Policy capacities for transformative innovation policy:
A case study of UK Research and Innovation

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WORKING PAPER
WP 2022/04

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ISSN 2635-0122

This report can be referenced as follows:

McLaren, J. and Kattel, R. (2022). *Policy capacities for transformative innovation policy: A case study of UK Research and Innovation*. UCL Institute for Innovation and Public Purpose, Working Paper Series (IIPP WP 2020-04). https://www.ucl.ac.uk/bartlett/public-purpose/wp2022-04.

Policy capacities for transformative innovation policy: A case study of UK Research and Innovation

Julie McLaren and Rainer Kattel

Abstract

The 2008 financial collapse, climate crisis and COVID-19 have raised many questions about the sustainability of current systems and how to rebalance the impacts these have on, for example, the environment or rising inequality. A new generation of innovation policy, including a reimagined 'mission' approach, centres around using innovations to tackle societal challenges. This emphasis on directionality, coordination of different actors and policy mixes goes beyond standard science, technology and innovation (STI) or wider innovation policy, engaging other policy domains. While transformative policy measures, such as challenges and missions, are popular and there is growing research on their implementation, there is much to understand about how such models evolve in practice. A stark gap in the literature is the policy capacities to deliver more transformative missions. This article provides a case study on how UK Research and Innovation (UKRI) — the main public funder of research and innovation in the UK — is implementing a mission- or challenge-oriented approach in practice. It finds that the policy capacities for missions are not fully present, but there is evidence of those capacities emerging as policies evolve. The paper makes recommendations for how funders like UKRI can enhance those policy capacities further, and suggestions for how mission-oriented innovation policy analysis might be developed to include a stronger emphasis on policy capacities, and for further conceptual and empirical research on this aspect of mission implementation.

Keywords: transformative innovation policy, mission-oriented innovation, policy capacities, research and innovation bureaucracies

JEL codes: O38, O33, H7

Acknowledgements:

The authors are grateful to all interviewees for their participation in this research

1. Introduction

The UK boasts one of the best research and innovation systems internationally and the current government promises to boost its status as a 'science superpower' to 'play a leading role in fixing the problems of the world' (PMO 2021). But does the UK have the policy capacities to mobilise its knowledge and innovation assets, and deliver solutions to society's problems, such as net zero and how we live healthy lives? UK Research and Innovation (UKRI), the primary agency for public investment in science, research and innovation in the UK, has led on the UK's shift towards a transformative policy approach to research and innovation since the launch of the 2017 Industrial Strategy and introduction of the Industrial Strategy Challenge Fund (ISCF).[1] Since then, 23 goal-oriented 'challenges' have been launched, each led by a 'challenge director' from industry. Five years on, ISCF is changing as it incorporates learning to date and in response to wider developments in the policy landscape. This includes the government's *Build Back Better* framework (HMT 2021), the Innovation Strategy (BEIS 2021a), which supplants the 2017 Industrial Strategy (BEIS 2017), and a 2022 *Levelling Up White Paper* (HMG 2022). These initiatives are impacting on overall innovation policy and the institutional architecture for its delivery, which includes UKRI and a new Advanced Research and Invention Agency (ARIA), legislation for which is in its final stages having passed through the House of Lords (BEIS 2021b; HoL 2021).

The focus of this article is transformative innovation policies, often signified through such concepts as 'mission-oriented' or 'challenge-led',[2] and their implementation, with a particular focus on how governmental organisations that lead public investment in research and innovation, like UKRI, are developing policy capacities to design, and capabilities to implement, new measures. This new generation of innovation policies and programmes — whatever their form — does not exist in a vacuum. Recent decades have seen the aftermath of the 2008 financial crisis, divisive politics (e.g. Brexit), environmental concerns and the COVID-19 pandemic. Each of these has brought existing social issues and challenges into sharp relief. This has implications for how we conceive innovative solutions and how we design innovation policy to achieve desired outcomes. Hence, we are witnessing a rise in popularity of more directional innovation policies that seek to address urgent or complex problems and guide broader societal transformations, e.g. the transition to a green economy or post-pandemic recovery (Mazzucato 2018a; Schot and Steinmueller 2018). These transformative innovation frames emphasise the shortcomings of conventional science, technology and innovation (STI) policy models, and recognise the cross-cutting and dynamic nature of societal problems and potential solutions, thereby pushing innovation policy actors to think and act systemically (Grillitsch et al 2019).

There is a diversity to transformative innovation and there is a growing body of literature exploring, in particular in the European context, the application of missions in practice in the aftermath of their introduction as part of the EU's official STI policy mix (Mazzucato 2018a). Emerging

[1] ISCF preceded the launch of the Industrial Strategy by 12 months (see timeline).
[2] Throughout, we use the terms 'mission-oriented' and 'challenge-led' policy interchangeably with transformative innovation policy.

literature is looking at mission types, governance and policy instruments, and frameworks to guide their design and successful implementation (see Larrue 2019; Wittmann et al 2020; Biegelbauer et al 2020; Breitinger et al 2021). However, significant gaps remain, including how mission approaches are implemented in context and how those leading the delivery of missions adapt their existing policy capacities as a result (Wittman et al 2021). This includes how existing capacities are adjusted to support greater directionality, along with 'horizontal' coordination across different domains, and 'vertical' or multi-scalar coordination, to attend to both supply and demand side aspects of system-wide change. This paper seeks to contribute to this frontier of critical understanding.

Our approach is nested in growing innovation policy capacities literature (e.g. Borras 2019; Borras and Edler 2020; Karo and Kattel 2018; Kattel and Mazzucato 2018) and the main research question is how institutions leading mission or challenge-led programmes, in this case UKRI, develop and evolve their policy capacities for successful implementation. The central research question explored in the case study can be broken down into a series of sub-questions:

- How do science and innovation funders like UKRI think about their role and the value they create in supporting innovation, and how is this changing with the introduction of transformative approaches?
- How is the approach to policy-making evolving through to formulating and implementing missions and challenges?
- How are science and innovation funders like UKRI develop their capacities and capabilities for 'mission' approaches?

The case study includes interviews with current employees of UKRI and challenge directors who lead specific challenge areas, as well as other senior officers in Innovate UK, and senior managers in research councils and the Department for Business, Energy and Industrial Strategy (BEIS). The qualitative approach allows for contribution to both empirical and conceptual understanding of how policy capacities for transformative missions are interpreted and are evolving in practice.

In order to answer our research questions, the sections that follow include a review of the conceptual literature on transformative innovation and the implementation of mission-oriented innovation policies (MOIPs) in practice. This establishes the policy capacities needed for transformative missions, which also draws on the literature on policy capacities in the public sector. This is followed by an explanation of the method and overview of the UKRI case. The results indicate that the full range of capacities we might expect are not in place. However, they are emerging in spite of institutional and wider structural challenges.

2. Conceptualising policy capacities for transformative innovation

2.1 Types and characteristics of transformative innovation policy

Transformative innovation policies such as missions acknowledge that more traditional horizontal innovation policies lack clear purpose and coordination, and offer an approach that can cut across policy domains, institutions and sectors, and facilitate genuine system transformation. This promised versatility has meant they have been adopted in different ways – from state-driven innovation policy through to more bottom-up, community-led social innovation (Jannsen et al 2021; Wittmann et al 2021). Table 1 highlights different approaches to defining mission-oriented innovation policies.

