear about their concerns and suggestions.[193] IT solutions such as sharepoints, newsletters and intranet sites were also suggested as internal communication tools.[194]

Another trait of good leadership mentioned by interviewees, is the ability to delegate down decisions and activities where possible.[195] This relates to the centralised/decentralised aspect of governance, which is discussed in the next section. In this section it will suffice to reiterate a trade-off mentioned by interviewees: while good leadership is characterised by transparent and final decisions, it should not stray into micromanagement.[196]

There is some literature to further illustrate a potential correlation between leadership styles and organisational success. In a study of six Australian federal agencies, Stewart & Kringas[197] highlighted the influence of the leadership style on the success of change management within these agencies. They found that leadership continuity throughout the change process, supported with sufficient resources, led to significant positive change in performance.

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[186] Stewart & Kringas 2003

[187] Asencio & Mujkic 2016

[188] Parry & Proctor-Thomson 2002

[189] Ryan et al. 2008

[190] Int 01; Int 02; Int 10; Int 14

[191] Int 10

[192] Int 10

[193] Int 10

[194] Int 01; Int 10; Int 17

[195] Int 03; Int 14

[196] Int 01; Int 17; Int 21

[197] Stewart & Kringas 2003

Veronesi & Keasey[198] investigated the way NHS boards were structured and the impact of various board members' relationships on the boards' effectiveness. Their research suggested that too much emphasis was being placed on designing the formal structure of boards and not enough on their processes and dynamics. This had several implications. First, there was a lack of internal consultation which impeded the creation of a cohesive and effective board and which restrained decision making activity. There was also a need for substantial investment in an information system to allow the effective delivery of boards' decisions across the organisation. Finally, the need for boards' members to move from simple accountability (which relates to performance measurement and management) to responsibility was also a critical factor for the boards' decision making effectiveness as board members may lack the sector experience to go beyond the performance measures they need to hit and adopt a more general perspective to make improvements.

Finally, with specific reference to research funders, one interviewee explicitly mentioned that leaders should be drawn from the scientific community in order to enjoy legitimacy in the eyes of the research community. In addition, a leader from the scientific community would be in a better position to bring together the different divisions within a research funding organisation because they enjoy that legitimacy.[199] Interviewees also discussed inclusion of members of the scientific community on funding council advisory boards and being seconded to funding bodies in programmes (e.g. as in the NSF's Temporary/Rotator Program[200]). They said this type of involvement gives individuals the chance to learn how the organisation works[201] (information that they are likely to share with colleagues in the research community), and promotes a sense of ownership of the organisation by the research community.[202]

3.4.2. Capabilities and skills

Capabilities relate to the various disciplines and domains that an organisation or funding council will need to maintain in order to carry out its mission. The literature acknowledges the importance of people skills and capabilities for organisational efficiency and effectiveness.[203] In particular some literature insists on the crucial importance of the capacity for people to absorb and deal with the information shared within the organisation.[204] The question of capabilities and skills, therefore, comes to the question of people management. A wide range of literature sees the educational level of employees as a source of labour productivity.[205] However, Burton et al highlighted that the degree of professionalisation was not only determined before entering the organisation by the level of education, training and experience, but was also formed by people management practices.[206]

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[198] Veronesi Keasey 2010

[199] Int 21

[200] In this programme, researchers and teachers become temporary program directors for one to four years. See NSF 2016.

[201] Int 17; Int 26

[202] Int 26

[203] Carmeli & Tishler 2004

[204] See for instance the literature on absorptive capacity, e.g. Cohen & Levinthal 1990

[205] Asefa & Huang 1994; Becker 1993; Hershberg 1996; OECD 2001; Schultz 1961 in Carmeli & Tishler 2004.

[206] Burton et al. 2015

Very few interviewees commented directly on capabilities and skills at an individual level, although we have some detail on this in relation to DARPA. As summarised in the case study in the Addendum, DARPA has two main levels in its organisation: directors and programme managers. At all levels, staff are not only selected for their 'eclectic and world class' talent, but also are only appointed for 4–5 year terms. The short tenure and continual rotation of DARPA's directors and programme managers is a distinctive feature and is identified by DARPA as 'the most important contributor to continuing innovation'. This is because they know they only have a short timeframe to accomplish their goals: their end date is clearly printed on their ID cards and is a 'constant reminder to them and their colleagues that time to accomplish important work is limited'.[207] DARPA's programme managers are considered the heart of the organisation and hiring new ones is a time-consuming, yet essential, part of daily work.

> *Programme managers must be brilliant people with brilliant ideas they are passionate to develop…[they] look for an individual who is technical strong and with some project management experience, but also who has a 'rare combination of vision and practicality'.[208]*

In order to hire these people, DARPA has special exemptions from traditional government contracting practices which allow it to hire people on higher salaries than most civil servants and also to hire them quickly and expediently so there are minimal bureaucratic delays.

Aside from these insights about particular people skills from DARPA, most interviewees primarily commented on the need for an organisation to have a horizon scanning and evidence synthesis capability. We turn to this next.

