May 2022

# The role of R&I levers in driving economic growth

## Final Report to UK Research and Innovation

SQW

# Contents



**Contact:**
Kadriann Deacon
Tel: 0113 225 6007
email: kdeacon@sqw.co.uk

**Approved by:**
Jonathan Cook
Director
Date: 30/05/2022

# Acknowledgements

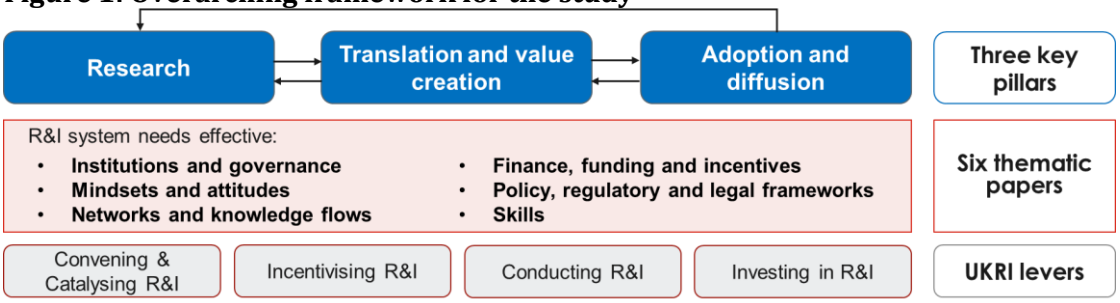
This report has been written by the core SQW team that led the study.

The authors are grateful to the project team's expert group, which provided advice and input throughout the course of the study. This group comprised: Osman Anwar (SQW); Joseph Duggett (SQW); Dr Jen Nelles; Professor Stephen Roper; Professor Philip Shapira; Carol Stanfield; and Professor Tim Vorley.

# Executive Summary

1. Investment in research and innovation (R&I) is widely regarded as a stimulus for economic growth. Despite the strong evidence supporting the link between publicly funded R&I and economic growth at a macro level, **there is less understanding of ways in which different policy interventions and other factors combine in the *pathways* from R&I investment to economic growth**. Therefore, UKRI commissioned the study to:
   - improve its understanding of the different factors that drive growth through R&I, and the policy levers and interventions that are effective
   - identify actionable findings relating to its own levers and interventions; the levers and interventions of other actors; and where there are key evidence gaps.
2. **This study examined existing evidence on the effectiveness of R&I interventions, and considered how policy levers influence, and could influence, economic growth.** Reflecting the complexity of the R&I landscape and the issues involved, the study was exploratory in nature. So whilst it was underpinned by evidence and review, it was by no means intended to be any kind of comprehensive review of literature. The study particularly explored ways in which the wider R&I system could be better understood through future research. The approach evolved during the assignment, as it reflected on the emerging findings and implications for areas of further investigation.
3. The study was undertaken in three phases. **Phase 1 involved a scoping and high-level evidence review** to determine the focus and framework for the study, drawing on scoping discussions with key stakeholders and a review of key papers on R&I systems. During this phase, six thematic areas were identified as priorities. These formed the basis of **phase 2, which involved producing six think pieces on the themes, drawing on existing evidence and expert knowledge of the team.** The key findings from the papers were synthesised in an interim report. The interim report identified a number of areas for further investigation, and these were the subject of **phase 3 through focused evidence reviews and two facilitated workshops** with external stakeholders and representatives from UKRI. The workshops discussed the evidence presented, evidence gaps and system-based issues.
4. **An overarching framework was developed in phase 1 to underpin the study** (see Figure 1). Central to this was the identification of three key pillars of the R&I system:
   - **Research**, including basic research, applied research and early concept development
   - **Translation and value creation**, i.e. the processes through which concepts are translated into use in policy or practice or into applications for commercial sale
   - **Adoption and diffusion**, which encompasses first adoption of new or improved applications through to the diffusion and spread across multiple user groups.
5. The six themes that were reviewed in the thematic papers are also set out in Figure 1 along with the way in which UKRI considers its levers. Specific policy interventions (such as funding programmes, networking support and business support) fall within these levers.

**Figure 1: Overarching framework for the study**




## Key findings from the evidence base

6. A selection of findings on interventions where the study has synthesised evidence are set out in Table 1. For the levers and interventions reviewed, the evidence can point to different conclusions and implications, highlighting that **'what works' may be context or programme-specific**. In other words, the effectiveness of different levers and interventions – i.e. 'what works – is dependent on various factors, including the 'who', 'where', 'when' and 'why'. Therefore, transferability of findings requires consideration of implementation and contextual issues. It also means that policy decisions may need to be informed by the 'balance' of evidence, with interventions subject to ongoing review and evaluation. The evidence on grants and tax incentives provides key examples of interventions where this is the case. Other implications from the analysis of evidence are as follows:

- If growth is a focus for UKRI, then the balance of basic and applied research, and the implications for incentives and practice-sharing, could be considered and be informed by further research in this area.
- The study considered the inter-related interventions that can help address the UK's diffusion gap (e.g. skills, technical advice and networks). There is a case for actors to consider how these can address the barriers to diffusion, as well as gaps in provision.
- Intermediaries play a range of roles in the R&I system, and these can expand and change. A key implication is that intermediaries need to evolve in response to changing market and technology needs (and this needs to be reflected in how impacts are measured).
- Standard-setting requires a range of actors including professional associations, intermediaries and businesses. UKRI could have a key convening role in this respect, including to bring in academic researchers and use links to draw in more businesses.

**Table 1: Selection of key evidence on interventions, outcomes and growth**

| Intervention | Evidence on outcomes/impacts | Implications for growth |
|---|---|---|
| **Intermediaries** (e.g. Catapults) | • Intermediaries can play a range of roles in supporting innovation and growth.<br>• Across different intermediaries, there are examples of impacts, including new product and process development, and business performance. | The evidence on impact needs to be considered carefully – it is less meaningful to quantify outcomes in terms of a growth contribution, but rather there are a mixture of outcomes relating to business |

| Intervention | Evidence on outcomes/impacts | Implications for growth |
|---|---|---|
| | • Benefits vary in their nature, scale and contexts, and the evidence needs further development. | performance, investment and the wider system. |
| **Grants and subsidies** | • Whilst there is mixed evidence on the effectiveness of grants and subsidies in stimulating R&D spend, the majority of studies find a positive link.<br>• Numerous studies find self-reported outcomes for beneficiaries relating to innovation and business performance outcomes (e.g. product development, new markets, firm growth).<br>• Studies on collaborative R&D grants find a positive effect on a range of outcomes including level of collaboration and IP applications (potentially leading to spillovers). | Grants and subsidies can contribute to economic growth by helping to stimulate private sector R&D investment, which can lead to subsequent innovation and business growth outcomes. This is especially for SMEs and can be aided by long-term stability of instruments and appropriate design (e.g. intervention rates[1]). |
| **Tax incentives** | • There is mixed evidence with some studies finding a positive effect on R&D spending (especially for small firms) whilst another recent study questioned the additionality of the UK R&D Tax Credit scheme. | The mixed evidence on the effect of tax incentives suggests uncertainty in the pathways to supporting economic growth. |
| **General and technical business support** | • Overall, there is a lack of conclusive evidence of how general business support affects innovation outcomes; and contribution to growth outcomes differs programme-to-programme.<br>• For technical advisory services, outcomes seem to vary by intensity of support and specific focus. | There is a gap in understanding the effects of business support on innovation outcomes specifically, and therefore the specific pathways to stimulating economic growth. |
| **Standards** | • Evidence points to several ways in which standards can contribute to innovation, e.g. serving as framework conditions; levelling the "playing field"; and creating focus/cohesion.<br>• However, there are challenges relating to knowledge leakages to competitors; firms using their influence over standards to serve own interests; and the differences in impact between companies, sectors and more widely. | Whilst there is evidence on the routes through which standardisation can lead to economic growth, more evidence is required to understand how this varies when looking at: (i) different domains; (ii) different types of companies; and (iii) intersections with regulation. |

## Intersections, synergies and interactions in the system

7. **The R&I system is complex and requires various parts, processes, interventions and conditions to perform optimally**. The landscape of institutions and levers has evolved over

[1] The amount of grant funding as a proportion of total eligible project costs.

many years through influence from an array of public and private actors, and it continues to evolve with resulting challenges associated with policy churn. There is blurring around the remits of different actors, and some competing objectives and behaviours.

8. **The evidence across the three pillars highlights a range of intersections, synergies and interactions in the system**. The study has assessed evidence on different policy interventions, and also the ways in which processes and contexts can affect R&I performance. Two examples illustrate this, and these also highlight the ways in which issues cut across the three pillars of the system:

   - The availability and use of R&I skills can be key enablers (or barriers, where they are constrained). There is a need for a clear definition of R&I skills, and this report has identified a range of elements, including technical skills, creativity, entrepreneurial skills, team-working, and leadership and management skills. This is an area where UKRI and other stakeholders could convene key actors, including employers, to agree and put into practice a framework from which skills needs/demands can be better understood and appropriate interventions identified.
   - There are various actors involved in supporting investment in R&D and innovation, from early-stage concepts through commercialisation and onto scaling. These include UK Government, UKRI, British Business Bank (BBB), universities, business angels, etc. This cuts across the pillars of the system. Aligning and linking these actors could help to serve the needs of knowledge- and technology-based businesses better.

9. Bringing these issues together, the R&I system cannot be understood simply by looking at the component parts, as they are often interdependent and interrelated. **A systems perspective seeks to understand how this constellation of institutions, interventions, processes and contexts may interact** using systems approaches (see below). As well as understanding better the complementarities between interventions and processes, such approaches would help policy to find ways to address potential conflicts and likely missed opportunities.

## Wider implications for developing the evidence base

10. The study has reaffirmed the view that the evidence base is not always clear-cut, with studies reaching different conclusions in terms of effectiveness (even where studies are of high quality). The evidence is also generally mixed in terms of its coverage, nature and quality. **The study has identified a range of evidence gaps as well as areas where there is existing evidence to build on.** Some of the more pertinent gaps in the evidence are presented in Table 2; these may partly reflect the non-exhaustive nature of the study. It is also important to note that many interventions in R&I have complicated and/or complex characteristics. This makes them challenging to research and evaluate using certain methods and/or in ways that lead to generalisable findings. Developmental approaches to evaluation may be required.

**Table 2: Examples of key evidence gaps**

| Subject area | Evidence gaps |
|---|---|
| **Basic and applied research** | • Effectiveness in routes to growth of different types of research, incl. through indirect routes, e.g. how they contribute to industry engagement and to the flow of skills/people into industry and policy |
| **Skills for research and innovation** | • No clear definition or framework for 'innovation skills' – clarity on this would highlight key gaps with existing evidence focused on STEM, role of migration and university-industry research training |
| **Grants and tax incentives for private investment in R&D** | • Whilst there is evidence on outcomes beyond R&D investment, i.e. innovation and business growth outcomes, this could be strengthened<br>• Effects on large companies (under evaluation by Innovate UK)<br>• Effectiveness at different stages of the R&I process |
| **Research-industry collaboration and engagement** | • Transferable practice between different types/contexts of institutions<br>• Effects of intermediaries on business growth for their customers – recognising mutual combinations of factors |
| **General business support** | • Effects through and on innovation outcomes specifically |
| **Interventions to support adoption** | • Effectiveness of technical advisory services<br>• Role of leadership and management provision for firms specifically relating to innovation adoption<br>• Role of networks and peer-to-peer in adoption |
| **Standards** | • Interface of standards with regulations<br>• Effectiveness of different types of standards, e.g. flexible standards |

11. Table 2 identifies evidence gaps that are specific to discrete subjects or policy areas, but another important point relates to evidence gaps at a broader system/sub-system level. **Systems approaches provide a set of tools** to view problem spaces as embedded in broader contexts and specifically seek to explain observed outcomes by searching out interdependencies, interactions, feedback loops and bottlenecks to better design (and experiment with) policy. **This provides an opportunity to better understand the inter-relationships between some of the many interventions and factors**, some of which have been reported on in this study.

12. There are numerous areas of potential inquiry from a systems perspective. Three types of examples that help to illustrate this are as follows:

- **influencing and incentivising actors** to change practices in ways that can help enable routes to growth, e.g. in relation to research-business collaboration and talent flows of research and innovation skills
- **convening existing interventions and actors to improve alignment**, e.g. in relation to the range of financial support and advice for early-stage innovations and scaling these up
- **investing where there are gaps or barriers in the R&I system**, e.g. in relation to adoption and diffusion of innovations to address the 'diffusion gap' in the UK.