Table 1. Definitions of mission-oriented innovation policies (MOIPs)

MOIP definitions	Emphasis
'a coordinated package of policy and regulatory measures tailored specifically to mobilise science, technology and innovation in order to address well-defined objectives related to a societal challenge, in a defined timeframe' (Larrue 2021, p.8)	Supply-side policy measures STI focus
MOIPs 'aim to effectively address pressing societal challenges and propel the transformation of socio-technical systems' (Wittman et al 2021, p.4)	Including demand-side societal change/transformation (but who is doing the propelling?)
'a directional policy that starts from the perspective of a societal problem, and focuses on the formulation and implementation of the goal-oriented strategy by acknowledging the degree of wickedness of the underlying challenge, and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors' (Wanzenböck et al 2020, p.3)	Complexity and role of the state in coordinating action across multiple actors

These definitions all indicate the goal-orientation and need for policy mixes (Kattel and Mazzucato 2018). However, the first emphasises more of a top-down, STI-driven approach than the others (Larrue 2021). It is a common critique of missions that they can be overly focused on supply-driven policy — via state investment in narrowly defined STI — without sufficient focus on diffusion or wider demand-side policy in complex, holistic, socio-technical systems (Brown and Mason 2014; Boon and Edler 2018; Weber and Truffer 2017).

Various studies distinguish between predominantly scientific/technological 'accelerator' missions and more 'transformational' system change missions, the latter having greater complexity and therefore demanding more elaborate forms of governance (Polt et al 2019; Wittmann et al 2020). The more tightly focused accelerator-type speaks to the attractiveness of missions to STI policy-makers for their time-bounded and measurable goals attached to more targeted scientific or technological investment. However, the problems that transformer missions are addressing — for example, the challenges brought about by aging societies or the technological and social

challenges around AI — make them more open-ended. As such, they demand a different degree of governance and coordination, including a wider set of instruments or policy mixes that interact in different ways (Borrás 2009; Flanagan et al 2011).

The OECD has undertaken the most extensive study of how countries are implementing missions in practice and it highlights a number of factors and principles important to successful implementation, including: strategic orientation (e.g. directionality, intention, legitimacy, flexibility); policy coordination (e.g. horizontality, verticality); and policy implementation (mix of interventions, fundability, evaluability, learning) (Larrue 2019, 2021). The research identifies four types of implementation: overarching mission-oriented strategic frameworks, challenge-based programmes, ecosystem-based programmes and mission-oriented thematic programmes. It finds that different types are more or less suited to the different types of mission that Wittmann et al identify, i.e. that the 'overarching mission-oriented strategic frameworks' are more suited to 'transformer' missions and come closest to the ideal mission approach (Wittman et al 2020). Meanwhile, 'challenge-based programmes' tend to focus on 'accelerator' mission types, though it acknowledges there may be a more nuanced association between different types and policies (Larrue 2021b).

In terms of problems raised by different policy types, the challenge-based programmes tend to be more focused, but also face the most significant problems between the supply-side and demand-side policy instruments, including issues with scaling initial experimentation to achieve wider diffusion, which relies on capacities to capture and reflect learning to build into new initiatives (Larrue 2021b). The OECD highlights how sensitive transformative innovation policy is to the specificities of national settings, reflecting a criticism that these policies are often not contextualised enough (Brown 2020; Edler and Fagerberg 2017). An aspect of this is institutional, in that the design of institutions, their specificity and organisation, influences their effectiveness (Breznitz et al 2018). In the case of transformative innovation policy, therefore, the history and remit of an organisation, the goals it adopts and the activities it pursues all matter in the effectiveness of these approaches (Borrás and Edquist 2013).

Work on types and design principles for MOIP implementation provides frameworks that are a useful basis for distinguishing some of the key characteristics of transformative innovation policies. These include:

- the key role of the state and/or one of its agencies holding ultimate responsibility for mission formulation and possible solutions based on socio-political inclusion and dialogue (Mazzucato 2018a; Edler et al 2021);
- emphasis on directionality or systems transformation via multi/transdisciplinary approaches and multi-sector involvement (Kuhlmann and Rip 2014; Foray 2018; Boon and Edler 2018);
- coordination in formulation and identifying possible pathways in scope, including recognition that this involves horizontal coordination across policy domains (Kulmann and Rip 2018) and vertical coordination at different geographical scales (Brown 2020; Borrás and Edler 2020);
- ability to access or mobilise a spectrum of policy instruments and/or create new instruments recognising that missions can involve both development and implementation

of the 'new' and phasing out of the 'old' practices and technologies (Kivimaa and Kern 2016); and

- agility and flexibility in the direction and targets, as well as the means and approaches to implementation.

These highlight the difficulties for STI policy actors leading these approaches in establishing governance and frameworks for aligning a broad set of elements and actors to achieve system transformation (Boon & Edler 2018; Kulmann and Rip 2018).

While there is a growing theoretical and empirical literature on mission characteristics and implementation, there has been little to no focus on the individuals and institutions leading the transformative innovation approach, and the capacities and capabilities that come into play when deploying missions (Janssen et al 2020; Larrue 2021). This is a major gap in the current literature — both theoretically and empirically — including how organisations are adapting to deliver these more conscious and complex approaches, and what policy capacities they need to develop for their implementation (Piening 2013).

2.2 What can we theorise about policy capacities for transformative missions?

Policy capacities are perceived as playing a pivotal role in effective governance and seen as fundamental to unlocking innovation (Gieske et al 2016). As such, policy capacity has emerged as a major concern of governments seeking to address complex problems (Wu et al 2018; Peters 2018). The concept of policy capacities draws from public policy and public administration research, and most define it from the perspective of governments' ability to: 'marshal necessary resources to make intelligent collective choices and set strategic direction for the allocation of scarce resources to public ends' (Painter and Pierre 2005 p.2). Others, however, use more expansive definitions, highlighting additional factors, including government's role in *implementing* policy as well as making choices, for example to include non-governmental or private actors (Wu et al 2018).

In innovation policy literature, policy capacity discussion has focused on the role of individual agencies. Thus, for instance, older industrial policy-based discussions focused on the so-called 'embedded autonomy' of central agencies (Evans 1995). This has also been understood as the transformative capacity of the state to initiate structural change in the economy (Weiss 1998). In more recent and STI policy-focused discussions, such notions of capacity have been complemented by what can be called the Schumpeterian alternative. Above all, Breznitz has shown that some of the key innovation agencies in the US, Finland, Sweden, Israel, Ireland and Singapore were not central agencies, but rather (at least initially) peripheral agencies (Breznitz and Ornston 2013; Breznitz, Ornston and Samford 2018). These agencies were crucial sources of the policy innovations necessary for promoting rapid innovation-based competition through explorations in innovation policy, driven partially by continuous, radical experimentation in their core mission and by the existence of sufficient managerial capacities (or slack) (Karo and Kattel 2014). As Kattel et al have argued, such central-peripheral dynamics are in fact key

to understanding how policy capacity evolves in the dynamic of multiple organisations interacting (2019).

A third important discussion in innovation policy capacity has focused on the impact of managerial reforms — the so-called New Public Management (Pollitt 2007; Drechsler 2005) — in the 1990s leading to the rise of relatively autonomous STI agencies with a focus on competitive grants, project management skills and the outsourcing of some of the key functions (e.g. peer-review), and the rise of market failure-based evaluation frameworks (Kattel et al. 2018; Suurna and Kattel 2010).