Horizon scanning and evidence synthesis capabilities

In addition to capabilities and skills at an individual level, several interviewees, from both within and outside the UK, saw potential for a research funding body to bring system-wide benefits through the use of centralised evidence gathering and analysis to inform strategy setting and other decisions.[209] As one explained, 'some money needs to be spent at the centre to have an understanding about where you are, where you want to go and how to get there.'[210]

According to many of the interviewees, this centralised approach could entail: *i)* foresight and horizon scanning (which is also helpful to be more ready to respond to emerging needs),[211] and *ii)* portfolio analysis.[212] An interviewee discussing the UK context said:

> *Across government, there are functions involved in intelligence gathering and evidence… you could put those intelligence functions together and allow more evidence-based direction setting using latest data and latest techniques to set priorities for future investment.[213]*

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[207] DARPA 2016

[208] ibid.

[209] Int 04; Int 13; Int 14; Int 16; Int 23; Int 24

[210] Int 24

[211] Int 04; Int 13; Int 16

[212] Int 23; Int 24

[213] Int 16

Similar approaches have been taken by other funding bodies. The Wellcome Trust, for example, recently brought together its Strategic Planning and Policy, and Evaluation teams, among others, into a central strategy division.[214] The division's tasks include helping to track progress made, and working with the Trust's strategic funding. The NIHR in the UK also has a formal Horizon Scanning and Research Intelligence Unit which is based at the University of Birmingham. It aims to 'supply timely information to key policy- and decision-makers and research funders within the English National Health Service (NHS) about emerging health technologies that may have a significant impact on patients or the provision of health services in the near future.'[215] Their reports feed into several other agencies on a regular basis, including other NIHR research and funding programmes, the National Institute for Health & Care Excellence, NHS England, and UK national screening programmes.

Box 3-6: Horizon scanning at the Research Council of Norway

The RCN also makes extensive use of portfolio analysis to get an overall picture of research investment and activities, to inform decisions about those activities, and to input to the national government's *Long-term Plan for Research and Higher Education 2015–2024*. As explained to us, their approach to horizon scanning has four main steps.

1. Knowledge gathering is a wide-ranging environmental scanning of the national and international knowledge bases is carried out by each research division and is compared against what is required by the long-term plan. In addition, the Director General's staff reviews international analyses and foresight exercises in order to determine the direction of developments in the research and innovation system in the coming years. All of this is carried out internally.

2. Analysis of trends, drivers and various scenarios based on the knowledge gathered.

3. Priority-setting of research areas based on the analysis.

4. Development of implementation plans which specify how the necessary new knowledge base will be delivered.[216]

In the USA, the NIH looks at gaps and opportunities as part of their overall strategic planning process, but the NSF does not have a formal horizon scanning process. DARPA also does not have a formal horizon scanning process, but rather uses its programme managers as their 'eyes and ears' doing the horizon scanning on a regular basis as part of their job. As one interviewee told us, horizon scanning is useful, but is also very hard to do properly as, if you are only looking for the 'next big thing', it is usually in front of you and not on the horizon.

> *If you horizon scan for the 'next big thing' it's underwhelming. You need to do it in two ways: the societal horizon and the technical/scientific horizon and the two are very different.*[217]

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[214] Farrar 2014

[215] NIHR N.d.(b)

[216] Internal communication with interviewee. Coding not provided so as to preserve confidentiality in other parts of the report.

[217] Int 06

Related to this point, some discussed how communication about evidence and needs should travel in both directions. One interviewee described the use of 'knowledge brokers' as being critical to those working within a funding body. These brokers would have a role to translate knowledge into useful information for policy makers and also to inform the scientific community about policy interests and questions to encourage research being done is relevant.[218] Another interviewee, discussing the innovation context, described the need for funding bodies to have a role in defining and advising on policy measures, and emphasised that there should be a strong feedback loop connecting funding recipients and programme outcomes to policy design and implementation.[219]

3.4.3. Organisational culture and identity

Organisational culture is one of those intangible organisational elements to consider when designing an organisation. Organisational culture can be defined as 'the internal environment or working atmosphere as experienced by organisational employees' and concerns all members of the organisation, whether leadership teams or subordinates employees.[220] Various dimensions of organisational culture can be found in the literature. They can encompass trust, conflict, morale, rewards, resistance to change, leader credibility or blaming others for mistakes and problems.[221]

A large number of interviewees in one way or another mentioned that one of the greatest challenges in either changing an organisation, or in bringing together existing organisations, is the understanding and bridging of different cultures. Organisations work in ways that have developed into cultures over time. For governance to be effective, an understanding by leaders of the cultures is required.[222] Communication is one of the ways to understand an organisation as one interviewee observed:

> *Communication is important – with industry, academia and government. You really have to have an understanding of what are the needs, what is the goal, what are the aims of each one of these entities, and again you can only do that[…] if you really come together.[223]*

Organisational culture and identity therefore have the capacity to influence an organisation's performance through various indirect effects. Hempel et al highlighted the strength of organisational culture on the psychological well-being and motivation of employees, and therefore indirectly on the organisation's performance.[224] Hakonsson et al suggested that organisational culture has an effect on employees' absorptive capacities and therefore the way they receive and treat information shared within the

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[218] Int 04

[219] Int 16

[220] Burton et al. 2015

[221] Zammuto & Krakower 1991

[222] These points were mentioned by nearly all interviewees in different ways. It also came out strongly in a consultation with the UK research councils.