**13.** In taking forward these types of approaches it is important to be realistic, assessing in depth particular sub-systems (rather than the whole) by setting the boundaries of analysis, whilst also accepting that there will be ambiguities and uncertainties.

# 1. Introduction

## Background, context and aims

**1.1** An SQW-led team was commissioned by UKRI to undertake a research study to improve UKRI's understanding of the role of research and innovation (R&I) levers in driving economic growth.

**1.2** Investment in R&I is widely regarded as a stimulus for economic growth (European Commission, 2017a). This relationship can be enabled, or hindered, by various factors, including globalisation, knowledge flows, access to talent and skills, technology changes, and diffusion and adoption. The UK government recognises the importance of R&I spending in policy terms and has committed to raise total investment in R&D (the first stages of the R&I process) to 2.4% of GDP, with substantial allocations of public investment, including to BEIS. A significant proportion of funding is channelled through UKRI[2], to *'drive economic growth and forge the UK's future as a global scientific superpower'.*[3]

**1.3** UKRI therefore plays a vital role in delivering economic growth through R&I spending. Indeed, UKRI has extensive influence in the R&I system, with a range of levers at its disposal, including investing in, incentivising, convening and catalysing R&I across multiple disciplines and sectors (UKRI, 2020). Its recent strategy, published towards the end of this study, also highlights its intent to help create a joined-up system to leverage research and innovation excellence (UKRI, 2022).

**1.4** However, despite the strong evidence supporting the link between publicly funded R&I and economic growth at a macro level, there is less understanding of the *pathways* from R&I investment to economic growth. UKRI was seeking to improve its evidence and understanding of how the different factors driving growth through R&I work (or do not work) together, and the policy levers and interventions that might influence this. This study considered existing evidence on the impact of R&I funding and interventions, but also looked more broadly at how policy levers influence and could influence economic growth through various inter-related mechanisms and interconnected actors.

**1.5** Reflecting the complexity of the R&I landscape, the study was intended to be exploratory in nature. Whilst it was underpinned by evidence and review, it was by no means intended to be any kind of comprehensive review of literature. The approach continued to evolve throughout the study, reflecting on the emerging findings (and implications for areas for further investigation) as well as feedback from the study's Advisory and Working Groups[4]. Given the

[2] BEIS confirmed an allocation of £7,908 million to UKRI for the financial year 2021-22 (*UKRI, Our budget*).
[3] Chancellor's Spending review
[4] The Working Group included four members from across UKRI/its councils. The Advisory Group included various representatives from across UKRI (including its different councils), BEIS and KTN to provide a range of perspectives.

breadth and complexity of the subject under investigation, the study raised perhaps more questions than answers, and this is reflected in the implications that have been drawn.

1.6 Within this context, this Report sets out a synthesis of the findings from the study, including key messages on the contributions of different factors to pathways to growth, linkages between themes, and the important enablers, barriers and levers for research and innovation. It also highlights the uncertainties in the evidence and points to areas for further investigation. The synthesis is structured under the three pillars that formed the basis of the study framework (see section 2): research; translation and value creation; and adoption and diffusion. Alongside this, we have presented perspectives on the intersections and issues in the R&I system, including where there are tensions and potential synergies and interactions. The implications of these linkages for UKRI actions have been considered, including as the basis for more formal systems-based research in the future.

## Report structure

1.7 The remainder of this report is structured as follows:

- **Section 2** summarises the overall study framework used; and provides a summary of the institutional landscape and framework in the UK (including different R&I policy interventions)
- **Sections 3-5** provide syntheses of findings in relation to the three pillars of the study framework, namely research (section 3), translation and value creation (section 4), and adoption and diffusion (section 5)
- **Section 6** presents the key issues from a systems perspective, including how levers and interventions could be analysed by taking a systems-based approach
- **Section 7** summarises the key conclusions and implications arising from the research.

# 2. Overview of the study framework

**2.1** This section sets out an overview of the study approach and framework that underpinned it. It also includes key contextual thinking and parameters that informed the study, in particular in relation to the R&I system; the institutional landscape; and the definition of economic growth. Two important and related points are noteworthy in how the study was undertaken:

- This is a challenging area of enquiry given the multi-faceted nature of the R&I system and its overlapping issues, and so the study evolved in response to the issues that were raised.
- There are many different issues that could have been covered in the study, and there was a need to prioritise the topics subject to review and discussion. Therefore, the study findings reflect what the study has been able to cover in the resources available and provide a starting point for further investigation.

**2.2** The study was steered by a Working Group[5] and a wider Advisory Group[6]. These two Groups have been key in informing the evolution and prioritisation of what the study has covered.

## Study overview

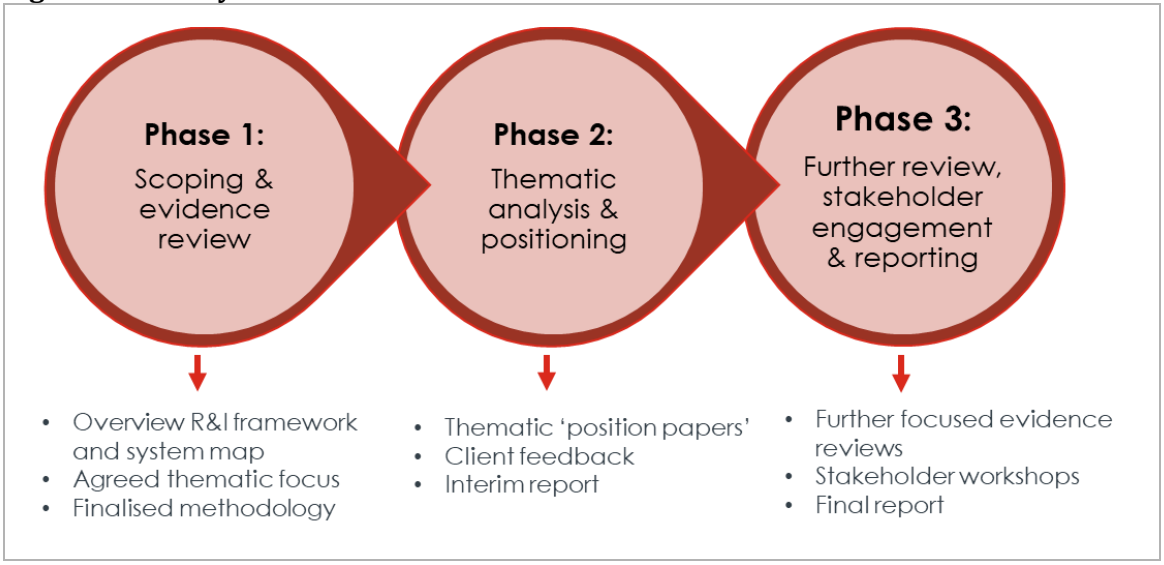
**2.3** The study was delivered in three phases (see Figure 2-1), as follows:

- **Phase 1: Scoping and high-level evidence review** – this involved determining the focus and framework for the study, drawing on scoping discussions with UKRI, BEIS and KTN representatives and a review of key papers on R&I systems. During this phase, six thematic areas and the key questions within these were agreed. In addition, the framework around three key pillars of the R&I system was established. A methodology paper was the agreed output of this phase.
- **Phase 2: Thematic papers** – this phase involved producing six thematic papers, drawing on existing evidence and expert knowledge, to set out the key issues associated with the themes. The six papers, written as exploratory think pieces, covered the following key aspects of the R&I system, and the key findings were synthesised into an interim report:
  - institutions and governance
  - mindsets and attitudes towards R&I
  - networks and knowledge flows
  - finance, funding and incentives
  - policy, regulatory and legal frameworks
  - skills.

[5] This comprised three representatives from UKRI and a representative from Innovate UK.
[6] In addition to the Working Group members, the Advisory Group included representatives from UKRI, individual Research Councils, BEIS and the KTN.

- **Phase 3: Further evidence review, workshops & reporting** – a number of key areas of policy intervention were identified in the interim report, and these were the subject of further focused evidence reviews. The findings of these reviews were tested with external stakeholders and representatives from UKRI through two facilitated online workshops. The workshops were used to discuss the evidence presented, gaps in the evidence base and issues that would need to inform systems-based enquiries in the future.

**Figure 2-1: Study Phases**




## Study structure

### Context of the R&I system

**2.4** A headline document review was undertaken as part of phase 1 of the study. This highlighted the following key points which informed the overall structure for the study:

- **The R&I system is complex and requires various parts, processes, interventions and conditions to perform optimally** (European Commission, 2017b). There is no definitive list of the components of the R&I system. However, the literature broadly agrees upon several key parts. These include: the business base; institutions (national/local and formal/informal); infrastructure (digital, physical and knowledge); public bodies (including R&D bodies, the public science base and support organisations); and the knowledge base. The parts of the R&I system are linked by a series of processes, such as knowledge flows, networks, and diffusion and adoption of ideas and practices. These processes, and the aforementioned system parts, are affected by various interventions. Interventions occur in all parts of the R&I system and include regulations, funding for R&D, fiscal incentives, and educational/skills policy interventions. As well as direct interventions, the system is also affected by, and therefore expands to include, wider framework conditions and contextual issues. For example, sectoral structure, quality of place and the wider cultural setting all shape the effectiveness of the R&I system.

- **The literature review found limited evidence on the strength of the links between any specific parts of the system and economic growth.** However, some parts were found to have a clearer role in the pathways to economic growth or economic growth-related outcomes. For example, with regards to processes within the system, knowledge flows and collaboration are important components in the pathway to economic growth. Fostering science-business links allows knowledge to spread more widely and to be used in industry, with a positive impact on R&D and subsequently productivity (European Commission, 2017b; RAND and Deloitte, 2017).

- **Rather than discussing the role and influence of parts of the R&I system on economic growth *per se*, where outcomes are considered, the reviewed literature focuses on what we would understand to be *intermediate* outcomes**, some of which can be associated with or lead to economic growth. These include new product development, improvement in firm-level production processes, or the design/redesign of services. The evidence reviewed indicates the multiple and varied routes through which R&I can lead to economic growth. Moreover, the literature suggests that the links between the different parts of the R&I system and economic growth-related outcomes are likely to be indirect with mutual causation. In other words, no one aspect of the system alone does not lead to growth, rather it is the effect of complementary and simultaneous factors.

## Overview of study framework

**2.5** The study was designed to consider the evidence base in a way that recognises that the R&I system is complex, relying on various interrelated parts, processes, interventions and conditions to function optimally (European Commission, 2017b). Components of the system are not individual parts, but rather a fraction of a complex adaptive system. Whilst the study has not formally undertaken systems mapping, we have sought to think about the issues by considering interdependencies, interactions and potential bottlenecks or feedback loops. This provides an opportunity to better understand the complex pathways from R&I to growth. This study could pave the way for further systems-based research in the future.

**2.6** **Central to our study of the R&I system are the three key pillars** around which this study has assessed the inter-related parts of the R&I system. The pillars were informed by a review of literature and discussions with the Working Group during Phase 1. These pillars are as follows, and it is acknowledged that there are many overlaps and cross-cutting issues:

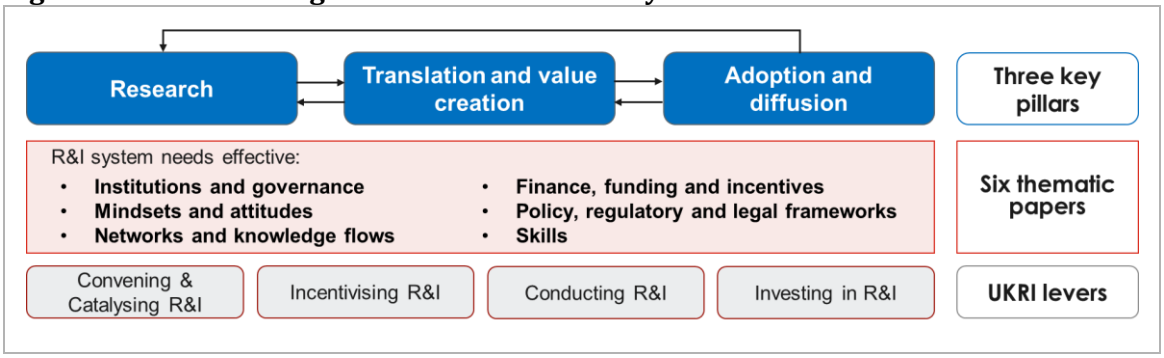
- **Research**, including basic research, applied research and early concept development

- **Translation and value creation**, including the processes through which concepts are translated into use in policy and practice, or into applications that are ready for commercial sale

- **Adoption and diffusion**, which encompasses first adoption of new or improved applications through to their diffusion and spread across multiple user groups.