Crucially, by definition policy capacities for missions cannot be understood in a purely institutional sense (Edler 2021) and market failure-based evaluation is a poor guide for societal challenges (Mazzucato 2021). Thus, transformative innovation policies call for a more expansive definition of policy capacities that focus attention on a meta-level of governance and the capacities of a constellation of actors, across public, private and civil society organisations (Kuhlman and Rip 2018). As such, they can be said to entail the effective coming together of both the endogenous capacities of the organisation(s) leading missions, and the exogenous capabilities of a wider network of agents and institutions, that contribute to the development and diffusion of innovation, and the ultimate success of a societal mission (Hekkert, et al 2020).

It is certainly the case that missions demand a broad range of capacities and capabilities in the lead organisation(s). These are best understood as a multi-level construct to include individual, institutional and network capabilities (Gieske et al 2016). At individual and institutional levels this includes capacities of sense-making for conceptual understanding and to navigate the system or systems the mission is seeking to influence (Edler et al 2021; Kuhlmann and Rip 2018). In a wider organisational context, lead organisations are also required to support networked systems of governance, thereby exercising their 'transformative power' though establishing frameworks for coordinating complex mission formulation and implementation (Weiss 1998; Kuhlmann and Rip 2018). The network of actors in any given mission are also embedded in wider power structures, and the contested nature of missions and possible solution pathways mean those leading need to be able to engage and attend to those power relations, to build legitimacy and to influence wider systems, while not being captured by those interests (Wanzenböck et al 2020).

Operational capacity is also needed at all stages of mission formulation and implementation, including expert functions for evidence gathering, coordination and learning. The timescale involved in missions and the often iterative and dynamic nature of the mission itself means this capacity needs to be agile (with flexibility of systems, governance and funding) to change direction when needed (Weber et al 2021). This also highlights the need for ongoing monitoring and evaluation that builds in reflexivity and learning throughout the mission design and implementation (Molas Gallart et al 2020).

While some of these capacities and capabilities will already exist in a lead STI institution, it may require an organisation to evolve its capabilities and/or bring in external expertise, e.g. those with particular experience of the mission area and relevant systems. Hence, a further aspect to institutional policy capacities is the degree of ambidexterity, including the ability to innovate and integrate new capabilities (Gieske et al 2016). In this respect, capacities and capabilities for

transformative innovation might be best understood in a more dynamic sense as an evolving set of routines and practices (Karo and Kattel 2018).

Bringing together the literature on transformative innovation policies such as missions, their characteristics and features, and the literature on policy capacities and capabilities helps to envisage the sort of capacities we might expect to be present or under development in a lead organisation for transformative missions. Thus, we can formulate the following theoretical expectations:

- *Navigation and dynamic portfolio management*: Missions are defined by their directionality and goal-oriented nature (Larrue 2019). However, that direction isn't fixed; it requires ongoing navigation, sense-making and appropriate frameworks for mission formulation and coordination (Wanzenböck et al 2020). Navigation relies on capacities for deep conceptual understanding of the mission and the analytical skills to identify system conditions, monitor change and influence narratives and direction (Edler et al 2021; Kuhlmann and Rip 2018). In this sense, it is closer to the capacity to use a compass effectively than the ability to read a static map. This also includes capacities to curate portfolios of projects, and to utilise and influence a range of funding instruments and policy mixes, including those in STI, but also beyond into other domains (Kattel and Mazzucato 2018). It also relies on the agility and levers to change direction via governance arrangements and/or within a portfolio (via instrument/investment adjustments) as needed (Kulmann and Rip 2018; Kivimaa and Kern 2016).

- *Connecting and coordinating*: Missions need to be understood in a wider organisational context to include the range of actors that contribute to the mission formulation and implementation (Wanzenböck et al 2020). This relies on capacities in the lead organisation to facilitate both intra- and inter-organisational collaboration (Gieke et al 2016). *Internally*, this means information sharing and establishing trust by connecting the necessary capabilities (cross-discipline, sector, specialist, organisational) for knowledge diffusion and innovation (Lin 2007). It can be supported by establishing cross-functional teams (Jansen et al 2005); and a potential shift from 'organisation as machine' characterised by vertical lines of reporting and decisions, to 'organisation as living system' with agile teams, matrix management and end-to-end accountability (Laloux 2014).

  Missions also rely on the capacities of a lead organisation to coordinate and nurture strong external collaborative networks, including at different scales — local, regional and national (Borrás and Edler 2020). These informal and formal interactions are key to building legitimacy and accountability for the mission (Wanzenböck et al 2020), and for ensuring wide diffusion and transformative systems change. Sharing or attributing roles or tasks across the membership can help sustain these wider networks (Gieske et al 2016), and therefore capacities for building equitable partnerships or devolving responsibilities and/or resources can play a key role.

- *Learning and reflexivity*: Mission policies are complex and require significant capacities for learning and reflexivity in the lead institution (Larrue 2021). This includes more formal performance management practices, including embedding learning and evaluation at programme and mission level, which in turn informs mission direction and system-change pathways (Kattel and Mazzucato 2018). However, it also requires an ability to stimulate creativity around the mission process, embedding a double-loop learning approach whereby learning and reflection is being captured throughout, engaged with critically and incorporated into future practice within the organisation or the wider mission (Jeppesen and Hauan 2017).

  Missions also demand a degree of ambidexterity at organisational level, i.e. the ability to balance incremental innovation alongside more explorative actions and activities, e.g. risk-taking and experimentation, thereby deploying resources in ways that mean more transformative innovation is achieved (Gieske et al 2016; Jansen et al 2005).

These categories are summarised in Table 2. and provide a framework for analysing the implementation of these policies in context.

Table 2. Framework for analysing policy capacities for transformative missions

Capacity	Indicators/keywords
Navigation and dynamic portfolio management	▪ *Goal-oriented* – mission type and behaviours ▪ *Frameworks* – for mission formulation, system change pathways and lifecycle ▪ *Portfolio and policy mixes* – combining different instruments including standard STI and beyond (supply and demand/wider diffusion) to create portfolios that address the mission ▪ *Levers for changing direction* – via governance and within a portfolio (e.g. discontinue investment)
Connecting and coordination	▪ *Internal to mission lead organisation* – a shift from organisation as 'machine' to 'living system' (e.g. agile teams, matrix management, end-to-end accountability) ▪ *External Networks (including at different scales – local, regional, national)* – building legitimacy and accountability for the challenge
Learning and reflexivity	▪ *Ongoing and reflexive learning* – performance management and evaluation at programme and mission level ▪ *Influencing/changing practice* – applying double loop learning to influence internal practice and in government and/or wider network

3. Methods and data

3.1 Methodology

This paper explores how transformative innovation policy approaches are being implemented in the UK's primary public funding institution for science, research and innovation. While the institutional setting is UKRI, the study recognises that transformative missions extend beyond, which is reflected in consideration of how UKRI is evolving its capacities to deliver across a wider set of domains.

The case study methodology was chosen to provide a rich understanding of how mission approaches are being interpreted and implemented in practice. The case study approach enabled a combination of inductive and deductive reasoning via observing an organisational interpretation of missions and challenges in a dynamic policy setting, where political shifts and organisational changes contribute to the evolution of strategic frameworks for innovation, and therefore missions sit among more traditional frames of innovation and modes of delivery. However, it also looked for evidence of how UKRI is evolving its practice for delivering missions against the sorts of capacities identified in the theoretical analysis of missions and policy capacities set out in the previous section.