[223] Int 10

[224] Hempel et al. 2012

organisation,[225] and Carmeli and Tishler highlighted that among other intangible organisational elements, organisation culture was the most important factor to explain organisational performance.[226]

Organisational culture can also be important when organisations are going through a significant change. Looking at the case of the merger of Glaxo-Wellcome, Hailey and Balogun,[227] highlighted that the readiness of an organisation in terms of awareness of the need for change, as well as the organisation's capability for change, is necessary for the success of an organisational transformation. The authors stressed that in order to lead successful organisational transformations, organisations may have to build organisational readiness and increase change capability before undertaking the change. Though this was not an explicit focus of our interview protocol, we did find some anecdotal evidence of this occurring at the NWO as they are currently undergoing a similar merging of research funding bodies into one central organisation. DARPA has built a risk-taking and change-oriented organisational culture by rewarding risk-taking behaviours from its programme managers even when their ideas fail, for instance through nominations as 'Programme Manager of the Year'.

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[225] Håkonsson et al. 2008

[226] Carmeli & Tishler 2004

[227] Hailey & Balogun 2002

Box 3-7: Organisational culture at DARPA

A drive towards innovation is a strong tenet of DARPA's organisational culture. There are four elements which define DARPA's creative culture and long history of innovation: limited tenure and the urgency it promotes; a sense of mission; trust and autonomy; and risk-taking and tolerance of failure.[228]

Limited tenure: The limited tenure (4–5 years) of all DARPA staff means that new people are always being hired, which brings fresh ideas and enthusiasm into the organisation on a regular basis. It also means that individuals have a time-limited sense of urgency to see their innovative projects come to fruition, something which drives them on a day-to-day basis. DARPA staff also tend to look at the downsides of a long institutional memory: when it comes to innovation, some of what might be remembered by people with a long tenure may be wrong or 'stand in the way of important innovations' (p. 3).

Sense of mission: DARPA's reason for being is to 'prevent and create technological surprise', but to do so it is determined to 'change the world' through innovation. The shared ownership and awareness of the importance of this mission helps to drive individuals to succeed.

Trust and autonomy: DARPA's programme managers are given large budgets to execute their programmes, and the trust and autonomy this entails operates as a two-way street. Programme managers are trusted to execute their programmes, while the managers themselves trust the directors to give them direction when needed and to act according to the values and mission of the organisation. One of the office directors has said of this approach: 'Get the best people, then trust them.'

Risk-taking and tolerance of failure: We know that a large percentage of innovations fail before the big breakthroughs happen. Failure is celebrated, and often rewarded, at DARPA as they realise it is crucial to enabling their culture of innovation. Ideas for new programmes are more likely to be rejected because they are not ambitious enough, rather than because they are too risky. DARPA also demonstrates its commitment to valuing failure by recognising and rewarding valuable work through mechanisms such as through its annual awards to programme managers. In the past, managers with unsuccessful programmes have been as likely to be recipients for best programme manager as those with successful programmes.

The literature on organisational changes also raises the notion of legitimacy, which was mentioned by interviewees in relation to culture. It was observed that an organisational structure will only be successful if it is accepted by staff.[229] This sounds very logical, but interviewees noted that the implication of this statement is that socialisation into a new structure is fundamentally important. Designing an organisation on paper is not the same as implementing it in reality. Redesigning an organisation is not so much the search for the 'perfect' evidence-based governance structure, but for the structure that fits with the culture of the community.[230]

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[228] Insights in this box taken from DARPA 2016.

[229] Int 21; Int 15

[230] Int 15

3.5. Structure and organisational functions

Box 3-8: Overview of insights on structure and organisational functions

Structure and organisational design principles form the skeleton of an organisation and determine its relation to external actors. The following issues emerged from our analysis of this topic:

- *Autonomy of research funding organisations can be divided into two aspects: process and content.* Content refers to the topics or areas of research that will be funded, while process refers to the method by which high-quality research projects are selected (usually through peer review).
- *Larger organisations tend to be more decentralised.* Funding organisations reviewed tend to be more decentralised, in line with most large organisations. In larger organisations there is a risk that decisions will not make use of all available information if they are moved upwards.
- *Clarity over roles and responsibility is important.* Irrespective of the level of centralisation is the importance of clarity over roles and responsibilities. Especially during periods of change, clarity over roles and responsibilities is deemed very important by interviewees.

Structure and organisational design principles bring together a number of topics arising from both the literature and the interviews that touch on the internal and external relations of an organisation. External relations, mainly to government, are captured under the notion of autonomy. In essence, the level of autonomy is a measure of the degree to which organisations can self-govern. Internally, organisations also govern relations and allocate power to different levels. Organisations operate with different degrees of centralisation and the literature provides mixed evidence for different levels.

3.5.1. Autonomy

The degree of influence that government maintains over an agency, and over decision making within the agency, reflects the agency's degree of autonomy. With explicit reference to research funding organisations, one interviewee made a distinction between two dimensions of autonomy that resonated with other interviewees in subsequent interviews.[231] Autonomy applies to both content and process, where content refers to the topics or areas of research that will be funded, while process refers to the method by which high-quality research projects are selected (usually through peer review). Finally, autonomy can apply to different sections and functions within an organisation. The internal autonomy of elements within an organisation is discussed in the next section.

Among the case studies, the non-governmental funding agencies, often charities, appear to have most autonomy as an organisation, both in terms of the topics they seek to fund and the processes by which they decide on funding allocations. Organisations like the Wellcome Trust and The Leverhulme Trust have complete authority as an organisation over the strategic direction that the organisation will take. This is different from government-funded organisations such as the NWO in which the government plays a central role in defining research priorities. The NWO has a particular stream of funding called 'Thematic research and PPP' explicitly focused on 'top-sectors', which are priority areas of the economy defined by the government. Through the NWO, research funding is therefore earmarked to support these sectors.