**2.7** Based on consultation feedback and an examination of R&I systems literature, six key components of the system were defined as the focus of the thematic papers for phase 2 of the study. **These were: (i) mindsets and attitudes in relation to R&I; (ii) networks and knowledge flows; (iii) finance, funding and incentives; (iv) policy, regulatory and legal frameworks; (v) skills; and (vi) institutions and governance** (Figure 2-2). These themes are not an exhaustive set of issues, but were considered (in discussion with the Working and Advisory Groups) to be a sensible set of areas on which to focus given the study's scope and aims.

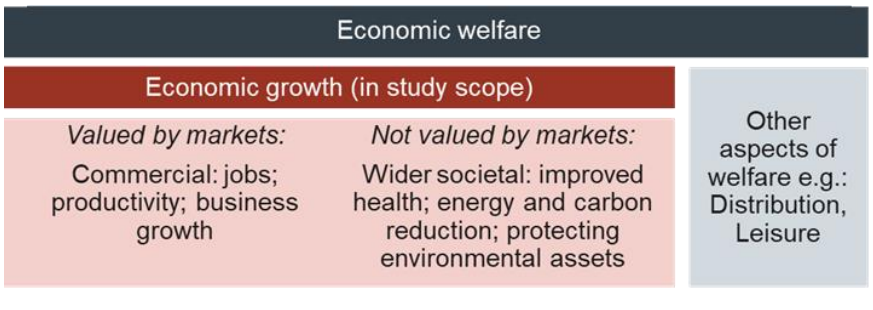
**Figure 2-2: Overarching framework for the study**




## Defining growth

**2.8** **A two-pronged definition of economic growth was agreed with the Working Group, encompassing growth in terms of both: i) outcomes that are valued by the markets** (e.g. jobs, productivity and business growth); and **ii) non-market, wider societal outcomes** (e.g. reducing energy use and protecting natural assets). The scope is set out in Figure 2-3, showing three wider societal outcomes, namely improved health, energy and carbon reduction, and protecting environmental assets. This definition of economic growth aligns with UKRI's overarching mission to build a *"thriving, inclusive R&I system that connects discovery to prosperity and public good"* (UKRI, 2020). Certain aspects of economic welfare were not included in the scope of the study, such as distributional effects and benefits through recreation. Moreover, local geographical outcomes were also not explicitly within scope. These were subject to a separate study, commissioned by UKRI, which explored the factors that influence place-based R&I outcomes and the role of UKRI's levers at a regional level.

**Figure 2-3: Growth as a subset of economic welfare to define study scope**



## Overview of institutions and governance

**2.9** As discussed above, the R&I landscape is inherently complicated, having evolved over many years through influence from a shifting array of public and private actors. Therefore, like other aspects of the R&I system, the complexity of 'institutions and governance' means it cannot be understood simply by looking at component parts, as they are often interdependent and interrelated. A systems perspective is therefore important in enabling an understanding of how the constellation of actors and interventions across departments and scales can interact. Sources of interactions have been considered in the study when reviewing and thinking about the evidence on different levers and interventions (summarised in chapters 3-5 of this report), and the issues relating to deeper analysis from a systems perspective are returned to in chapter 6.

**2.10** It has become broadly accepted that stimulating R&I is a valid role for public policy. This stems from a perception that R&I is essential for growth and can drive increases in living standards and wellbeing. It is also thought that in absence of intervention, R&I will occur at suboptimal levels and be insufficiently transformative. These suboptimal conditions are often conceptualised in terms of failures – of markets, among other things, or systems – that public actors can address using financial and regulatory incentives as well as using interventions or levers to shape systems and environments to nurture R&I activities.

### Key institutions

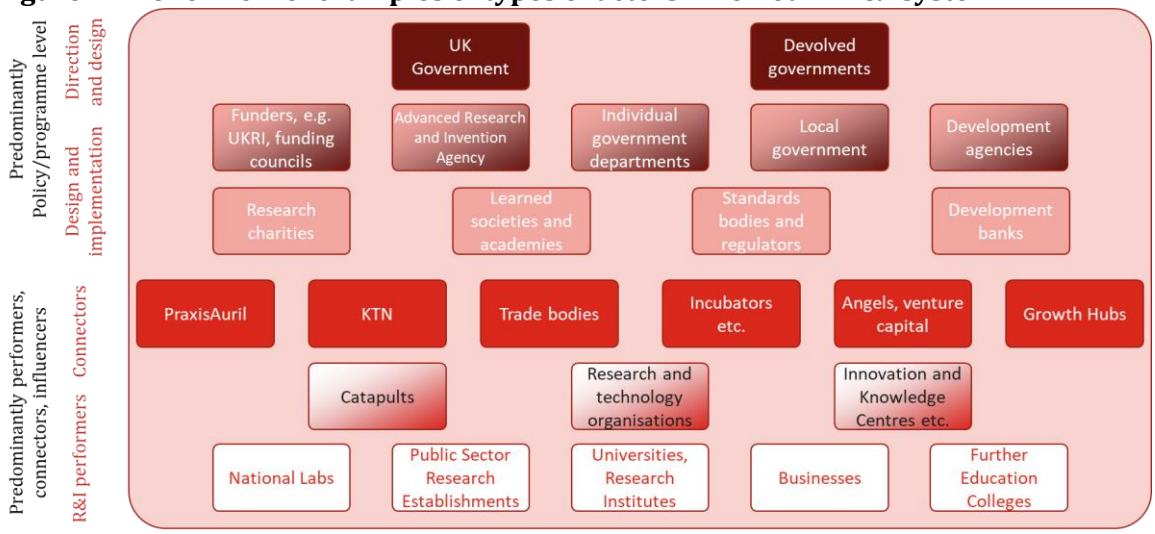
**2.11** 'Institutions' can refer to the range of *actors, organisations and other players* in the R&I system, with 'governance' understood to represent the *ensemble of policies and practices* which emanate from institutions and shape the environment in which R&I takes place. There are multiple institutions operating in the R&I system and each has a varying degree of influence over different levels of governance. Figure 2-4 sets out examples of the types of actors involved. We have identified four levels of actors, though it is important to note that these actors may also play roles at other levels, with there being potential for expansions of remit to meet specific requirements or in particular contexts. In this way, it is important to acknowledge the heterogeneity of institutions in the system. The four levels are as follows:

- **Policy/programme level – direction and design:** Actors primarily set broad policy directions and agenda and identify key priorities. As an example, UK government (and departments within it) set the policy objective to raise R&D spending to 2.4% of GDP. In addition, these actors may design specific policies or programmes.
- **Policy/programme level – design and implementation:** Actors design specific policies and implement them. Within government, for example, there are multiple departments engaged in research, innovation and technology related activities. These actors may also set or influence broader policy agendas.
- **R&I performers:** Actors undertake the research and generate innovation and are normally the target of R&I policies. This includes universities, national research

laboratories, public sector research establishments, Further Education Colleges, and businesses, among others.

- **Connectors:** Actors broker or help to broker relationships between R&I performers and with users, share practice, and/or enable R&I in other ways that draw on networks and connections.

**Figure 2-4: Overview of examples of types of actors involved in R&I system**




## Policy interventions

**2.12** One of the key levers available to UKRI is to 'invest in' R&I, which it does through an array of funding programmes. These include different types of grant schemes (e.g. single company grants, research grants, collaborative R&D grants), and also other instruments such as repayable loans. Beyond investing in R&I, there are various other types of levers to convene, catalyse and incentivise R&I, and a range of policy interventions across these levers. Drawing on Edler and Fagerberg (2017), Table 2-1 summarises a series of interventions. Further detail and evidence on some of these is reviewed in subsequent chapters.

**Table 2-1: Key types of policy interventions beyond direct investment in R&I**

| Intervention type | Overview | Example(s) |
|---|---|---|
| **Policies for training and skills** | Implemented by various operational actors, e.g. government departments to improve training and skills necessary for R&I. | • Support to firms to incentivise private sector training initiatives<br>• Initiatives to align skills provision with business needs |
| **Entrepreneurship policies** | Encourage socially and economically productive activities by addressing entrepreneurs' direct needs | • Provision of advice/support<br>• Finance for incubator or accelerator infrastructure<br>• Incentives for entrepreneurship, e.g. tax incentives |

| Intervention type | Overview | Example(s) |
|---|---|---|
| **Technical services and advice** | Overlaps with entrepreneurship support programmes. Often directed at specific sectors or business types (SMEs) | • Programmes to stimulate adoption of new technologies |
| **Cluster policies** | Interventions to seed, grow, and support industrial clusters as engines of innovation. Overlap with other instruments. | • Supporting networks and collaboration<br>• Ensuring access to finance and human capital |
| **Collaboration policies** (potential subset of cluster) | Aim to enhance learning, knowledge transmission and spillovers, and manage risk. | • Encouraging collaborative research, licencing and commercialisation |
| **Network policies** (potential subset of cluster) | Also aim to increase knowledge exchange | • Innovate UK<br>• Knowledge Transfer Network |
| **Demand/diffusion policies** | Involves enhancing the willingness and ability of actors to buy and use an innovation. | • Financial incentives for technology adoption, incl. tax<br>• Training and support resources |
| **Public procurement policies** | Related to diffusion policy – public procurement policy can be adapted to stimulate R&I in specific industries or technologies. | • Setting specific requirements in public tenders |
| **Regulation and reward** | Used to shift incentives for innovation. | • Regulations and standards<br>• Innovation prizes<br>• Tax incentives |
| **Foresight activities** | Aim to develop collective visions around innovation priorities – primarily activity of policy level actors | • Analysis of technology potentials<br>• Articulation of growth objectives<br>• Network building |

*Source: Draws on Edler and Fagerberg (2017)*

## Barriers and enablers

**2.13** The innovation policies presented above demonstrate that different interventions can be used by different actors, each supporting an assortment of R&I objectives. As touched on above, this fragmentation introduces a degree of complexity and tensions within the system. Three main barriers are highlighted here:

- **Policy tension:** Across the system, tensions exist between different actors which have conflicting policy rationales and goals, or where there is variation in policy implementation and approach. Such tensions exist at different levels (e.g. policy and operational), or at the same level where actors may have different priorities (Kuhlman and Rip 2018; Wittman et al 2021). This can result in a lack of alignment in working towards growth objectives. For example, operational actors may have set targets that

mean that they are disincentivised from aligning or working with other operational actors, or that are not entirely aligned with policy objectives.

- **Geographical tensions:** Policies envisioned at one scale may not translate to others (e.g. due to varying contexts and needs of different geographical areas), or geographically targeted policies may fail because they are not being implemented in closed systems (e.g. because of knock-on effects or dependencies on other spatial areas). This means policies may not be effective across every location, restricting their impact, including on growth.
- **Time tensions:** Policies are implemented over varying timeframes and often overlap. Policies also take time to take effect and for their full impacts to proliferate through the system; lags between intervention and outcome are common. This can make understanding the effects of policy difficult, particularly in terms of attribution. This creates challenges in understanding what works in achieving or driving growth.

**2.14** These tensions should not necessarily be removed. However, to enable the system to work more effectively, better coordination is required among key actors and policy makers to ensure they are working towards the same system outcomes. Greater join-up in policy at all levels and across geographies would also address the barriers.

**2.15** We return to these issues of tensions and coordination in chapter 6, in which we discuss the important issues and opportunities that could arise from taking a more formal systems-based approach. This follows the presentation of evidence and analysis under the three pillars of the R&I system (chapters 3-5).

# 3. Synthesis of findings: Research

**3.1** This section presents an overview of the findings in relation to the research pillar. At the outset, the section sets out some of the key pathways to growth. For select areas within these pathways, the section then sets out the issues relating to: barriers and enablers to growth; interventions that can support outcomes in the routes to growth (and the evidence on the effectiveness of these); evidence gaps; and key interrelationships and linkages in the wider R&I system.