The case study drew upon documentary review, analysis of specific mission/challenge approaches to supporting innovation and 14 interviews with UKRI staff, challenge leads and senior managers in individual research councils, Innovate UK and BEIS, all conducted via Zoom. Choice of interviewees was initially based on identifying key individuals involved in challenge-based innovation and/or place-based innovation policy and implementation; further interviewees were added via a snowballing sampling approach by asking for suggestions from interviewees based on subject matter and areas of focus (Weiss 1994). This was deemed an appropriate method in this context where representativeness was not a necessary standard for the overall sample (Small 2009).

The thematic analysis was based on transcription of each interview, which were coded against the capacities identified in the theoretical analysis, but also allowing new themes to emerge. The case study uses an 'optimistic research' approach, which included drawing out examples of where policy capacities were evident or developing, along with a constructive approach of helping practitioners reflect on how they are supporting change (Bogdan and Taylor 1990). This allowed for bridging between practitioner knowledge and empirically grounded research, thereby creating research outcomes that are useful to participants in their own ongoing reflections. Behind everything was a self-reflective process given one of the author's previous experience working at research councils in the UK, and in the research and innovation sector more generally.

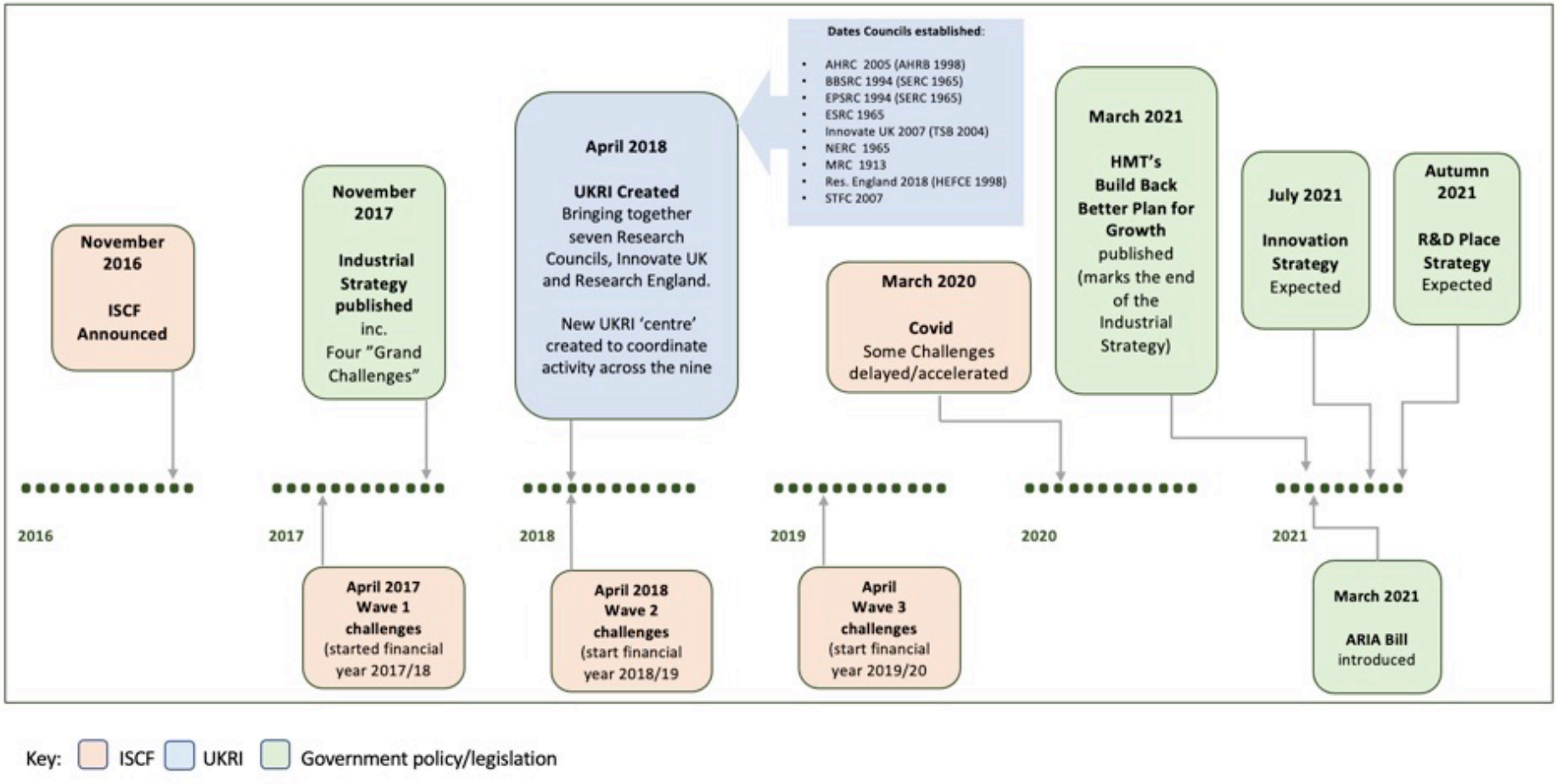
3.2 Case study overview

UK Research and Innovation

UK Research and Innovation (UKRI) is a non-departmental public body, created by the Higher Education and Research Act 2017, which brings together nine separately chartered organisations (see Figure 1). With an annual budget of £7908 million in 2021/22[3] and 7463 staff,[4] UKRI's purpose is to 'invest in and facilitate research and innovation activities across the UK' (BEIS 2017 p.6). It is managed by an executive board comprising the UKRI chief executive officer as chair and the executive chairs of each of the nine organisations, along with senior officers from BEIS, and is governed by a board made up of the chair, CEO, chief finance officer and between nine and 12 independent members drawn from higher education, industry and commerce, policy, charities and other non-governmental organisations (BEIS 2018). UKRI's Corporate Plan sets out its mission *'to convene, catalyse and invest in close collaboration with others to build a thriving, inclusive research and innovation system that connects discovery to prosperity and public good'* (UKRI 2020b, p.6). While a relatively young organisation, the various constituent organisations in UKRI have been in existence for longer periods and have their own histories. These trajectories have shaped organisational cultures and practices, and resulted in the development of discipline- or sector-specific understandings of research and innovation approaches. UKRI also includes a core resource providing strategic and coordination capacity, as recommended in the Nurse Review that led to UKRI's establishment (BEIS 2015). The timeline at Figure 1 sets out the key dates of relevance to this study.

[3] This is £403 million (5%) lower than the 20/21 budget, primarily accounted for by a £284 million reduction in Overseas Development Aid (ODA) (BEIS 2021c).
[4] This is for 2019/20 (UKRI 2020a).