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[231] Int 11; Int 12; Int 15; Int 21

The RCN state spending on R&D from sixteen different ministries and has internalised processes to manage the interests of multiple ministries, as described in the case study Addendum. A number of interviewees indicated that with increasing attention of governments to 'grand challenges' or strategic research priorities, there is an increasing direct influence from the top down over the content of research.[232] While this may decrease the autonomy on content, it may not affect the autonomy of the process if research councils continue to safeguard the procedures by which research projects are selected. Several interviewees referred to concerns among the research community about attempts by governments to influence research direction, indicating this was seen as unwelcome interference that is often brought about by political interests rather than evidence.[233]

In the literature the relationships between the agency and the central government are often presented in the form of a principal-agent relationship, where the agent (the agency) acts on behalf of the principal (the government) who has less information about the agency than the agency itself (asymmetric information) and needs to find some ways to ensure that the agent's interests are aligned with the government interests. This notion of asymmetric information links back to the importance of bottom-up approaches to decision making (Sections 3.2 and 3.3). Interviewees[234] also referred to the Haldane principle[235] as being an important concept for safeguarding autonomy.[236] One interviewee described the balancing of government priorities with community expertise in this way:

> *One can still have [an overarching body] setting strategic priorities and you can still work out how to deliver those priorities according to the Haldane principle, so a top-down and bottom-up approach. I think there is a role for government in identifying priorities for the country, where there are research gaps... but then the research councils and scientists need to be able to decide how best to deliver that priority.[237]*

Formal arrangements, such as statutes and the terms of reference of an organisation, determine the autonomy of an organisation. As one interviewee noted, the wording of the terms of reference of an organisation is important when it is established as it will indicate the power or strength the organisation will have. This is reflected in literature which highlights the importance of public agencies' statutes in determining its external autonomy from the government.[238] Selin outlines the capacity of an organisation's statutes to limit the influence of the government, for instance by placing limitations or qualifications on the appointment of officials in agencies leadership or fixing the terms of political

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[232] Int 05; Int 11; Int 13; Int 15; Int 17; Int 21; Int 23

[233] Int 02; Int 08; Int 11; Int 19; Int 22; Int 24

[234] Int 11; Int 12; Int 24

[235] Described in the white paper as the principle that 'decisions on individual research proposals are best taken by researchers themselves through peer review.'

[236] One interviewee (Int 16) questioned the extent to which the Haldane Principle 'is held up as untouchable in the UK,' suggesting that researchers who have been active in a particular area over many years may not be best placed to evaluate highly innovative proposals. The idea that there is a need for increased diversity among the members of the community responsible for decision making and direction setting to ensure the UK remains open and responsive to opportunities, was echoed by Int 24.

[237] Int 14

[238] Selin 2015

appointees and an official's removal. In similar vein, organisations respond to changes in funding imposed by the government.[239]

Still, in practice differences do still arise between what is on paper and what actually happens. Governments, for example, do not always exercise all their rights. Arnold described the state influence within research organisations in Germany and found that in most cases the veto right was not used as an agreement about the decision was generally achieved beforehand.[240] Furthermore, Arnold found that the research policy requirements set by the government through the supervisory boards were not restrictive for the research organisations due to their general character and the fact that research decisions were generally taken at lower organisational levels.[241] The author found that the scientific advisory council of the institution plays a more important role in putting together research programs than a supervisory board consisting of state representatives. Interviewees also confirmed that while supervisory boards have substantial power over the organisation on paper, in reality their role was often more passive and focused on providing approval for initiatives coming from within the organisation.[242]

While formal rules therefore determine the shape of an organisation, the autonomy of organisation is also determined by how the rules are applied in practice. An interesting example in this case is the development of the ESRC which shows how, in the mid-60s, the research council temporarily solved the influence of the government on research funding decisions by deciding that initiatives for research should come from social scientists in the universities, rather than being centrally dictated by the Council. This enabled the Council to mitigate the risk that government would not fund research which was potentially critical of the government. More recently, at the beginning of the 2000s, significant development of quality contacts with the government, thanks to the creation of formalised 'Concordats' with eleven central government departments and devolved governments, which has enabled them to build partnerships with the government departments on strategic themes.[243]

Some interviewees feel that full autonomy can only be maintained when both dimensions are fully under the authority of the research funding agency.[244] There is of course, no clear answer to the question what the level of autonomy of a research funding should be, but one interviewee mentioned that autonomy of research funding organisations should be seen as relatively unique and different from the autonomy of other public organisations or agencies. Comparisons with other public agencies are therefore unlikely to be useful in thinking through the autonomy of public research funding organisations.[245] In addition, it is worth noting that other, non-public research funding organisations will have their own parameters of autonomy because they are accountable to a different group of stakeholders, whilst public funding bodies are ultimately accountable to the taxpayer. Determining who should be responsible for representing the

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[239] For exemple, Sanz-Menéndez & Cruz-Castro 2003

[240] Arnold 2007

[241] Ibid.