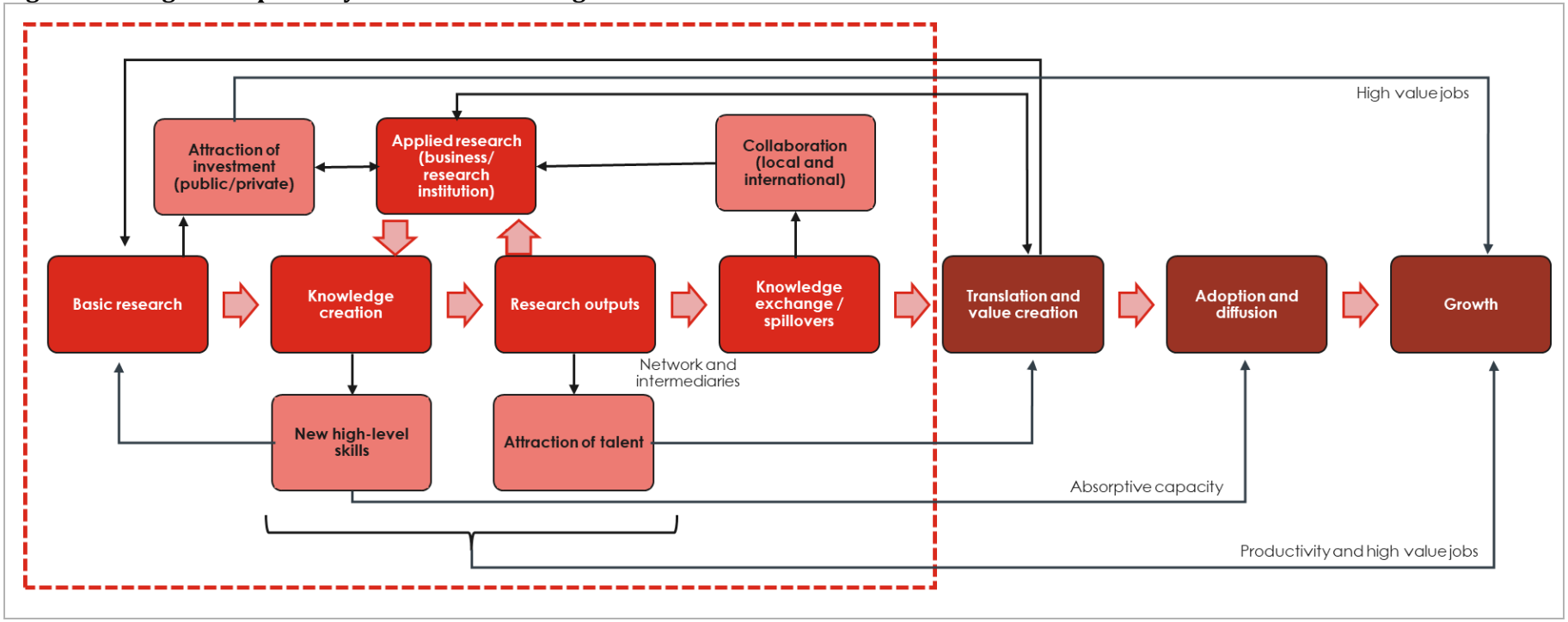
## Pathways to growth

**3.2** The routes to economic growth through investment in research activities are varied. These can often be long-term and deliver wider and/or indirect outcomes that enable economic growth as is set out in Figure 3-1. Examples of these wider and indirect outcomes include the development of new high-level skills, entrepreneurial experience, platforms for other developments and research, organisational prestige, and collaboration/knowledge transfer (or the opportunities for them). In addition, research can be varied in its scope, including: basic research and discovery; research that may have a more specific focus around potential applications for commercial benefit; or research that is intended to break ground in ways that can contribute to wider growth (e.g. in relation to environment, energy, health and other scopes). There are also varied actors involved, including universities, other public research institutes, research and technology organisations, and private sector firms.

**3.3** This section covers a mix of these aspects, considering the role, issues, barriers and enablers, and interventions associated with:

- basic and applied research
- collaborative research
- the role of skills development and talent
- private investment in R&D.

**Figure 3-1: High level pathways from research to growth**




*Note that outcomes/intermediate outcomes are highlighted in light red, while the latter stages in the innovation pathway are shown in dark red. The main pathways relevant to the research pillar are highlighted in the (bright) red dashed square.*

## Basic and applied research

**3.4** Research is a strength in the UK and there are significant investments and levels of research being undertaken, especially through *basic* (or *fundamental*) research in universities and other research institutions. Whilst *applied* research is arguably more focused on translational potential, and so has more direct pathways to growth, both types have different roles. There is limited evidence on the optimum balance in the focus of research institutions between basic and applied research in achieving growth objectives.

**3.5** Basic research is necessary to explore and understand unknown areas and to further scientific knowledge. The routes to growth are not well-evidenced and tend to be indirect and long-term (Akcigit et al, 2021). The routes may include: new high-level skills/knowledge and research outputs that provide a platform for other developments and research; organisational reputation that helps attract talent and investment; and collaborations with other research organisations and the private sector that may lead to applied research that has translation potential. Given its focus, the routes to growth from applied research can be clearer, particularly where there is a clear commercial objective or route to translation into policy or practice that is associated with a growth outcome.

**3.6** In view of this, if contributing to growth (both market and non-market) is a key objective for UKRI, further research into the routes to impact through different types of research (e.g. basic and applied) would be beneficial. Such research could draw on Research Excellence Framework impact case studies and other secondary material (or indeed primary research) to map how different types of research funded by UKRI have led to intermediate outcomes on the pathways to growth, and potentially growth outcomes themselves, as well as the scale of these outcomes. There would be challenges in attribution, though some form of 'outcome harvesting' approach[7] would at least help to build the evidence base. If the evidence is instructive in guiding decisions to bring about greater economic value, then this evidence could inform policy and investments on the balance of research with different emphases and priorities.

**3.7** Research priorities within universities (and similar institutions) are shaped by various factors (e.g. funding, mindsets and attitudes, policy objectives, institutional focus, and networks) and are not necessarily focused (or as focused) on growth objectives (Dowling, 2015). For example, universities receiving public funding are required to complete the Research Excellence Framework. A study by Grove (2017) found that the requirement of the Research Excellence Framework influences the focus of academic research, which could be geared more towards publications and high-quality research, rather than impact per se. At an individual level, career progression has tended to rely on the quality of an academic's publication record, rather than the impact of their research (Dowling, 2015). This has potential implications that are important when considering the pursuit of growth from research and innovation: it incentivises research with less immediate real-world application;

[7] See for example: https://www.betterevaluation.org/en/plan/approach/outcome_harvesting

it can restrict human resource transfer (e.g. from industry to research institutions, due to differences in culture and organisational objectives [Hall, 2003]); and it can act as a barrier to collaboration between research institutions and industry where collaborative research is not a valued part of an academic career (e.g. Dowling, 2015). The second and third points in particular can limit the translational potential of the research by reducing knowledge flows and spillovers.

**3.8** If the policy intent was to increase the amount of research focused on growth or other related purposes then this may require changing the balance of incentives for universities; the higher weighting on 'impact' in the Research Excellence Framework and the Knowledge Exchange Framework have started to address this imbalance. Other changes could follow the findings from the aforementioned research using outcome harvesting. Given the important remit of basic research, it does also highlight the key role of other actors in the system, including amongst intermediary institutions. These intermediaries are technology and knowledge brokers that operate in between the research base and users (e.g. research and technology organisations, and private innovation intermediaries). Chapter 4 examines the evidence on intermediaries.

## Collaborative research

**3.9** Collaboration, knowledge transfer and people movements are important factors in the pathway from research to growth. Two of the key reasons for this are to: ensure that research is undertaken with regard for real-world application, enabled by enhanced understanding of industry or wider societal requirements/challenges; and enable research findings and new knowledge to be disseminated more easily through the partnerships and relationships developed, thereby increasing the potential for knowledge spillovers and translation (Almeida and Kogut, 1999). There are various interrelationships that can enhance or inhibit levels of collaboration and knowledge transfer, and policy interventions have sought to address and/or capitalise on these.

**3.10** The focus of university research on research outputs such as publications (rather than growth objectives) can result in a less diverse community being attracted to research careers and be a barrier to the movement of researchers from industry to academia (Dowling, 2015). Note that the ease or difficulty of the movement of people also has implications for skills in firms (including the level of research talent), which is associated with levels of R&D and absorptive capacity (Fleming and Waguespack 2007).

**3.11** The factors influencing the focus of university research (as set out above) also affect the type and number of research partnerships and collaborations. For example, collaborative research may not be as valued a part of an academic career as other avenues, at least within some universities (Dowling, 2015), meaning fewer research partnerships or collaborations are formed with industry for academic research projects. Industrial funding can also make researchers wary due to actual or potential conflicts of interest. Several differences, such as cognitive and cultural, exist between academia and industry which creates barriers to

effective collaboration (Vries et al., 2019). These differences may limit universities' ability both to develop and effectively operate partnerships with conditions that are acceptable to firms. This has knock on effects to the nature of research projects, and the links to networks and translation, as highlighted above.

**3.12** Mindsets and attitudes of researchers, businesses and institutions can influence the extent to which collaboration takes place – and *type* of collaboration (e.g. local or international) – and thus knowledge transfer. For example, key traits such as openness, agreeableness and conscientiousness are required for collaboration, as are positive attitudes towards new possibilities, intellectual curiosity, and being open to other perspectives. The way in which institutional cultures encourage openness and collaboration is also key (Syed, 2020). It is important to consider the incentives set by institutions, including universities and the role that wider research system actors play (e.g. funders) in terms of the aspects or types of research that are valued most. The attitudes of funders, and how these manifest in funding programmes and decisions, also affect the nature of research and how it is undertaken. These themselves may be a reflection of policy direction.

**3.13** Collaboration between the research base and industry can potentially influence the focus of research through better understanding business needs and challenges and can provide access to expertise. Evaluation evidence exists on the role of collaborative R&D programmes (such as Catalyst programmes and Industrial Strategy schemes like the Aerospace Technology Institute R&D programme), and a range of evidence is expected on collaborative R&D programmes through the evaluations of the Industrial Strategy Challenge Funds. Collaborative R&D programmes enable access to appropriate expertise, leverage further investment in R&D, and lead to progress of technologies (e.g. SQW, 2017, unpublished; SQW, 2020). Barriers can exist in working styles and cultures between different types of organisations, though well-established relationships and strong project management can help mitigate these. Strong personal relationships have been highlighted as underpinning high quality collaborative research projects (Elsevier, 2013), emphasising the need for investment to support researchers in getting to know each other. Previous evidence has highlighted the importance of in-person time to build relationships that are key to collaborations, before these become workable and effective virtually (Elsevier, 2013)[8]. Spatial proximity can also influence levels of collaboration. Clusters and dense localised networks may support both collaborative innovation and diffusion as well as contributing to localised knowledge spillovers with potential implications for innovation (He and Wong, 2012).

**3.14** The implications for R&I actors include the dissemination and implementation of good practice amongst institutions, and the role and design of interventions to foster collaborations. Within institutions, there is good practice that can help change the attitudes towards research-industry partnerships, e.g.: career progression of academics taking account of wider factors including industry collaboration; and the role of senior level appointments in institutions that highlight the importance attributed to industry partnerships within the

[8] Note that the evidence reference is close to a decade old, but is particularly interesting in the context of changing face-to-face and virtual working dynamics.

broader agendas of enterprise and commercialisation. Specific interventions, and their design, can help to address barriers and create incentives for some of the key features of collaborations, e.g. people movements and industrial partnerships such as through fellowship schemes, and encouraging new collaborations (and/or SME involvement in collaborations) to help spread expertise and learning.

### Skills

**3.15** The point above on people movements and knowledge development has implications for research (and innovation) skills. Publications of Shortage Occupation Lists (SOL) confirm shortages in science, technology, engineering and maths (STEM) and creative skills (despite increasing numbers of people studying science courses in universities) (Migration Advisory Committee, 2019; UK Visas and Immigration, 2021). The key questions are how R&I skills are defined, what skills are needed by different people/organisations, and at what stages of the innovation process (Gabriel, 2018 for Nesta provides a helpful starting point on this). This cuts across all three pillars of the R&I system.

**3.16** Levers in the research environment have focused on developing the number of graduates in STEM subjects through attracting talent (including through migration or those from low-income and low-represented backgrounds). However, there is contention whether focusing on the pipeline of STEM graduates addresses skills shortages as research indicates that only a minority of STEM graduates enter high-skilled occupations, even within areas where there are shortages (SQW, 2019, drawing on Smith and White, 2018). Furthermore, it has been found that there is little variation between the immediate and long-term occupational destinations of STEM and non-STEM graduates; in fact, the majority of high-skilled STEM workers are non-graduates.