Figure 1. Timeline showing the creation of ISCF and UKRI in the context of government policy for industrial/innovation strategy



Source: Adapted from a version in the 2021 audit of ISCF (NAO 2021)

Industrial Strategy Challenge Fund programme

UKRI leads the Industrial Strategy Challenge Fund (ISCF), an 'industry-led' programme to support the government's aim to raise long-term productivity. Established by BEIS and launched in 2016 using funding from the National Productivity Investment Fund (NPIF), the budget for ISCF is £3.0 billion from 2017/18-2024/25. At January 2021, £1.2 billion of that had been committed across 1613 projects, leveraging a further £567 million from industry against a co-investment target of £2.8 million (NAO 2021). That funding is geographically concentrated with circa 63% going to organisations in London, the Southeast and West Midlands, a pattern not fully explained by the distribution of businesses undertaking R&D (ibid.). ISCF aims to tackle four 'grand challenges' published in the 2017 Industrial Strategy (see Table 3): clean growth; aging society; future of mobility and AI and data economy. To date there have been three funding waves supporting 23 individual challenges. Each challenge has a number of objectives (e.g. for the audience of the future challenge, the objective is that the UK creates 10% of global creative immersive content). Both BEIS and HM Treasury play a role in scrutinising and approving spend from the fund, based on prepared business cases.

Table 3. ISCF challenges by funding wave

Grand challenge	Wave 1	Wave 2	Wave 3
Aging society (£607m)	▪ Medicine manufacturing (£207m)	▪ Early diagnosis and precision medicine (£223m) ▪ Healthy aging (£98m)	▪ Accelerating detection of disease (£79m)
AI and data (£302m)	▪ Quantum pioneer (£20m)	▪ Audience of the future (£39m) ▪ Commercialising quantum technology (£153m) ▪ Next generation services (£20m)	▪ Digital security by design (£70m)
Future mobility (£770m)	▪ Faraday battery challenge (£318m) ▪ Self-driving vehicles (£26m) ▪ Future flight (£125m) ▪ National satellite test facility (109m) ▪ Robots for a safer world (£112m)		▪ Driving the electric revolution (£80m)

Clean growth (£1049m)	▪ Transforming construction (173m) ▪ Transforming food production (£90m) ▪ Prospering from the energy revolution (£108m)	▪ Industrial decarbonisation (£170m) ▪ Smart sustainable plastic packaging (£60m) ▪ Low-cost nuclear (£235m) ▪ Manufacturing made smarter (£147m) ▪ Transforming foundation industries (£66m)

UKRI operates within a specific economic and political context which creates enabling and constraining factors in how it practices its support for innovation. This includes shifts in policy, like the switch from the 2017 Industrial Strategy to the 2021 Innovation Strategy. These changes are not expected to alter the course of goal-oriented research and innovation, though they may have implications at a conceptual level (i.e. the particular grand challenges) and in practical terms (the scale of funding or the inclusion of other criteria such as 'levelling up').

4. Findings and discussion

This section includes an overview of the findings, beginning with an analysis of specific issues and general findings relating to the operation of UKRI and the establishment of ISCF, before moving on to the policy capacities and capabilities for ISCF challenge design and implementation. These are summarised more fully in Table 4 and are mapped against the policy capacities set out earlier (in Table 2), including positive indications of where policy capacities were present or emerging alongside identified gaps or where they were less prevalent. This is followed by a narrative providing examples of specific issues or illustrative evidence under the three policy capacity headings.

4.1 UKRI organisational leadership of ISCF

The interviews with key staff indicated that UKRI is still establishing its role in the wider ecosystem and the balance across the core aspects of its remit: namely science (or research) and innovation. Currently research and innovation appear to sit a little uneasily together in UKRI. The 'how' of innovation investment was explained by several respondents in the dichotomous language of science push (research councils) or business pull (Innovate UK), though there was recognition it was not quite so simple in practice with all nine organisations investing in research and innovation in multiple ways. There was also evidence of tension in the balance of investment between science (or research) and innovation. This was felt keenly due to UKRI's budget being

under recent pressure (i.e. with changes to Overseas Development Aid having led to a reduction in the Global Challenges Research Fund budget).

Related to this was a perceived imbalance of power on the UKRI Executive, which is seen by some to favour investment in research over its role in innovation, if only by voting numbers (i.e. seven research councils to one Innovate UK), leading one respondent to remark: 'UKRI management don't see innovation as a core part of their thing' (Interviewee 10).[5] In addition, several respondents referenced the appointment of a new *CEO* for Innovate UK (emphasis on the language of CEO as a departure from the executive chair roles leading the individual councils) as a significant moment that could help clarify Innovate UK's purpose and role within UKRI's overall strategy.

The ISCF programme has marked a new way of working for UKRI, bringing these key roles in research and innovation closer together. A focus of this paper is whether and how UKRI is developing its policy capacities for this more intertwined way of working, and evidence points to this being a work in progress at best. As one respondent put it: 'This integration of innovation and research is going to be absolutely critical and I'm not sure UKRI is really… well, they can continue to learn about how to do that' (Interviewee 2).

Operationally, there is a growing team at the centre of UKRI. Several respondents remarked on this being 400+ strong (larger than two of the individual councils in full-term equivalence), but that it had not yet fully established agile and/or matrix ways of working across the nine entities that would support ISCF: 'We have had no input from UKRI central and it would seem that is one of the problems of framing up that mission/challenge based stuff' (Interviewee 1) and also the recommendation: '[The] first thing it's got to do [is] work out its own devolved processes' (Interviewee 9).

4.2 ISCF evolving challenges

The emergence of ISCF and its pace meant a pragmatic formulation of wave 1 challenges drawing on internal knowledge and expertise. These were primarily framed in terms of accelerating technological change (see Table 3): 'For wave one, because that happened before the industrial strategy it didn't really have a framework. I guess, [it was] more, you know, "What's the big, interesting things that we all sort of know that the UK should map against"' (Interviewee 3).

Wave 2 then coincided with the launch of the Industrial Strategy in 2017/18 setting out the grand challenges against which all challenges have been mapped subsequently (see Table 3). It also coincided with the Industrial Strategy's 'sector deals'[6] and challenges aligned with the promises set out in those: '…and then wave two was launched at the same time as the Industrial Strategy so they had a bit of a sector flavour' (Interviewee 5).

[5] To maintain anonymity, interviewees have been randomised and allocated a number.
[6] Sector deals are a partnership between government and industry to focus attention and resources on sector-specific issues to boost productivity and innovation. Relevant challenges in ISCF have sometimes been aligned to or an integral part of a sector deal (e.g. Construction Sector Deal and the Transforming Construction Challenge).

A wider consultation helped identify wave 3 challenges, drawing more than 250 responses, mainly from business, government and researchers, which were then sifted down to ten challenges, including areas that were 'matched up' or synthesised, e.g. foundational industries, which combined several submissions.

The challenge 'type' has evolved: though the majority retain a focus on either technological solutions or transforming sectors, there are some that include a more societal emphasis, e.g. healthy aging. That said, from the examples looked at in more detail, none could be described as focusing solely on technological solutions and the interview responses indicate that the pathways or possible solutions are more complex:

> [T]rying to put all of that sort of stuff together in a holistic, whole system way where whole system doesn't just mean the technical system and it means you know what the consumers actually want to pay for, what finance want to finance, what regulators want to regulate, and [then] how does the technological piece play into that (Interviewee 2).

Multiple objectives and evolving narratives

The purpose of ISCF and individual challenges mean different things to different actors across UKRI and BEIS. ISCF is an ambitious programme and government is looking for it to contribute to an increasing number of objectives, including its commitment to raise spend on R&D to 2.4% GDP and, more recently, commitments to the net zero and 'levelling up' agendas (NAO 2021).