[242] Int 19

[243] Fox 2005

[244] Int 03

[245] Int 12

best interests of the public is not always a straightforward question, as the public, researchers and the government may all have different ideas about what should be funded.[246]

3.5.2. Decentralised versus centralised organisational structures

The literature highlights that organisational structure depends on the goals, strategy and external context of the organisation. Within an organisation there are different degrees of autonomy that sectors or divisions enjoy. A concentration of decision making at the higher levels of an organisation creates a centralised organisation, in contrast to a decentralised organisation. A decentralised versus centralised structure therefore depends on the level of devolution of responsibilities from the top management to lower organisational levels. The level of centralisation tends to depend on the size of the organisation. Larger organisations tend to be more decentralised in order to accommodate increasing coordination and communication problems and thus increasing need for information exchange.[247]

Most funding agencies included in the case studies are relatively large organisations which operate with a reasonably decentralised structure. Especially the larger government funded organisations typically are decentralised to allow decisions to be made at the level where the expertise sits, for example at the division level. This is the case for government-funded organisations such as the NSF and the NIH in the USA, but also for larger non-government organisations such as the Gates Foundation.

The literature does not provide conclusive evidence for a particular approach and presents evidence of successful impacts of both decentralisation and centralisation of decision making processes on organisational performance. As the summaries below show, the suitable level of decentralisation appears to depend on the context.

A number of studies provide evidence of a link between decentralisation and organisational performance. Hope and Fraser[248] for example found that increased divisional autonomy, with managers having discretion to make decisions and being accountable for the profitability of their unit, enabled organisations to realise the full potential of radical decentralisation. This allowed large private companies to ensure enough organisational flexibility, entrepreneurial spirit and adaptability to be able to quickly react to changes. By contrast, Raynor and Bower[249] found that more direction from the centre in large and diversified private sector organisations is suitable in uncertain environments in order to define divisions' strategy and roles.

With regard to different organisational models (e.g. centralised versus decentralised), a number of interviewees echoed the observation in some of the literature that the 'right' structure depends on the context within which it is implemented. This point follows on from the earlier point about legitimacy, i.e. to succeed an organisation needs to be perceived as legitimate, as captured well by one interviewee:

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[246] Pollitt et al. 2016

[247] Burton et al 2011

[248] Hope & Fraser 2003

[249] Raynor & Bower 2001

> *There are as many different organisational models as there are funding organisations in the world – there is no 'right or 'wrong' way to do it*[250]

Trade-offs between centralised and decentralised governance structure were identified however by the interviewees. Centralised decision making for example provides an organisation with the capacity to act quickly and to make decisions that will bind an organisation to a particular action.[251] However, one governance expert noted that generally the downside of centralised decision making is that, compared to decentralised decision making, decisions made at a central level use less information in the process. The higher up a decision is made, the less likely it is the decision makers will be able to use all the information that is available at lower levels.[252] The proposition of one research funding organisation currently undergoing a restructure, is to introduce 'management from the middle'.[253] This means employees and middle management will be encouraged to take decisions and to carefully consider when to move decisions upwards.

An important point that appears to arise from the literature is the need for clarity over roles and responsibilities, irrespective of the degree of centralisation.[254] Several interviewees affirm that especially in a period of change, clarity over roles and responsibilities in a new structure is essential to ensure the new organisation will be understood and accepted.[255] Literature focused on the private sector seems to support this emphasis on clarity over roles and responsibilities.[256,257]

Finally, there is some literature that looks at the different ways in which an organisation can be organised or configured. This is summarised in Table 3-1 below.

Table 3-1 Advantages and disadvantages of various types of configurations

	Advantages	Disadvantages
Functional configuration	Efficient in stable environment	Does not allow answer to rapid changes
Divisional configuration	Flexibility	Does not foster collaborations among units
Matrix configuration	Flexibility; allows to adapt to unpredictable environment	Can be complex and costly to manage
	Handle large amount of information	Need to develop complex cross organisational coordination mechanisms
	Achieve both efficiency and effectiveness goals	Can lead to poor performance if conflicts arise and poor or costly coordination

Source: RAND Europe based on Burton et al (2011)

The literature on organisational architecture underlines that the choice of the organisational architecture depends on the goals, strategy and external context of the organisation. Typically the configuration of

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[250] Int 04

[251] Int 11

[252] Int 12

[253] Int 21

[254] Rogers & Blenko 2006

[255] Int 15; Int 21

[256] Hempel et al. 2012

[257] Rogers & Blenko 2006

units is reflected into the organisational chart, which present the division of tasks among the organisation and indicates the formal relationships among the various units. Two dimensions can be considered when thinking about the tasks division within the organisation, namely a topic-based or a function-based specialisation, which can also be a combination of both. Topic-based specialisation leads a specific configuration with an executive level overseeing each unit which are relatively independent from each other.[258] Additionally the top management sets policy for the units which can be quite detailed or remain at a general level.[259] Divisions can be further divided into functional sub-units or topic-based sub-units or have simple configuration. This type of configuration works best when low coordination is needed from the centre and units are expected to work with relative autonomy. A matrix configuration combines both topic and function-based specialisation where coordination problems are handled by managers who act as links between topic and function-based units.

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[258] Burton et al. 2011

[259] Ibid.

4. Conclusion: Applying the analytical framework in practice

4.1. A set of integrated and core principles can influence and shape the organisational culture and values

Our insights can be captured in a conceptual framework as depicted in the figure below. At the core of this framework is the place for a strategic mission and set of operating principles which support the overarching vision and mission for a complex organisation such as UKRI will be.

Figure 4-1 A conceptual framework for our analysis. The inner ring consists of four principles which are discussed in further detail in the text below. The outer ring consists of the four main analytical themes of the report and the supporting evidence for each.