**3.17** The workshop discussions raised the importance of 'absorptive capacity' in relation to the ability of industry to facilitate the number of STEM graduates coming through the university system. Further, absorptive capacity varies across the UK, particularly at the subregional level, including due to the non-work-based factors influencing the choice of workplace.

**3.18** A series of studies on University-Industry (UI) research training indicate diverse learning experiences and private sector career trajectories (Jones and Grimshaw, 2012, drawing on a series of studies by Thune). When compared to non-UI graduates, students on UI programmes are exposed to a more heterogenous learning environment where there is a greater demand for a more diverse skill set, including management, project management and collaboration. The findings imply that these approaches to human capital formation could provide a means of developing a broader set of 'innovation skills' that can be important to the pathways to growth – though the authors point out that the mechanisms are not very well understood.

**3.19** In developing a broader set of innovation skills that can be used across the system and by different actors, there is a role for demand-led approaches that are responsive to the needs of employers (whether firms, research organisations or others). The UK Futures Programme is an example of a scheme that experimented with such approaches. It ran between April 2014

and June 2016 and was designed to co-create with industry to research, develop, pilot and scale innovative solutions in order to tackle workforce development issues. This approach focused on collaboration between employers, often facilitated by intermediaries and wider stakeholders, in order to address issues identified by the employers themselves. An evaluation of the programme concluded that a relatively small public investment can stimulate employer investment in workforce development when supported by strong employer leadership and co-creation support from public sector project managers (SQW, 2016). A number of lessons were identified that would be relevant to similar types of intervention in the future, including that:

- a high level of resource is required from the programme team to support projects, including for writing initial applications and for spotting opportunities for collaboration
- there was very limited co-creation activity between projects, though co-creation between the programme funder and the projects was evident
- employer-led projects may have hindered achieving the programme's objective of transformative innovative thinking due to the industry's reluctance to take risks.

## Private investment in R&D

**3.20** Through the expansion of a firm's stock of knowledge, R&D investments facilitate increases in the output and productivity of production, improving the economic performance of firms and therefore enabling economic growth (OECD, 2015). However, R&D at firm level is relatively low in the UK compared to competitor nations – particularly among SMEs (Okamuro et al, 2019); it is primarily undertaken by frontier firms with greater internal resources and access to external resources. This is likely to affect SME performance due to the issue being exacerbated by low levels of diffusion from larger, frontier firms to SMEs or laggard firms (Andrews et al., 2016; Berlingieri et al., 2017; see also the section on the adoption and diffusion pillar).

**3.21** Research activities can generate large commercial returns, but carry risk and uncertainty. Investment in R&I is influenced by mindsets and attitudes, both of businesses and funders. To address market failures, different types of interventions can be used, including grants, tax incentives, soft loans and equity investment.

**3.22** The reviewed literature suggests mixed conclusions on whether grants, loans and subsidies to firms have positive effects on R&D spend at firm-level, the first step towards growth. Nevertheless, the balance of evidence indicates a positive effect of grant schemes, especially for smaller firms (see Table 3-1). Whilst some evidence points to examples of crowding out, overall, the literature reviewed tends to reject the crowding out of private investment, with some indication of crowding in (Becker, 2015; WWC, 2015). Different mechanisms can be effective in this context: grants to academics have been found to lead to more patents filed by private firms; increases in publicly funded R&D to private firms can leverage further R&D; and grants to private firms for R&D can lead to further investment (including through venture

capital). There is less evidence available on the next stage effects in the pathways to growth, e.g. on innovation outcomes (such as new products launched) and business performance; though a recent study on firms in receipt of Research Council grants found positive effects on employment and turnover (Vanino et al., 2018). In addition, an unpublished review of Innovate UK-commissioned evaluations found that beneficiaries of different grant schemes reported various effects on outcomes in the pathways to growth, e.g. product and process development, access to markets, and business growth.

**3.23** The evidence in relation to tax incentives appears to be disputed. Some find a positive effect on R&D expenditure, notably in relation to small firms (Kohler et al., 2012; Bloom et al., 2019). However, there is some caution that small firms may have a greater tendency to reallocate some expenditure to R&D in order to take advantage of the tax incentives, which may reduce the overall positive effect (WWC, 2015). Moreover, a recent study questioned whether the UK R&D Tax Credit scheme led to additional business investment in R&D (Connell, 2021). Studies also suggest that any effects diminish in the long-run, and this is especially found for larger firms (though there are challenges in evaluating effects on large firms).

**3.24** The evidence indicates that different forms of incentive can help to stimulate private sector R&D investment. Targeting instruments towards the specific needs of different types of firms may help to improve the efficiency and effectiveness of schemes. Long-term stability of instruments, adjustments in design features such as intervention rates, and coordination between different instruments may all help in this regard.

**3.25** There are some gaps in evidence, including in relation to the effectiveness of government support by stages of the innovation process. The evidence on the effects on innovation and business performance outcomes could also be strengthened. There is limited evidence on large firms due to difficulties in detecting effects when levels of R&D are high in any case, though we understand that Innovate UK is currently undertaking work to seek to help address this gap.

**3.26** The UK Government, UKRI and BBB are key actors in the R&I system in relation to private investment in R&D, e.g. through interventions in the SME finance market, in particular through support to research-led businesses (alongside local provision, e.g. LEPs and Growth Hubs). All of these organisations have active roles (in various forms) in supporting early-stage innovation and providing support to start-up and growth businesses. These actors also provide support in subsequent stages of the innovation process, as set out in chapter 4 (on translation and value creation) and chapter 5 (on adoption and diffusion).

**Table 3-1: Key findings on private investment in R&D from evidence review**

| Key findings |
| --- |
| **What does the evidence say on the effectiveness of different subsidies and incentives in stimulating or leveraging private sector investment in R&D?** |
| • **Whilst there is mixed evidence on the effectiveness of grants and subsidies in stimulating R&D spend, the majority of studies find a positive link.** Recent literature |

**Key findings**

suggests a shift away from earlier findings that public subsidies crowd out private R&D (Becker, 2015), and in some cases there is evidence of crowding in (WWC, 2015).

- There are several studies investigating the effect of government subsidies on collaborative R&D activities, finding a positive effect on a range of outcomes including level of collaboration, research productivity and IP applications (and potentially leading to spillovers).

- **The evidence indicates that the effectiveness of tax incentives on R&D expenditure is disputed.** A review of evidence indicates a positive effect (Kohler et al., 2012), and Bloom et al. (2019) estimate that across the macro and micro studies, a reasonable conclusion would be that a 10% fall in the tax price of R&D results in at least a 10% increase in R&D in the long run. However, other evidence has questioned the ability of the UK R&D Tax Credit scheme to deliver significant additional business R&D spending (Connell, 2021).
- WWC (2015) note that small firms may re-classify expenditure to take advantage of incentives, reducing/limiting any effects. In addition, Bloom et al. (2019) point out that targeting policies at small firms may discourage them from growing beyond a certain point that would make them ineligible for public support.

**What evidence is there on effectiveness at different stages of the innovation process?**

- **There is generally limited evidence on the effectiveness of incentives and subsidies at different stages of the innovation process.** Vanino et al. (2018) review the evidence on the effectiveness of **grants** across the different stages of the innovation process, finding some evidence that grants might best be used to support riskier projects or scale up certain activities (including for start-ups and young firms with growth potential); other studies suggest that research grants have stronger impacts than development grants.

**What evidence is there on the conditions/contexts under which subsidies and incentives work?**

- **There are a number of preconditions which are critical for implementing any effective public support programmes (regardless of the specific type of instrument)**, including low barriers to access; flexibility in application procedures; low transaction/compliance costs; the stability of programmes; and sequencing of funding instruments (Hutschenreiter et al., 2019).

- The What Works Centre for Local Growth (2015) found the following:
  - **R&D grants, loans and subsidies are more likely to improve outcomes for smaller companies.** This may be due to public support making up a relatively small amount of overall R&D spend (making statistically significant effects harder to detect), or due to smaller firms facing more financial constraints (and so subsidies leading to additional R&D).
  - **Programmes targeting particular sectors appear to be slightly less effective** in stimulating R&D expenditure and innovation, compared to those that are 'sector neutral'.
  - **Programmes that emphasise collaboration perform better** (also Vanino et al., 2018).
  - The limited evidence on automatic vs competitive schemes seems to point at **only competitive subsidies having positive effects** (in both cases on productivity).

- Hutschenreiter et al (2019) suggests that **loans** may be useful under specific macroeconomic and financial conditions, and in facilitating diffusion-oriented R&D.

*Source: SQW evidence review*

## Implications

**3.27** The evidence base on interventions under the research pillar, in common with other pillars, could be developed further. That said, **there are some areas where there is a good base upon which to build:**

- There is a range of robust and clear evidence in relation to instruments to encourage private investment in R&D. In particular, small firms see positive effects from grants where the intended outcome is R&D spend itself. Key implications to consider in implementing levers to invest in and incentivise R&D are the alignment between schemes, specifics of design (such as intervention rates), and policy stability. There are some areas where the evidence base could be strengthened, in particular on the effects for large firms (though this is tricky to evidence robustly); for outcomes beyond R&D spend itself (e.g. more robust published evidence on innovation and business performance outcomes); and for stages of the innovation process. There is also mixed evidence on the role of tax incentives, with studies conflicting in their conclusions.

- There are studies on the lessons from implementing collaborative R&D (CR&D) programmes, in particular associated with relationship development, and the factors that are viewed as important in developing and sustaining these collaborations. These point to good practice lessons for the design of such schemes, such as requirements/criteria for collaborations within application guidance, having strong and clear management within CR&D projects to make collaborations work, and networking/showcase events at or towards the end of programmes that can lead to further collaboration and investment in innovations.

- There is some evidence on schemes that can encourage progression and flows of people between research and industry – notably through university-industry research training schemes. However, the mechanisms of why these occur could be better understood. The evidence on the development of STEM skills is not compelling given the varying destinations of such graduates – and this could be developed further, as well as for other types of research and innovation skills. In this context, demand-led policy may be an important principle, helping to ensure that provision is meeting an evidenced need from employers.

**3.28** **A range of other gaps are highlighted in this chapter, and some of these relate to more systemic issues and relationships.** The discussion on basic and applied research raised questions about how these types of research contribute to routes to growth, not just in terms of how the research outputs are used, but also through other more indirect effects such as through university-industry relationships and people flows. In relation to private investment, there are a range of actors involved, including in subsequent stages of the R&I process. We return to these in subsequent chapters, and this is potentially an important area for further research to consider the extent of alignment and whether the system itself could work better.

3.29 **Finally, previous research has highlighted that there is a lack of an overarching and consistent framework or definition through which to consider research and innovation skills.** Developing such a framework could aid building the evidence base in this important area, under the research pillar as well as the other two pillars.

# 4. Synthesis of findings: Translation and value creation

**4.1** This section presents an overview of the findings in relation to the translation and value creation pillar. At the outset, the section sets out some of the key pathways to growth. For select areas within these pathways, the section then sets out the issues relating to: barriers and enablers to growth; interventions that can support outcomes in the routes to growth (and the evidence on the effectiveness of these); evidence gaps; and key interrelationships and linkages in the wider R&I system.