The driver to unlock investment from the private sector has been present since its inception. This is not surprising given the growth in private sector R&D since World War Two has meant the state's role in innovation had become more focused on finding ways to incentivise the private sector to invest and indeed some see this as a factor in the popularity of mission approaches (Edler et al 2021). However, here it was also recognised as a potential point of friction with the concept of 'missions' and systems change. It also raised operational challenges around dynamic portfolio management (i.e. difficulties in discontinuing investments that are co-funded):

> [S]ome of the stuff we've been doing are sort of missions and challenges, but how do you develop a programme which is predominately co-funded? I think what we've been trying to do with the challenge fund, you know, one of the requirements, from both politicians, but also officials, was how do you help encourage industry to invest? (Interviewee 5).

> [A] big drive to make [ISCF] happen was getting industry money on board. That driver to make it happen was, 'Can you prove to me for every £100 million of government investment you've got £200 million from X, Y or Z.' That was the driver, not a whole system approach (Interviewee 9).

In reality ISCF seeks to address multiple agendas, including changing political priorities, whether at the level of the ISCF programme or individual challenges:

> [B]ecause there [are] so many good things one can do, what you're trying to do is think about, 'How does this deliver against multiple agendas?' You [referencing

> interviewer] talk there about a portfolio approach or a fit with missions/grand challenges, however you might frame them. The other bit would be – what does that mean in the context of levelling up? What does that mean in the context of carbon reduction? What does it mean in the context of skills? And when we were trying to make choices, we were trying to look at those things and so part of the portfolio is about – does it address several things? (Interviewee 5).

A shift can be seen in the narrative around the ISCF programme, adjusting to a language of addressing *societal* challenges. For those working at the heart of UKRI and preparing for how ISCF will feature in the Innovation Strategy, it is an: 'experimental way of thinking about innovation, so rather than targeting sectors or disciplines, as we were more used to in the UK, we targeted industrial and societal challenges or problems' (Interviewee 3).

However, for others who have observed ISCF from the beginning, those changing narratives are just that, and don't fully reflect the more complex reality of ISCF and its evolution:

> I don't know if you followed that whole evolution of the Innovation Strategy and its approach to missions. [UKRI] was tasked with reconciling the unreconcilable and ended up producing a paper that everybody could sign up to, apart from anybody who knows anything about it. So, it was fine if [they were] talking to number 10, BEIS. But as soon as [they] introduced it to anybody who knew anything, then the fact that [they'd] made the language line up didn't convince anybody, because you can't make the things line up (Interviewee 10).

Table 4. Interview coding: summary of findings

	Evidence of policy capacities for transformative missions/challenges	Areas of weakness/gaps
Navigation and dynamic portfolio management Keywords (from Table 2): ▪ *Goal-oriented* ▪ *Frameworks* ▪ *Portfolio* ▪ *Levers for changing direction*	▪ **Goal-oriented** – challenges including some with systems change focus. ▪ **Frameworks** – strategic and programme frameworks for challenges are evolving, i.e. that look beyond funding cycle and deal with uncertainty/multiple pathways (though not yet embedded fully in practice). However, level of autonomy in decision-making at mission level is fuzzy. ▪ **Portfolio/mix** – standard UKRI/STI investments though some examples of challenges innovating with new funded entities and ways of integrating research and innovation, e.g. short and long loop research investments working alongside demonstrators and other innovation investments. Also seeking to influence other innovation policy levers/levels, e.g. regulatory policies, local innovation systems. ▪ **Levers for change** – can be built into funding design, e.g. state-gates. Discontinued projects are still a small minority. Within portfolio, agility relies on investment lead university/PI flexibility to change direction or focus.	▪ **Goal-oriented** – on balance majority technology or sector focused. More traditional innovation frames dominant though appetite for systems approach. ▪ **Frameworks** – for engagement to inform Challenges could be wider (and is recognised as a shortcoming or gap). Governance around missions: predominantly government, business and research actors. No guidelines to shape engagement at challenge level (though evidence based on select challenges suggests it is broader at that level) ▪ **Portfolio/mix** – tension in balance of research (long term, 'blue sky') and innovation. Constrained in part by what UKRI funding can do and decision-making rules/culture (though informal workarounds common). Reference to creating a funding instruments 'playbook' for use across challenges. ▪ **Levers for change** – at programme level: constrained by lack of agility in government. Scale of funding means greater HMT scrutiny of changes to original business case. However, Covid has provided a precedent for greater flexibility. Lighter touch process for revision of business case and higher tolerances for budget virement are needed. Other barriers to portfolio change: potential

		for tension with private co-investment (i.e. stopping investments that are co-funded).
Connection and coordination Keywords (from Table 2): ▪ *Internal to UKRI* ▪ *External networks (including national and local/regional)*	**Internal** ▪ Appointment of challenge directors with external business expertise seen as positive overall. Becoming an expert community in own right within UKRI. ▪ Cross-UKRI engagement in challenges has increased as challenges have evolved (specific references made to positive of growing involvement of social science input into innovation & diffusion). **External networks** ▪ Differs by mission and at different levels: range of actors narrower at governance level and increases at portfolio level. ▪ Evidence of involvement of local actors in some challenge investments (i.e. local authorities and expectation this will expand with 'place' emphasis at national level). ▪ Challenges connect well with other parts of the innovation infrastructure e.g. catapults. ▪ Examples of novelty in engaging broader stakeholders in challenges (e.g. use of arts, performance). ▪ Regional managers in Innovate UK and EPSRC (separate teams) connect local actors to funding	**Internal** ▪ Challenge teams not fully integrated in UKRI. ▪ Ability of challenge teams to draw on resource across organisation is constrained by UKRI silos and hierarchies and needs more agile teams/matrix approaches. ▪ Communication across challenges is ad hoc. **External networks** ▪ Depends heavily on challenge director capabilities and network. Some have deputy directors (also industry or internal). May need to broaden expertise to achieve real systems change i.e. pilot directors or deputies from other sectors/backgrounds. ▪ Little to no delegation of challenge responsibilities to actors beyond UKRI. Some delegation and devolution of funding to be dispensed by portfolio investments (not systematised at this stage). ▪ Governance needs to reflect wide range of stakeholders for each challenge (going beyond usual actors). ▪ Scope to expand engagement of local actors in shaping challenges. Existing capacities/ capabilities could also play more of a role i.e. catapults and regional teams.

	opportunities and enhance UKRI knowledge of local strengths, ambitions etc. (not limited to challenges).	▪ Danger of 'missions and place' being overly politicised as a blanket requirement, though innovation strategy and place-based R&D strategy may clarify.
Learning and reflexivity Keywords (from Table 2) ▪ *Ongoing and reflexive learning* ▪ *Influencing practices*	**Evolution of challenge approach** ▪ Challenges types have evolved since first wave – including some that are societal and/or more complex. **Ongoing and reflexive learning.** ▪ Performance management becoming embedded in challenges – logic models, learning frames and evidence of date being used to inform direction. ▪ Example of sharing learning around user-centred design across challenges with the aim of embedding that further. **Influencing change in practice.** ▪ Embedding use of programme management methodologies. ▪ Active portfolio management, i.e. challenge directors sharing monitoring data collected with portfolio investments – leading to changes in focus/new opportunities.	**Evolution of challenge approach** ▪ Overall emphasis still balanced towards science or technological innovation. **Ongoing and reflexive learning.** ▪ Evaluation of ISCF underway (nothing publicly available as yet). ▪ Limited evidence of systematic sharing of practice across challenges. **Influencing change in practice.** ▪ Little to no evidence of formal change in standard procedures, i.e. decision-making practices to ensure highest quality aligning with challenge goals (some examples of gradual change in norms i.e. willingness to look at balance of portfolio alongside quality but not consistently applied). ▪ Little evidence of ambidexterity in balancing incremental approaches with more experimentation and risk taking (however, would warrant further research to fully determine this aspect).