It is not an aim of our work to articulate any particular set of principles for UKRI itself, many interviewees and evidence from our case studies suggest that a set of guiding, or governing principles, can help to establish the culture and values which an organisation aims to achieve, and can therefore guide organisational decisions and behaviours.

We highlight below some of the principles that emerged from the evidence we have synthesised. The first, and most frequently mentioned, of these is the *Haldane Principle*. The Haldane Principle, as it has come to be called, is derived from the Haldane Report of 1918. Viscount Haldane, at the time, argued that 'decisions about the allocation of research funding are best taken by those who have the expertise and experience to know where it will best be spent'.[260] The Haldane Principle actually has six components, though the one above is often pointed to as the main principle. All six components are:

1. That research and evidence was important to the development of government policy.
2. That each government department should provide funds to answer specific policy questions.
3. That there should be a department of government charged with funding general research questions.
4. That the choice of how and by whom that research should be conducted should be left to the decision of experts.
5. That the questions and topics to be tackled should be considered as a result of close collaboration between the administrative and the general departments.
6. That there should be a department that supports research applied to trade and industry.

Thus, Haldane does point to the importance of experts deciding how and who conducts research, but there is also an element of subsidiarity implied with a role for government to play in the process. However, it has been widely interpreted within a UK context to imply independence and autonomy of research funding decisions at a project-by-project level, in particular, from political bodies or politicians.

The Haldane principle emerged as crucial to the UK research and innovation system, in particular, in nearly all our interviews. It is already embedded in the way the research councils operate at the moment and one cannot foresee this principle losing its influence and fundamental importance within any future UKRI. Indeed, the recent white paper and the Nurse Review both place it at the core of their arguments for any future changes to the system. In practice, it means that all operations will be affected by the need to have a system which draws on the academic community for peer review, consultation on research priorities, participation in advisory bodies, and to be a trusted partner within the wider research system.

Another feature which emerged as a core facet of a complex organisation is *agility*. Agility refers to the need for any organisational design and system of governance to allow for flexibility and responsiveness to changing contexts and conditions. It is a feature of both the literature on successful, complex organisations and emerged from our interviews and case studies as an important component of a research funding organisation. Several authors have suggested there is a positive relationship between organizational flexibility and performance.[261]

Openness and transparency featured strongly throughout our review of the evidence, in particular from the case studies and the interviews. Many interviewees who are part of government funding bodies spoke about the importance of openness and transparency with the research community as critically important to gaining trust of that community and therefore having freedom to operate as a funding body. This could be achieved in many ways, for example by having regular consultations, meetings, 'pounding the

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[260] Nurse 2015, 7

[261] e.g Hailey & Balogun 2002; Hope & Fraser 2003; and Raynor & Bower 2001

pavement', getting out into the community, etc. It was also seen as a means of achieving accountability – the more open and transparent an organisation the more accountable it might be to different communities.

Finally, the introduction of impact into the Research Excellence Framework in 2014 formalised the role of *societal relevance* for government funded research in universities, but in reality the idea of funding research which is of relevance to society has been around in research councils for many years through the requirement to include statements of societal relevance, or more recently so-called 'impact pathways', in funding applications. It was also a feature of many of the funding criteria for the case studies we looked at and emerged through many interviews. As a principle, it would have an effect on the way an organisation funds research and views the work that it does.

The framework which has guided our analysis and the principles summarised above will not be wholly sufficient to design the new UKRI, but they will provide insights into some of the features that should be considered and how different organisational designs and governance arrangements operate in practice. This evidence base can hopefully serve as a fruitful starting point in discussions about organisational design of the new UKRI and its eventual governance approach to the UK's research and innovation system.

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Annex 1: Literature review methodology

Research funding literature review

Search strategy and methods used

The following questions were used to guide the search strategy and selection of search criteria:

1. What evidence is there to link research outputs/outcomes/impacts to different types of research funding organisations and governance rules in order to discern which types function better than others?
2. What empirical evidence is there about different research funding models and relative 'success' of research in a wider research system?

The searches comprised the following steps:

- Database searches were conducted in Web of Science, Academic Search Complete and Business Source Complete from 1996 to 2016. Using the search terms (research NEAR Fund*) OR (science NEAR fund*) OR (academic NEAR fund*) OR 'funding agency' OR 'research council' OR foundation OR 'national institute' OR 'funding institute' OR 'charity', as well as agency names AND Funding OR strategy OR 'science of science' or R&D AND bibliometric* OR impact OR benefit* OR publication OR (Scientific OR research OR academic) AND productivity) OR success OR outcomes OR outputs OR volume OR quality OR patents.
- OpenGrey database was searched for grey literature.
- General internet searches were also conducted in Google Scholar using additional search terms, e.g. "NSF analysis of funding mechanisms".
- UK government departments and third sector websites were checked for relevant studies.
- Citation searches were conducted in Web of Science, Academic Search Complete and Business Source Complete, using the following papers: (1)D. Guellec and B. de la Potterie, 'R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries', 2001; (2) D. Guellec and B. Van Pottelsberghe de la Potterie, 'From R&D to Productivity Growth: Do the Institutional Settings and the Source of Funds of R&D Matter?', *Oxford Bulletin of Economics and Statistics* 66, no. 3 (2004): 353–78; (3) A Salter and B. Martin, 'The Economic Benefits of Publicly Funded Basic Research: A Critical Review', *Research Policy* 30, no. 3 (2001): 509–32; (4) A. Geuna and B. Martin, 'University Research Evaluation and Funding: An International Comparison', *Minerva* 41, no. 4 (2003): 277–304; (5) D. Hicks,