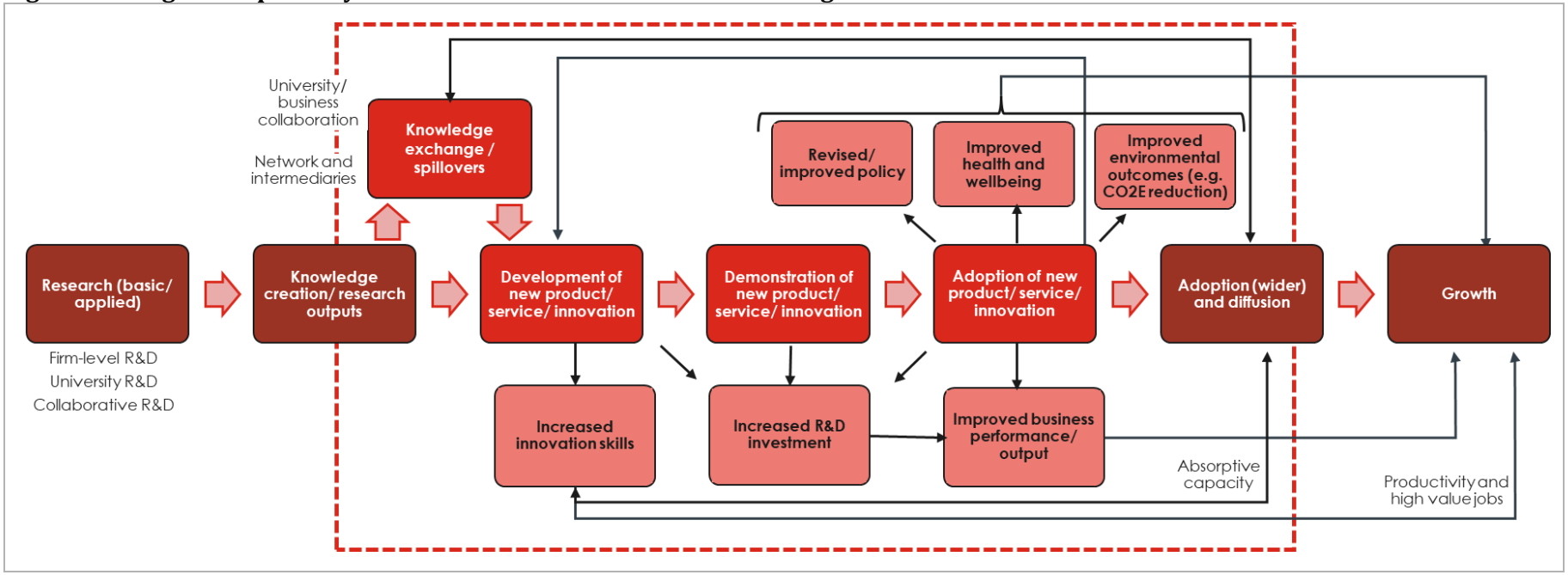
## Pathways to growth

**4.2** The routes to growth through translation and value creation can deliver both direct outcomes that lead to growth and wider and/or indirect outcomes that enable growth. For example, direct outcomes include improved business performance and output that can be scaled up with wider adoption. Indirect outcomes include increased innovation skills and R&D investment, which can lead to improved absorptive capacity, thereby facilitating adoption of innovations and subsequent growth. Figure 4-1 presents a high-level diagram which illustrates some of the key links and intermediate outcomes from translation and value creation to growth. The translation (and value creation) of research/knowledge outputs can occur through multiple routes, including through university-business collaboration, firm-level R&D, and through intermediaries or networks. Translation can occur through the development of products and services for the market, and through non-market routes such as policy influence, environmental benefits and health outcomes, which can also be scaled up through wider adoption.

**4.3** Reflecting on these outcomes and routes to outcomes, this chapter discusses a number of key aspects:

- university-business collaboration, and the barriers and enablers of this
- the role of intermediaries in supporting the translation of research into applications that can generate value
- access to funding, finance and expertise to help with the scale-up of innovations
- the role of demand-side interventions, in particular standards.

**Figure 4-1: High level pathways from translation and value creation to growth**




*Note that outcomes/intermediate outcomes are highlighted in light red, while the earlier and latter stages in the innovation pathway are shown in dark red. The main pathways relevant to the translation and value creation pillar is highlighted in the (bright) red dashed square.*

## University-business collaboration

**4.4** Despite a large amount of research undertaken in Higher Education institutions (HEIs), very few businesses reportedly regard research by universities or research institutions as 'highly important' for their innovation (around 3% of innovating firms) – indicating a potential disconnect between the translation from the research base into real-world application (UK Innovation Survey, 2019). However, this does not take account of the extent to which HEIs may be important indirectly to innovating firms, e.g. through other organisations such as firms in supply chains or intermediaries.

**4.5** On commercialisation specifically, the McMillan Review (2015) found that licensing activity in the UK is lower than in the USA (even with scale factored in), which may reflect greater absorptive capacity in the USA. However, the Review suggested that the UK has leading support for university commercialisation.

**4.6** The evidence suggests that there remains considerable variability in the capacity and transparency of commercialisation processes across UK universities and widely varying outcomes and income profiles. By implementing a clear pathway to commercialise IP, universities can become more attractive and are able to secure the best academic talent and projects (Hill Dickinson LLP, 2020). There could be an important role in exemplifying and supporting the spread of best practice across the UK university system to ensure that wherever research is being conducted its full commercial potential is realised. This would need a review of the evidence on best practice, taking account of context-specificity relating to different institutions.

**4.7** Beyond commercialisation through spin-outs and licensing, research partnerships with industry and other organisations (e.g. policy) are increasingly important to transferring knowledge (Perkmann and Walsh 2007). Collaborations for R&D and innovation projects are key, due to the mix of expertise and perspectives afforded.

**4.8** Strong personal relationships are highlighted as underpinning high quality collaborative R&D – and this is borne out in evaluation evidence on CR&D programmes (e.g. Elsevier, 2013; Dyer et al, 2008; Cunningham and Gok, 2012). The evidence from our own evaluations of collaborative R&D programmes indicates that it is often established partnerships that are drawn on, due to the trusted relationships and the known complementary expertise. That said, new links can be formed due to requirements for specific expertise – and these can provide the basis for developing new relationships.

**4.9** Organisational attitudes and university management and policies, including incentives for academics (e.g. financial incentives, policies in relation to career progression, and publication records), can all affect the extent of involvement in translation of different kinds, including in relation to policy/practice and commercialisation (Dowling, 2015; Ulrichsen, 2019; Jessani et al., 2020). Feedback from the workshop discussions also highlighted the difficulty in ensuring flexibility from all parties. For example, those in senior positions are unlikely to make permanent moves over to industry/academia because they have already established their

career path, and so opportunities for work on a part-time basis are likely to be important in incentivising people movements.

**4.10** Other aspects of the research literature focus on indirect knowledge spillovers from university research – the idea that being located near to a university confers a benefit to firm innovation or performance over and above any direct connection. There is evidence from the clusters literature relating to how greater people movements and knowledge sharing can be achieved in well-functioning clusters. However, in relation to specific interventions such as collaborative R&D programmes, the evidence on spillovers is not well-developed, to a large extent due to the challenges in assessing them (SQW, 2017, unpublished).

### Role of intermediaries

**4.11** Recent evidence suggests that technological intermediaries can be effective in helping firms to overcome proximity issues in accessing new technologies in terms of issues around geography, cognition and organisational barriers (Villani et al. 2017). This is relevant to adoption and diffusion, as well as translation and value creation. The success of intervention, however, depends significantly on the strategic orientation and capability of the intermediary organisation. There are a range of intermediary organisations in the UK, including the Catapult network, various RTOs and others. There are also similar organisations overseas, including some that the Catapults were partly based on.

**4.12** Catapults were set up as key infrastructure to help bridge the gap between early-stage research and the later stage industrial commercialisation, typically at TRLs 4-7 (BEIS, 2021). Various reports, including some unpublished evaluations and syntheses, highlight the range of roles they play in relation to supporting translation and commercialisation of research, including through access to equipment and expertise, and collaborative R&D projects. The nature of evidence on impact needs to be considered carefully – it is not straightforward or meaningful to quantify outcomes in terms of a growth contribution, but rather there are a mixture of outcomes relating to business performance, investment and the wider system (and more broadly through the nature of technologies and innovations developed). Partly as a result of this, the evidence base around them is still very much developing.

**4.13** There are examples of impacts on a range of key issues by intermediaries, including Catapults (see Table 4-1). These vary in their nature, scale and contexts, making it challenging to synthesise definitively the contributions made by these technology intermediaries[9]. Further, workshop discussions highlighted that the role of intermediaries is not static but evolves over time in response to market needs. For example, the role of the Cell and Gene Therapy Catapult now is very different from when it was established a decade ago.

[9] Elsewhere in Europe, studies on European research and technology organisations (e.g. IMEC in Belgium, Fraunhofer Institutes in Germany and TNO in the Netherlands) highlight the roles played by these intermediaries but with limited evidence on their impacts.

4.14 Interdependencies and synergies with different elements of the system are important when considering the roles of intermediaries. The extent to which different interdependencies are important will vary between intermediaries. The different elements include the following:

- **Collaborative R&D programmes:** These are key funding streams for intermediaries and the firms they work with, and can encourage new partnerships/networks.
- **Skills, doctoral training and apprenticeships:** Intermediaries partner with other organisations for training delivery and are a place of training on behalf of their sectors/industries. The workshops also highlighted that an appropriately skilled workforce within the intermediary organisations themselves is absolutely fundamental to enabling outcomes, and can itself lead to knowledge spillovers as a result of labour market flows.
- **Access to finance:** Intermediaries help companies to make the case for investment, including through technology development and assessing/demonstrating commercial potential, and can act as an interface between companies and investors.
- **Standards and regulations:** Intermediaries play a role in convening and influencing standards and regulations that can shape innovation and wider adoption.

**Table 4-1: Key findings on intermediaries from evidence review**

| Key findings |
|---|
| **What evidence is there on the role of intermediaries in supporting the translation or commercialisation of research?** |
| • **For Catapults, there is specific evidence of effects on new product development and new processes, and on business performance** (e.g. turnover), though available evidence indicated that many of these effects were expected at the time of evaluation. BEIS (2021) suggests that Catapults should better engage with universities in order to identify and support ideas that need to be proven before a service or technology can be developed.<br>• Looking specifically at the High Value Manufacturing Catapult, Hutschenreiter et al (2019) identifies two critical success factors: the critical mass of engineers and scientists at the Catapult; and the three-pillar funding model which maintains a balance between risk-taking, collaboration and stimulating innovation. |
| • **Evidence on the Norwegian Technical-Industrial (TI) Institutes** indicates a role as a bridge between university-based fundamental research and industry; however, this has become more diffuse with universities addressing industry directly and specialised TI institutes also conducting fundamental research. There is scope for TI Institutes to play a larger role in supporting commercialisation, e.g. by providing tangible incentives.<br>• There is evidence that the TI Institutes have contributed to economic growth through business performance effects, with the Institutes contributing to a considerable expansion of industry turnover in the last decade (Åström et al. 2015; and evidence presented to a European Commission exercise to share evaluation practice – see Weresa et al., 2018). |
| **What evidence is there on the role of intermediaries in stimulating business investment in R&D and innovation?** |
| • **Unpublished evaluation reports, including syntheses of evidence, describe and evidence the impacts of Catapults and other Centres/Hubs supported by Innovate UK on private** |

**Key findings**

**investment in R&D**, in particular through innovating companies investing their own funding, and through collaborative R&D projects that leverage both public and private investment.

- **As intermediaries, Catapults are well placed to help potential investors understand how investments in new ideas could make returns.** Catapults have varying methods for, and success at, helping businesses to access finance – partly due to the different levels of maturity and the nature of sectors that they align with. Some Catapults have developed their own investment models (e.g. the Satellite Applications Catapult, the Centre for Process Innovation).
- The healthy proportions of industry incomes for both **UK Catapults and the Norwegian TI Institutes** indicate some success in leveraging private investment into R&D.

**What evidence is there on outcomes that may contribute to wider system effects, e.g. knowledge and skills development, people flows and networks?**

- Intermediaries should not be viewed as stand-alone instruments, but rather as part of the wider landscape of finance and other support programmes:
  - **Collaboration:** There is evidence of networking within the Catapults encouraging new partnerships (BEIS, 2021). International good practice includes Germany's SME (Mittelstand) 4.0 initiative encouraging pooling of resources between participating institutes (Hutschenreiter et al, 2019).
  - **Skills:** The Catapult Centres are well-placed to identify and address skills requirements due to their convening role (although skills development is not their core objective). Whilst there are examples of facilitating knowledge transfer between the research base and industry, there is potential for the Centres to have a greater focus on skills as part of their offer (e.g. through apprenticeship schemes or other skills training/courses).
  - **Equality, diversity and inclusion (EDI):** Increasing attention is given to this area with Catapults recognising that there is an opportunity to utilise their diverse talent pool for driving societal and economic growth across the UK. However, there is limited evidence of this commitment feeding into practice across the network at this stage (BEIS, 2021).
  - **The role of clusters:** Connecting different parts of the ecosystem can help to reduce costs, and help to bring innovations to market by linking users and producers (Hutschenreiter et al, 2019).