4.3 Policy capacity I: navigation and dynamic portfolio management

Goal-oriented/innovation frames

Mission approaches are not delivered in a vacuum, they're embedded in institutions that have norms, belief systems and practices, all of which influence how investment in innovation is perceived (Larrue 2021). ISCF is not wholly viewed in terms of addressing a 'mission' or effecting systems change. In fact, several respondents described UKRI's role in innovation and the purpose of ISCF in a more traditional 'market-fixing' frame: 'Where there is a market failure, as you know, government will stimulate the market by creating an artificial market' (Interviewee 4). Challenges were viewed by some as purely another means to incentivise industry to invest, perhaps not entirely surprisingly given the 'industry-led' emphasis of ISCF.

However, those more closely involved also recognised the complexity of innovation and the need for direction: '[There's a] real push to think more in terms of systems… [an] appreciation of the complexity of innovation and… [for] innovation with purpose' (Interviewee 3). This more purposeful systems language was also echoed in how most respondents described UKRI's organisational roles as 'investor' in research and innovation, not merely 'funder'.

These different frames were apparent around the value of UKRI's role in innovation too, which many described in terms of increasing the rate of economic growth. As one respondent made clear: 'Economic outcomes are a massive thing for UKRI' (Interviewee 3). However, there was nuance in this, including reference to 'sustainable economic growth' being the preferred terminology in strategy and policy documents, though also reference to any ambiguity in that being seen as advantageous.

Frameworks

ISCF challenges are often long term, though in the first instance the funding commitment for them might be just 3 to 4 years in duration. This creates difficulties for those facilitating the process in terms of the strategic-level navigation needed for formulating the challenge and carving a path, particularly when medium- and longer-term needs are less clear.

Respondents at the centre of ISCF reported a more open-ended way of working as something they were moving towards, including seeking to configure relevant principles and practices into governance and programme architecture. This, however, is a work in progress:

> Big missions: let's call it a ten-year strategic goal. To do that, there are all the stepping stones across that big river that you need, from UKRI and beyond… the reality with those stepping stones is a colossal amount of management to make sure we're spending on the right things. I think governance in one way is misleading on this because [what] you need to do is think about — what's the big framework to help these things to happen (Interviewee 8).

Portfolio mix

The portfolio mix has remained predominantly STI-focused so far, utilising standard UKRI investment tools and mechanisms. However, within some of the challenges there is evidence that investment in research and innovation is becoming a more integrated affair, including new types of investment, or changes in practice within existing investment models that create shorter feedback loops than traditional research. This makes research and innovation more of a live learning cycle that informs how the challenge evolves:

> [Specific named research investment] is a £10 million-ish programme with a very different approach to research. With [investment name] we said: 'Look, we need to figure out what is known about [challenge-relevant] systems and about how they can scale across whole system, and we need to know about the technology and the financing and the business models and the consumer engagement, from this whole systems perspective.' This kind of synthesis approach is very interesting in a challenge like this where it's bringing the whole system knowledge to the party and trying to make sense of all of that. There are bits of primary research going on as well. So, they're working with the demonstrators to test what's going on in the real world, who can swap out what they're trying or develop new theories of change. [Y]ou don't [just] need a different kind of programme, but you also need and a different kind of leadership. [The] PI is very open to sort of doing things in a different way, to create a flexible programme that learns and that is able to flex resource and funding (Interviewee 2).

Changing direction

ISCF funding is at a larger scale to previous UKRI investments and is accompanied by a higher degree of scrutiny from BEIS and HMT, both at business case stage and in an ongoing sense. The recent National Audit Office report on ISCF highlighted the inconsistency in the government's short timescales for spend and the lengthy process to approve a business case and/or for UKRI to get the funding out of the door (NAO 2021). However, this rigidity is also a problem once the challenge is progressing:

> How do you then create enough autonomy within let's call it the mission framework that allows people to go, 'I expected £40 million to be done on this, but actually something's happened to the world and I'm going to divert [spend] over here.' How do you do that in a way that's agile and flexible enough that allows people to pivot because the world changes? (Interviewee 8).

As with many areas of public investment, COVID-19 proved to be a stress-test for the flexibility built around the funding and UKRI was given approval to vire resources. This has further highlighted the need for both higher degrees of funding certainty for long-term challenges and tolerance around spend to enable agility; capacities which are important for more transformative missions.

4.4 Policy capacity II: coordination

Internal coordination

There was evidence to suggest good engagement across UKRI in the shaping of challenges. However, difficulties have been experienced at an operational level. As one interviewee put it: "Challenge directors were hired to do a job and it's certainly the case that the system wasn't set up for them to do it at all' (Interviewee 10). The 'system' here includes policy and operational procedures, and norms which don't provide the sort of agility needed to work across organisations:

> There are some things [about challenge directors that] should have helped, that is that they're all used to working in goal-oriented, multi-disciplinary, matrix-managed or collaborative teams. So, they're actually used [to] this idea that you talk to some people who work over there in that bit of the organisation and some people who live over there with that bit [of] the organisation, and they come together to work on a team. Unfortunately, UKRI as an organisation does not recognise that and it has struggled with it (Interviewee 10).

On the design of funding instruments, one interviewee described it as about the ability to forge a programme using all the options in the 'UKRI toolkit' and therefore highlighted the need for UKRI to create a 'playbook' to enable challenge teams to navigate the existing instruments and approaches available to them.

External networks, including vertical coordination

Missions often need expanded forms of governance and therefore place different demands on the organisations leading (Kuhlmann and Rip 2018). This requires new forms of external coordination, including horizonal engagement across policy domains and vertical engagement with subnational levels. This is expanding traditional engagement points, which have been more focused on industry and universities, rather than actors in places such as local authorities:

> I think in a lot of these missions, certainly the sort of more society-facing ones, you know, perhaps not the ones simply trying to develop a particular industrial sector, which can be a bit more traditionally formatted, but these big society-facing ones, you need to work with a whole raft of new types of organisations. You know, we're not only working with local authorities and businesses and research, we're also working with lots of NGOs, consumer groups, we're working with stage companies, who are helping with consumer engagement, [and] we're working with researchers, who are right at the sort of cutting edge of delivering this stuff (Interviewee 2).

'Place' has a central role in several of the challenges, including those that are engaged in local systems change and therefore introducing 'living lab' approaches or 'clusters'. However, until recently — despite being one of the pillars of the 2017 Industrial Strategy — place hasn't been an explicit driver in the overall governance and implementation of ISCF, and there remains caution around whether and how local actors might play a more active role:

> [There's] an interesting tension between what's coming from the top and what's happening on the ground — a lack of connectivity between the trinity of actors in places: local governments, central government and then the R&D system. It needs more localised experimentation because local contextual factors matter. [But] it's unclear how much traction 'missions' have in places, partly because of dysfunctional relationships between Whitehall and different parts of UK. [The] system's out of alignment and therefore UKRI levers don't have maximum effect (Interviewee 7).