'Performance-Based University Research Funding Systems', *Research Policy* 41, no. 2 (2012): 251–61; (6) B. Jongbloed and H. Vossensteyn, 'Keeping up Performances: An International Survey of Performance-Based Funding in Higher Education', *Journal of Higher Education Policy and Management* 23, no. 2 (2001): 127–45; (7) J. Wang and D. Hicks, 'Policy Screening by Structural Change Detection: Can Policies Effectively Boost Research System Performance?', in *Proceedings of 17th International Conference on Science and Technology Indicators*, vol. 2, 2012, 815–25; and on Google Scholar using the following paper: Azoulay, P., Graff Zivin, J. S., & Manso, G. (2011). Incentives and creativity: evidence from the academic life sciences. *The RAND Journal of Economics*, 42(3): 527–554.

- Talking with experts to check whether we had missed any relevant papers.

Citations identified by the search were selected for inclusion in the review in a two-stage process using the inclusion criteria below.

Inclusion criteria

- UK or overseas research funding agencies, foundations, charities, government departments or any other relevant agencies.
- Intervention – Funding strategies, organisation of funding, funding objectives.
- Comparator – What was in place before the funding strategy, organisation or objective was put in place, or compared to a different funding strategy, organisation or objective in that country or another country.
- Outcomes – Any quantitative or qualitative measure of success, including bibliometrics, publication numbers, quality of publications, patents, citations, funding decisions, research recruitment, project revenues.
- Study design – any comparative studies including those with historical controls.

Retrieved papers were screened and a master database of the literature searches was constructed by amalgamation of all the citations from various databases and sources. The citations were scrutinised by two reviewers for inclusion. Disagreements were resolved by consensus and/or arbitration involving a third, more senior reviewer. From this a full set of included studies was produced.
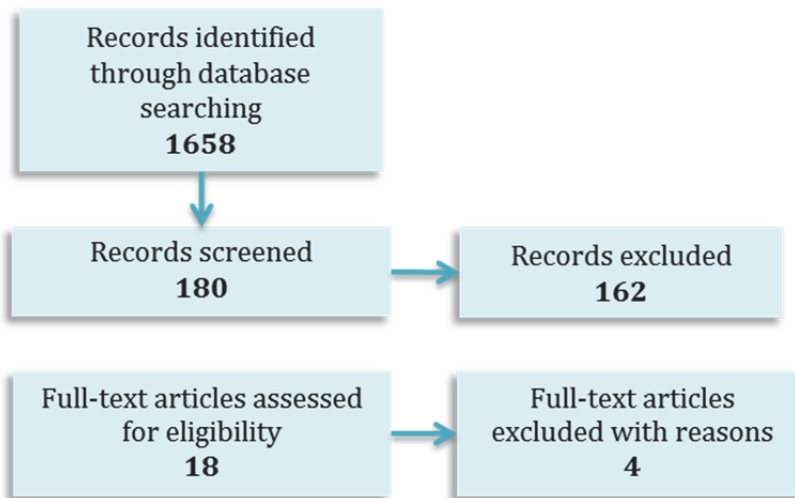
Figure A1-1: Research funding searches flow diagram showing the total number of papers identified (1658) and the numbers screened (180) and excluded (162). 18 full text articles were assessed for eligibility with four being excluded.

Data from these studies was then extracted using pre-designed and piloted data extraction forms in an Excel spreadsheet. Studies were described by details including type of organisations and setting, type of funding, comparators, outcomes assessed, study designs and numerical results if given or qualitative results as appropriate. Quality assessment of studies investigated selection, performance, attrition and detection biases as appropriate to the study designs of the studies.

Corporate governance literature review

Search strategy

The following research questions were used to guide the search strategy:

1. Are there key characteristics or principles that support the most effective and successful organisations?
2. What are the strengths, weaknesses, opportunities and threats in the following areas of public sector and corporate governance: Fiduciary care; Directors' duties; Transparency; Organisational objectives; Monitoring, evaluation, reporting; Incentives; Sanctions; Appointments; Devolved responsibility; Transitions.

The searches were similar to those for the research funding above and comprised the following steps:

- Database searches were conducted in Web of Science, Academic Search Complete and Business Source Complete from 1996 to 2016. Using the search terms ("Research funding agencies" OR "research funding agency" OR foundation OR charity OR "public sector" OR "private sector") AND ("corporate governance" OR "organisational design" OR organizational design" OR "decision-making" OR strategy OR accountability

OR stakeholders engagement OR independence OR transparency OR leadership) AND (productivity OR effectiveness OR efficiency OR accountability) AND (UK OR USA OR "United States" OR Canada OR "Western Europe" OR Singapore OR "South Korea" OR Japan OR Australia OR "New Zealand") AND (research OR report).

- OpenGrey database was searched for grey literature.
- UK government departments and third sector websites were checked for relevant studies.
- Talking with experts to check whether we had missed any relevant papers.

Citations identified by the search were selected for inclusion in the review in a two-stage process using the inclusion criteria below.

Inclusion criteria

- Participants - UK or overseas research funding agencies, foundations, charity, or agencies in country of focus; private sector and business.
- Intervention - Different corporate governance model or design or structure.
- Comparator - what would have happened without that corporate governance intervention?
- Outcomes - productivity or effectiveness or efficiency or accountability of research funding.
- Study design - any comparative study including historical control.