*Source: SQW evidence review*

## Firms access to funding/finance and scale-up support

**4.15** SMEs find it difficult to obtain private external funding for commercialisation and scaling-up due to a lack of trading track record and collateral (that banks demand) – and as a result of the information asymmetries that occur between financiers and businesses. These funding gaps and barriers are more acute at the translation stage (innovation stages from pre-trading to start-up, spanning the 'Valley of Death' and prior to entering commercial markets).

**4.16** One reason for this is that the organisation is not capable of supporting and driving growth – either because it does not have necessary skills and/or access to finance/knowledge of how to access finance (Logan, 2020). Finance and business support is required (especially in relation to management and leadership) to overcome these issues and so enable early-stage and smaller businesses to make a step change and contribute substantively to growth. Good leadership in particular is required to enable effective teamwork; utilisation of the skills, knowledge and talents of staff; good use of data and customer relations; and appropriate investment decisions.

**4.17** Various interventions exist in this space, though the evidence base on their effectiveness is mixed. In particular, it is often programme or context-specific as to whether interventions are found to be effective. Interventions can include: private sector activity/support through accelerators and incubator programmes (e.g. through mentorship, skills development, networking, and co-working space); schemes designed to provide 'smart money'; coaching programmes; and peer mentoring. Innovate UK delivers support to innovative companies with growth potential through its EDGE programme, which is due to be evaluated.

**4.18** There are a range of business support services available including those which provide general business assistance. For general business advice schemes, the evidence base is focused on outcomes relating to sales and employment growth, and productivity (rather than innovation). An existing synthesis of evidence suggests that there is stronger evidence that these schemes have positive effects on sales growth rather than other outcomes (What Works Centre for Local Growth, 2016); however, the findings are mixed and dependent on programme-specific factors (see Table 4-2).

**4.19** A study looking at the effects of, and links between, regional and national innovation schemes in the UK and Spain finds that these have different types of effects in relation to innovation (Becker et al., 2016). Regional innovation support tended to influence process and organisational innovation, whereas national support had more influence on the development of new products/services. This may reflect the nature of support and the types of firms taking it up. For the UK, the results point to the role of regional schemes in broad-based innovation and in supporting non-innovators, and the focus of national support measures in encouraging novel product and service innovation.

**4.20** The stakeholder workshops highlighted the importance of interaction between different types of schemes, creating a holistic business support "journey" for firms. In this context, programme continuity is crucial in raising awareness of the available support. Workshop attendees agreed that there is no need to "reinvent the wheel" but there are opportunities in joining up the existing organisations and support mechanisms. In doing so, it is important to ensure that different schemes are incentivised to work holistically across the landscape (e.g. by designing key performance indicators that capture this as an outcome). However, there are likely to be cases where incentives do not align across the wider landscape, for example due to the fragmented nature of funding pots (and the pressures to demonstrate the impact of each investment). The Industrial Strategy Challenge Fund (ISCF) and Innovate UK EDGE were highlighted as examples of a "one pot" model with a more joined up approach to support.

**Table 4-2: Key findings on business growth support from evidence review**

| Key findings |
| --- |
| **What is the evidence on the effectiveness of complementary business support in contributing to innovation outcomes from the perspective of translation and value creation?** |
| • According to a study by the What Works Centre for Local Growth (2016) **business advice programmes** show largely mixed results across the board. The nine evaluations looking at productivity show consistently mixed results, with one third of studies finding positive results, just over one third of studies finding no impacts, and just under one third of studies finding mixed results.<br>• Of the 17 studies that look at employment outcomes, only six report positive programme effects, whilst eight evaluations report zero effects. For the two studies that look at employment duration or small business survival, results are substantially worse, with no positive findings.<br>• Results for sales and turnover outcomes are somewhat better than for employment and productivity, with eight of 16 studies reporting positive results. |
| • Becker et al. (2016) reviewed **national and regional innovation support schemes** in the UK and Spain to consider the complementarities between them. They found that national schemes were more likely to contribute to translation, through effects on new product and service development. Regional programmes had a broader effect on process improvement and organisational development – i.e. more on adoption and diffusion. |

*Source: SQW evidence review*

**4.21** UK Government policy has started to consider and adopt repayable finance options. For example, an interim evaluation of Innovate UK's pilot of the Innovation Loans programme (which targets late-stage R&D, close-to-market projects) provides early evidence on key outcomes being achieved, including innovation capacity/skills; R&D investment; progression through Technology Readiness Levels (TRLs); employment; turnover; productivity; and securing follow-on funding. The implication is that more Innovation Loans would be expected to lead to further growth-related outcomes, and the Government has recently decided to launch a full-scale programme. The evaluation identified a number of considerations for future development of the programme, including: further integration with Innovate UK's other funding and programmes to accelerate project commercialisation; possible expansion of the programme to include (non-financial) business support; and options for introducing rolling applications in between competitions to enable businesses to better plan around their own business cycles and needs. A future impact evaluation of the programme will need to provide evidence on the long term outcomes and impacts of the programme (including spillovers), as well as consider the default rates and the extent of crowding out of private R&D investment.

## Demand-side interventions

**4.22** The role of standards[10] in contributing to economic growth has been shown in various empirical studies (Blind, 2013; based on DIN, 2000). For example, it was estimated that the information contained in standards and technical rules was responsible for 1% of Germany's gross national product between 1961 and 1996. Encouraging the development of standards is a relatively cost-effective approach for policy makers, particularly compared to measures such as tax incentives, price subsidies and awareness campaigns (Ernst & Young et al., 2014). However, although there is some evidence on the relationship between standards and innovation (see below), the plans set out in the Innovation Strategy may help fill the evidence gap.

**4.23** It will offer the opportunity for UKRI to play a lead role in developing and disseminating the evidence base that demonstrates the distinction between voluntary standards and mandatory legal requirements enacted by Government through regulations, and how the impacts on innovation can be varied and differentiated – including in different sectors and emerging areas of technology – in order to inform policy approaches. Further, the workshop discussions suggested that the domains covered by standards are expanding (e.g. Artificial Intelligence and Big Data), suggesting growing importance going forward. The issue of standards is also important at the adoption and diffusion stage, and is returned to in the next chapter.

**4.24** In a similar vein, the Innovation Strategy also refers to a review of pro-innovation regulations to be undertaken by the Regulatory Horizons Council – which again may help fill an evidence gap on the role of regulations in pulling through innovations (relevant to both translation/value creation and adoption/diffusion pillars).

**4.25** Evidence points to a number of ways in which standards can support the development of innovations, and so help contribute to growth (see Table 5-2), including by:

- serving as framework conditions for future research, e.g. quality standards to reduce the risks associated with new technologies
- levelling the playing field and therefore promoting competition (and so innovation)
- facilitating the substitution of old technologies by new ones
- reducing production and other costs associated with new technologies.

**4.26** However, there are some challenges relating to the development and adoption of standards, including the threat of knowledge leakages to competitors (Baron et al., 2018; based on Blind and Thumm, 2004); and the possibility of firms using their influence over standard setting to

[10] Blind (2013) defines standards as a '*voluntary process for the development of technical, but more and more also other types of specifications based on consensus amongst the interested parties themselves'*. Most standards have two key characteristics: they are voluntary, and they are made available for use free of charge. Standards can be informative (e.g. codifying knowledge) or constraining (e.g. health and safety/environmental), and many standards contain elements of both. Standards are different from regulations, which represent a top-down approach, whereas even formal standards are typically the result of a market-driven process (Blind et al., 2017).

serve their own interests (Blind et al, 2017). Further, workshop discussions highlighted that the impact of standards varies between companies, sectors and more widely (e.g. what might be good for one business might not be good for others).

**Table 4-3: Key findings on demand-side interventions from evidence review**

| Key findings |
|---|
| **What evidence is there on the role of standards in driving the development of innovations?** |
| • Blind (2013) identifies a number of roles for standards in driving innovation, including:<br>➢ **serving as framework conditions for future research**, e.g. quality or health and safety standards are crucial for reducing risks associated with innovative technologies/products<br>➢ **levelling the playing field** and therefore promoting competition (and thus innovation)<br>➢ **technology standards facilitating the substitution of old technologies by new ones,** particularly in network industries where compatibility/interoperability standards are crucial, e.g. to enable data sharing and electric vehicle charging<br>➢ **reducing production and other costs** associated with new technologies. |
| • Swann (2010) suggests that standardisation **codifies and diffuses state of the art technology and best practice**. It is widely accepted that standards can play both an enabling and a constraining role. A key debate within literature is the balance between these two forces. Swann (2010) refers to the 'infrastructure perspective' which posits that these two are inextricably linked: any infrastructure may appear to limit the user's options, but it also opens up opportunities. Therefore, **whilst standardisation does constrain activities, in doing so it also creates an infrastructure to enable subsequent innovation** (for example through increasing credibility and focus, or reducing undesirable outcomes). |
| **Are there particular barriers/enablers to their use?** |
| • Baron et al. (2018), based on Blind and Thumm (2004), suggest that a firm is likely to abstain from engaging in standardisation if **costs resulting from knowledge leakages to competitors exceed the benefits** that the business can derive from developing and/or adopting standards. |
| • In markets with low uncertainty, firms have a much better chance to influence formal standards to align with their technological preferences (Blind et al., 2017). Under these conditions, firms involved in standard setting are able to identify and involve interested stakeholders and set standards in a way to minimise their own proprietary compliance and innovation cost. However, **firms not involved in setting the standards are likely to face higher compliance and innovation costs** if the developed standards are not in line with their preferred production technology. |
| • Baron et al. (2018) found a highly robust **positive effect of the level of a firm's R&D expenditure on its involvement in standards organisations**. The findings show that a firm's product-market position is significant in incentivising engagement in standards development, as measured by trademarking intensity, brand value or the number of standard-compliant end product models. However, the authors note that there is some previous evidence to contest this finding, suggesting that firms with strong market positions may avoid standardisation activities to allow them to achieve commercial success on their own. |

*Source: SQW evidence review*

## Implications

**4.27** There are three key sets of implications from this chapter. **First, intermediaries can play important roles in the R&I system, but the evidence base in relation to them is complicated.** The effectiveness of Catapults and others in leveraging funding for R&D investment has been shown to some extent, but the evidence on the contribution to business performance and other measures of growth is not (yet) compelling, partly given the challenges thrown up by the range of other mutual factors in play. The literature also points to varied potential roles for intermediaries, including in relation to skills development, informing standards and regulations, and access to finance. This mix of roles, together with feedback from the workshop on the need for these actors to evolve in response to changing market needs, points to the requirement for different types of evaluation that are more developmental. Developmental evaluation supports innovation development to guide adaptation to emergent and dynamic realities in complex environments, such as the R&I landscape and system (Patton, 2010). Such evaluation, therefore, would need to be grounded in how intermediaries operate within the wider R&I landscape and system, how they affect different aspects of it, and what the subsequent knock-on effects are. This can then provide, as far as possible, real time evidence on how varying needs are being met, whether the needs continue to exist or what the new ones are, and how intermediaries can provide a role.

**4.28** **Second, there is some robust evidence on the contribution of business support to growth, but the findings can be context or programme-specific with some schemes found to be effective and others not**, e.g. reflecting who has been supported, in what contexts etc**.** There is little that is directly relevant to innovation programmes or innovation outcomes – this is a gap that requires filling. Building on the previous chapter, more evidence on how this support aligns or could align with innovation funding and other interventions in the system may be beneficial. For instance, companies may be 'technically ready' as a result of investment in R&I and the achievement of innovation outcomes. However, they may not be 'commercially ready.' Joining up between UKRI and those providing advice on commercial aspects (e.g. BEIS, BBB, business support providers) could be worth testing and evaluating.

**4.29** **Finally, collaboration between universities and business has been subject to various reviews, which show the variation in practice in existence.** UKRI's role, alongside others, could be key here in terms of sharing such practice where there may be transferable lessons, including between university institutions on how partnerships with industry (and other organisations) are encouraged as part of incentives for translation.

# 5. Synthesis of findings: Adoption and diffusion

**5.1** This section presents an overview of the findings in relation to the adoption and diffusion pillar. At the outset, the section sets out some of the key pathways to growth. For select areas within these pathways, the section then sets out the issues relating to: barriers and enablers to growth; interventions that can support outcomes in the routes to growth and the evidence on the effectiveness of these; evidence gaps; and key interrelationships and linkages in the wider R&I system.