UKRI does have some capacities that could support more experimental ways of working with 'places'. This was apparent in discussions about the different roles the various 'catapults' play, including those that are system-focused (in contrast to those with a stronger asset or sector emphasis) such as the connected places catapult (CPC).

4.5 Policy capacity III: learning and reflexivity

The approach to ISCF has evolved since its set-up, influenced by a range of factors, including changes in the wider policy environment and major events/shocks (e.g. COVID), along with internal learning (both to UKRI and to the mission areas).

UKRI has commissioned an evaluation of ISCF, not yet publicly available, though according to one respondent its initial evidence suggests 'missions work', even if it is still quite early in the process. In fact, the general feedback from the interview findings is that this approach is positive, and this was as much about how effective it is at drawing together research and the innovation activity and actors, as about solving a particular mission or challenge.

Within challenges, there is clear evidence for how performance management is informing how the challenge evolves. This includes the use of logic models, theories of change and ongoing monitoring to inform next steps:

> One of the other things that is different about the challenge model and challenging for, as far as I can see, every bit of UKRI, is that emphasis and the embracing of performance management — in benefit analysis, benefits capture, impact culture. So that's a big deal and, to be honest, I don't think that's been appreciated by the other bits [of] UKRI (Interviewee 10).

However, elsewhere, there are considerable difficulties with identifying meaningful ways to measure success:

> I think one of the issues is unrealistic expectations of what an evaluation can show you after two, three, five years even [in terms of attribution]. I think that's the bigger issue (Interviewee 9).

> Our logic model extends out by 15 years or so, you know, in terms of some of the long-term impacts that we think will generate, but also the way we're tracking our KPIs, some of those are just really difficult to do to be honest. You know if you make a change locally, how much of that change can you attribute to the local impact [versus] what's going on nationally? …So, it's a really complex problem to evaluate (Interviewee 2).

In other areas, learning and influencing change is more of a work in progress. One example is the balance between goal-oriented investment and current operational systems for programmes design and decision-making. Challenge directors are empowered to take decisions around the overall shape and direction of the challenge. However, funding protocols mean they don't always have a say in final decisions, even though they are ultimately charged with delivering the goal/challenge and making sure the individual projects cohere to the common purpose. This is primarily about culture and norms at organisational and wider research sector levels, though it can get muddled in issues of interpretation around the Haldane Principle and academic freedom, which remain firmly rooted in decision-making practice.[7] In reality, UKRI has the capacity to evolve how it makes funding decisions for transformative innovation, but would need to take the wider research and innovation community with it in any changes introduced.

5. Conclusions

This paper has explored how UKRI, the organisation leading transformative innovation policy approaches in the UK, is developing its policy capacities for such new policy initiatives.

Agencies like UKRI are seen as important factors of success in the development, coordination and delivery of national innovation policies; 'as "change agents" they bundle expertise, orchestrate innovation processes and serve as liaisons across sectors and levels of activity' (Breitinger et al 2021, p.7). However, missions present a challenge to those leading on STI policy and implementation, and demand a shift in approach — moving from investing mainly in supply-led or 'frontier' innovation to a more holistic approach, balancing supply- and demand-led policies, and involving multiple actors across different policy domains to address the mission (Wanzenböck et al 2020). What follows are some conclusions on this specific case study, followed by reflections on the literature and areas for future research.

UKRI case study

With transformative innovation policies, context matters. The UK has sought to implement what Larrue has labelled a 'challenge-based' mission policy approach, more suited to 'accelerator' missions (Larrue 2021). However, since its launch, various policy changes, as well as incremental learning from within the programme itself, have influenced the framing and narratives around ISCF and what it might hope to deliver. The challenges in ISCF have also evolved and are a mix of that Wittmann and others would describe as 'accelerator' through to more 'transformer' types, which require more complex governance and coordination (Wittmann et al 2020). So, what began as a fund to incentivise industry to co-invest in innovation has evolved and shows signs of becoming more focused on societal-transition missions.

We proposed that the policy capacities required for transformative societal missions include: strategic navigation capacities, the capacity for coordination — internally, across external networks

[7] The Higher Education and Research Act 2017 that established UKRI also embedded the Haldane Principle, which indicates that, 'Decisions on individual proposals are best taken following an evaluation of the research quality and likely impact… such as a peer review process' (HER 2017: 103 (3)).

— and capacities to embed learning and reflexivity. Based on interviews, we can conclude that, on balance, the range of policy capacities needed for more transformative missions are not fully present in UKRI. However, there are transformative aspects and signs that some of those capacities are emerging, with some notable positives alongside other areas of constraint:

- *Navigation/portfolio management*: UKRI's capacities for formulating and implementing large-scale complex investment are growing. Examples given from some of the challenges suggest the ability to innovate and create new ways of engaging partners, including devolving funding via larger investments. However, more generally, its ability to deliver at pace and with agility is constrained by the capacities of others, including BEIS and HM Treasury. This includes long timescales around business case approvals and micromanagement of delivery. This takes away from the ability to experiment and the agility needed in challenge implementation.
- *Coordination*: Challenge directors brought in from industry have been positive in two respects. First, their system knowledge and networks provide vital momentum to the challenges and potential solutions. Second, they are proving to be a disruptive force for change within UKRI, similar to the positive role played by peripheral agencies, described by Breznitz. Positioned as neither inside nor outside the organisation, they are unsettling established power bases, cultures and practices. On the whole, they are viewed as a positive. However, their industry expertise would benefit from being balanced or complemented by other forms of system knowledge for more transformative challenges.

What is less clear is whether these and other new ways of working are becoming embedded in ISCF or influencing ways of working in UKRI or BEIS. UKRI was established in parallel with the introduction of ISCF and perhaps has been doubly challenged with regard to establishing the sorts of capacities and capabilities required at a time of significant change. That said, the creation of UKRI was also an opportunity to better integrate research and innovation investment, and create a more agile central core to support matrix working across the nine organisations and beyond, as recommended by the Nurse Review (BEIS 2015).

At a policy level, challenges are demonstrating a means to bridge research and innovation in addressing missions or goals. They also have potential to enable more integrated innovation that brings together supply-led and wider diffusion of innovation, thereby incorporating place-based assets and intelligence in addressing challenges. This has been demonstrated in those challenges using key investments like living labs and clusters, but can also be bolstered by the wider UKRI infrastructure, including catapults, for example. In terms of operation, a dominant civil service culture is not helping UKRI's 'centre' get established in an effective way: 'UKRI is a very large organisation with very old-fashioned public sector management… It's as if every transformation in industrial management that's happened since 1980 just hadn't occurred' (Interviewee 10).

For transformative innovation policy approaches to be truly effective will require wider changes to ensure UKRI can operate with sufficient autonomy to work across the wider policy space. This includes empowerment to work in the more experimental ways needed to enable transformative policies. Otherwise, the danger is that these approaches are all rhetoric and a

repackaging of traditional policies as ‘old wine [in] new bottles’ (Wittman et al 2020, quoting Daimer et al 2012, p. 223).

There are limitations to this case study research in both its timescale and number of interviews. There would be merit in undertaking an expanded analysis of the capacities being developed across the ISCF programme, including all challenges, to explore how policy capacities are progressing and could be further enhanced.

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