Retrieved papers were screened and a master database of the literature searches was constructed by amalgamation of all the citations from various databases and sources. The citations were scrutinised by two reviewers for inclusion. Disagreements were resolved by consensus and/or arbitration involving a third, more senior reviewer. From this a full set of included studies was produced.

Data from these studies was then extracted using pre-designed and piloted data extraction forms in an Excel spreadsheet. Studies were described by details including type of organisations and setting, type of funding, comparators, outcomes assessed, study designs and numerical results if given or qualitative results as appropriate. Quality assessment of studies investigated selection, performance, attrition and detection biases as appropriate to the study designs of the studies.

Annex 2: Interview protocol

Introduction and topics to be covered:

We will seek to understand whether or not there is evidence on strengths and weaknesses of practices related to the following aspects of governance, in particular for public institutions. These areas are based on our initial synthesis of evidence – others may emerge through discussion and we will cover these as needed.

- Autonomy
- Accountability
- Strategic decision making
- Organisational models
- Interdisciplinary decision making

Further explanation: We are aware not all interviewees will be able to comment on all aspects – we can focus on a few. And some interviewees will have expertise directly related to governance of public research funding systems, whereas others may have experience in funding bodies that are not government-funded, or more general governance knowledge as opposed to research funding knowledge. Questions will be adapted accordingly.

Background questions

1. Could you briefly inform us of your professional background and what your area of expertise is in relation to research funding, and governance of organisations in the public sector?

2. One of the aims of this project is to gather evidence about the governance of research funding systems and public institutions more generally.

   a. In general, do you think there is a good evidence base on this in the academic literature, or in grey literature sources?

   b. Do you think there is a literature around 'good' or 'best' practice of governance in public institutions?

3. [*For interviewees familiar with the Nurse review and recent BIS white paper*] Do you have any general comments you would like to make about these documents (your general reaction)?

Autonomy

In research funding, an influential idea is that the research community is best placed to decide what research areas should be funded.[262] On the other hand, there is also a strong emphasis on the need for publicly-funded research to benefit society and respond to societal needs. There can be a tension between the topics that are deemed of strategic importance by the government, and the topics deemed important by funding organisations or the research community.

4. How can a public body's autonomy from central government be maintained? What arrangements work better to ensure autonomy than others?

5. What governance arrangements can be used to ensure a fruitful collaboration between: central government – funding agency – research community? (e.g. consultations with the research community)

   a. How can different government departments (outside the one most closely linked to the funding system) be engaged effectively?

Accountability

6. At which levels (or in which people) should accountability lie within a research funding system (or similar body)? (i.e. Who should ultimately be accountable to whom?)

7. What common practices around transparency exist to ensure accountability exists within an organisation (e.g. between a non-departmental public body and the government itself)? Is there any evidence that some forms perform better than others (e.g. more efficient, more transparent)? This can relate to:

   i. Monitoring and evaluation

   ii. Fiduciary care and financial policies/reporting

   iii. Roles and responsibilities within the organisation.

   a. Are any practices recognised as 'best practice'?

   b. Is greater transparency always better? (If not, when could it be problematic?)

   c. How can communication within an organisation be improved?

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[262] In British research policy, this idea is commonly referred to as the Haldane Principle.

Strategic decision making

8. What common processes are used to develop new organisational strategies? Is there any evidence that some processes work better than others? (e.g. consultation, expert groups)

    a. What is the role of an executive board?

    b. What are useful ways to include multiple stakeholders so divergent interests can be managed?

    c. What are efficient processes for organisations to choose priorities?

    d. What aspects of the process should happen in the centre and what should be decentralised?

9. Are there governance arrangements that enable or restrict the ability to change strategic direction in response to new evidence or other external changes?

    a. How can greater flexibility and responsiveness be encouraged or incentivised in an organisation?

10. What are the important points to consider when designing a new organisation to ensure it is capable of implementing strategy?

    a. Is a 'strong' board required?

    b. Are particular incentives or sanctions required?

Organisational models and organisational design

11. Thinking about either research funding systems in general or the system(s) you know best, what sort of organisational model do you think would be most appropriate: a hub & spoke model (centralisation of control), multiple hub system (with various units all having a centralised control) or a completely decentralised model (and why)?

    a. Does one model allow for more flexibility and adaptability to change?

    b. Does one model better enable support for achieving the objectives of the organisation?

    c. Does one model better support top-down versus bottom-up decision making, and is that an advantage or drawback?

12. Focusing on a particular model you are familiar with, do you know how the organisational model was developed? (For instance, was it influenced by the national/local context?

Multidisciplinary strategy *(Mainly for interviewees with expertise in research funding.)*

13. What are the biggest challenges and risks in creating cross-disciplinary organisations and programmes?

    a. How might these risks be mitigated?

14. Is there any evidence that some agencies/governance arrangements are better able to support and organise multidisciplinary and or inter disciplinary research? (e.g. processes supporting cross-team

and cross-division collaboration such as cross-unit groups/committees, individuals making links themselves?)

    a.   If so, how do they run?

        i.   How is a diverse range of stakeholders brought together to collaborate effectively?

       ii.   How can cultural differences across disciplines be managed?

      iii.   What is the role of the funding agency, and specifically the board of the funding agency?