## Pathways to growth

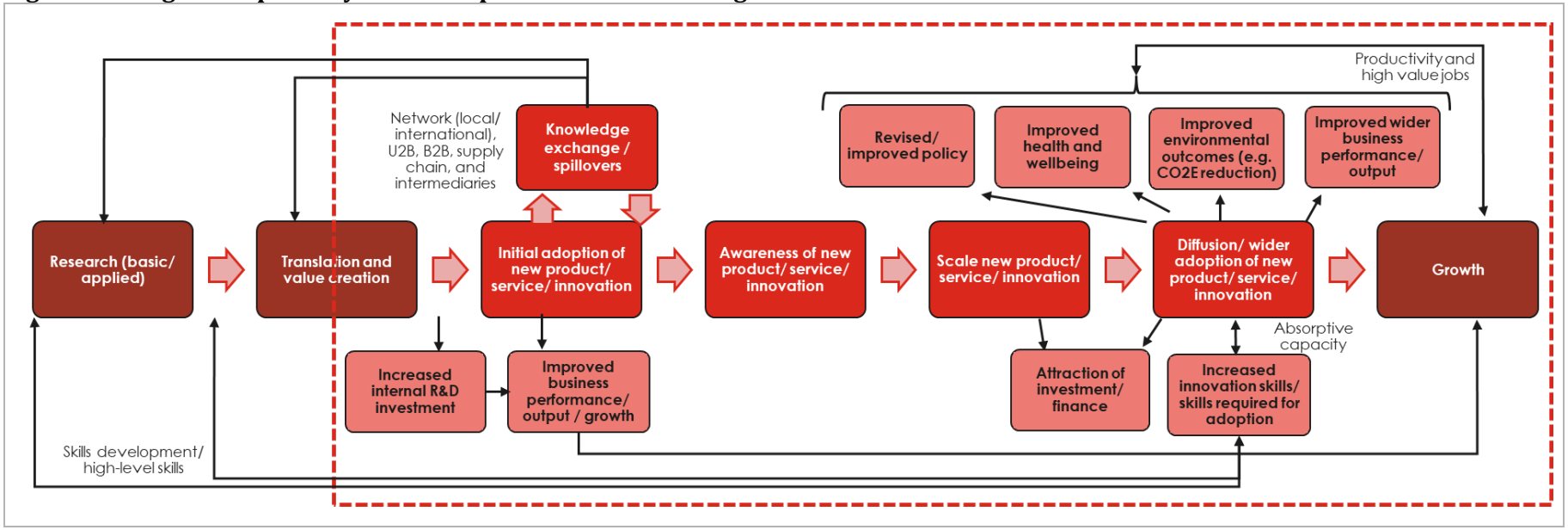
**5.2** The route to growth through adoption and diffusion can be more direct and shorter-term than for the other two pillars. Nevertheless, there are a range of intermediate or indirect outcomes in the pathways that enable growth, such as increased private R&D investment and improved business performance/growth. Multiple feedback loops also exist at this stage, including links back to and from the first two pillars. For example, skills development under research and/or translation and value creation can lead to increased innovation skills and/or absorptive capacity that enables or encourages adoption and diffusion. Similarly, knowledge exchange and spillovers under the adoption and diffusion pillar could lead to subsequent collaboration in research and/or translation and value creation. Figure 5-1 presents a high-level diagram which illustrates the key links and some of the intermediate outcomes on the route to growth.

**5.3** There is a perceived diffusion gap in the UK. Absorptive capacity is key to diffusion, but in the UK, this capacity is low according to the Global Innovation Index (GII) (Dutta et al., 2020). The UK's low ranking is partly related to a relative weakness in research talent working in businesses (ranking 33rd). This relates back to issues regarding people movements (or the absence of these), which were identified under the research pillar in chapter 3. Other factors which feed into the relatively low ranking on knowledge absorption for the UK include low levels of intellectual property payments (i.e. licensing), and weaknesses in ICT services (Roper, 2021).

**5.4** This chapter focuses on four aspects related to the adoption and diffusion challenge:

- business support, in particular technical advisory support
- the role of different types of skills in enabling adoption
- networks, and how these can facilitate diffusion of ideas and practice
- demand-side interventions to help encourage wider adoption.

**Figure 5-1: High level pathways from adoption and diffusion to growth**




*Note that outcomes/intermediate outcomes are highlighted in light red, while the earlier (and final) stages in the innovation pathway are shown in dark red. The main pathways relevant to the adoption and diffusion pillar are highlighted in the (bright) red dashed square.*

## Business support, including technical advisory support

**5.5** Business-to-business (B2B) knowledge flows and sharing are viewed as the most important drivers of business innovation by innovating firms. Innovation Survey data emphasises the importance of collaboration within the supply chain in particular (UK Innovation Survey, 2019). As noted in chapter 3 on the research pillar, the importance attributed to HEIs directly by innovating firms is limited, though this may imply that networks and knowledge flows, facilitated through supply chains and intermediaries, are critical in addressing adoption and diffusion.

**5.6** There is convincing evidence of an increased divergence in innovation and productivity between frontier and laggard firms (Andrews et al., 2016; Berlingieri et al., 2017b) accompanied by suggestions that it is the failure for technologies to diffuse rapidly from frontier to laggard firms which is part of the explanation. Informational barriers prevent B2B knowledge sharing and technology adoption (Berlingieri et al., 2020). In particular, if firms are unaware of the availability of new technologies or unable to assess their benefits, they may be unable or more reluctant to adopt these. This effect may be exacerbated by shortages of investment finance or other resources. Recent studies emphasise the diversity of firms within the laggard group and suggest the importance of investments in intangible ICT (Berlingieri et al 2020).

**5.7** Technical advisory and assistance programmes can support firms to become aware of, and adopt and deploy, new technologies and innovations. Prominent examples of technical advisory services include the Manufacturing Advisory Service (England), the Manufacturing Extension Partnership (USA), and the Industrial Research Assistance Program (Canada). Most studies tend to investigate business outcomes rather than those specifically relating to innovation, and the evidence base reviewed here is less robust than in relation to the sub-section on business support in chapter 4. When considering the scope of technology and innovation advisory services, it is important to note that the emphasis is not on technology transfer from labs to firms, but rather on measures to improve capabilities *within firms*. Services include: technical assistance; consultancy to support adopting new technologies; and advice on commercialising innovations.

**5.8** Intermediate outputs can be divided into three parts: (1) the capacity for change in practice, (2) changes in practice, and (3) changed firm capability. Technology and innovation advisory services do not necessarily impart advanced technology in isolation, but are frequently involved in diagnosing and facilitating pragmatic improvements in operations and practices, usually with commercially-proven technologies. Firm outcomes have been found to vary by service mix and intensity. Moderate but intense customised services in the product development and marketing area lead to bigger benefits, while routine services oriented around quality and process improvement lead only to modest firm effects.

**Table 5-1: Key findings on business support from evidence review**

| Key findings |
| --- |
| **What is the evidence on the effectiveness of complementary business support in contributing to innovation outcomes from the perspective of adoption and diffusion?** |
| • Shapira and Youtie (2014) reviewed and synthesised evidence from different studies on **technology and innovation advisory services**:<br>➢ Regarding firm effects, evidence from US and Canadian schemes shows that moderate but intense customised services in the product development and marketing area lead to bigger benefits, while routine services oriented around quality and process improvement lead to modest firm effects.<br>➢ UK results present more of a mixed view. Shapira and Youtie (2014) refer to the DTZ (2007) evaluation of the Manufacturing Advisory Service (MAS), which reported that benefits were higher for clients receiving intensive services. Intensity matters for general business support: intensive Business Links assistance associated with employment growth (Mole et al.,2008)). |
| • The DTZ (2007) evaluation of MAS services over the 2002-2005 period found that positive, albeit modest, economic returns were generated. For Level 4 consultancy services, £1.40 to £1.80 of economic benefit was received by firms, on average, for each £1 of public funding (with an estimated internal rate of return of 15–17% over a five-year period). |
| • Intermediate outputs connect assistance from **technology and innovation advisory services** to business performance and broader outcomes. Assistance by an expert advisor or field agent usually does not directly result in increased sales or business performance, rather it tends to lead to intermediate capacities to learn and make changes (such as adoption of new practices). These practices can then, in turn, produce business and broader outcomes. |

*Source: SQW evidence review*

## Skills, workforce practices and leadership & management

5.9 In addition to technical solutions and advice, evidence indicates that internal leadership and managerial competencies in firms are important in driving technology adoption and productivity growth (Jibril et al. 2020). There are related aspects to this:

- There are a mix of skills requirements. These include: leadership and management skills and effective management; employees' functional skills to adopt new processes; and potentially R&I skills to identify opportunities for adoption and implementation of innovation.
- Workforce practices, and how these encourage employees' openness and ability to learn and adopt new processes, need to be aligned, and are linked to issues such as motivations, culture and reward structures.
- Networks can help to enable the transfer of knowledge and ideas, including through business-to-business relationships such as through collaboration within supply chains (see below for more on networks).

5.10 Common barriers faced by employers to investing in skills include: underestimating the value of investment; fears of poaching of staff by competitor firms; the complex array of education and training providers and funding rules which are difficult to navigate, particularly for small

firms which do not have human resource functions; the cost of training or the impact of time away from the place of work for staff; and access to suitable provision.

**5.11** A potential question in the supply of innovation management skills is the extent to which management programmes or short courses specifically focus on innovation management. There are specific and complex success factors to include in such training beyond basic management. For example, workshop discussions highlighted the importance of marketing skills in attracting investors.

**5.12** Other levers for fostering workforce training include levy schemes. However, there is no evidence specific to the development of leadership and management or innovation skills. The evidence on the effect of levies appears to depend on their ties to industrial bodies, types of training providers supported, how the funding levels are maintained, and the size of the firm and the sector environment they are operating in (Jones and Grimshaw, 2012).

### Networks as a means of sharing and spillovers

**5.13** Dense localised networks and clusters may support both collaborative innovation and diffusion as well as contributing to localised knowledge spillovers with potential implications for innovation (Wolfe, 2009; He and Wong, 2012). In both cases these effects depend on the pool of knowledge available locally.

- As He and Wong (2012, p542) suggest: *'local knowledge is … a semi-public good that is spatially bounded, and access to which requires nothing more than cluster membership. Next, local knowledge exchange is prompt or spontaneous because local firms are assumed to be more willing to share knowledge and exchange ideas with other local actors as a result of shared norms, values, and other formal and informal institutions that hold down misunderstanding and opportunism'.*

- Localised knowledge may also have other spatially distinct characteristics, reflecting the presence of specific institutions (typically universities, research labs), and concentrations of industrial activity and/or specific types of human capital. Universities with particular areas of research strength may intensify local knowledge in particular disciplines or technologies promoting cluster development and sustainability (Calzonetti et al. 2012). Alternatively, the presence of large-scale scientific research facilities, which could be related to facilities supported by Research Councils or other government actors, or those tied to universities or private firms, may create very specific local knowledge conditions and stimulate cluster formation.

- Labour mobility within localised networks may also act as a key mechanism for knowledge sharing (Almeida and Kogut 1999; Breschi and Lissoni 2009).

## Demand-side factors

**5.14** In considering diffusion and adoption, standards have effects on the demand side, as they help to create network effects, and reduce information asymmetries and risks (Edler et al, 2013). Evidence indicates that standards are seen as supporting innovation by businesses as information is made more accessible through the dissemination of innovation and technology through standards, and innovation is encouraged through the diffusion of new knowledge as a result of the use of standards.

**5.15** Evidence points to a number of ways in which standards can support the adoption of innovations (see Table 5-2), including by:

- reducing the time to market of inventions
- helping to build focus, cohesion and critical mass in the formative stages of a market
- adding credibility to innovative products and services.

**5.16** Contexts are important in the effectiveness of standards as a policy lever. They are more likely to be effective in industries where compatibility is important (e.g. network industries and information and communication technologies) and those where the "social licence" to operate is critical (e.g. energy or energy-intensive sectors). There is also some evidence to suggest that formal standards lead to higher innovation efficiency in markets with high uncertainty (Blind et al., 2017). In any scenario, actors will only choose to adopt standards if the benefits of doing so outweigh any possible drawbacks, such as knowledge leakages to competitors or the costs associated with standardisation.

**Table 5-2: Key findings on demand-side interventions from evidence review**

| Key findings |
|---|
| **What evidence is there on the role of standards in driving the adoption of innovations?** |
| • Based on a literature review, Swann (2010) identified several ways in which standards might help the adoption and diffusion of innovation, including the following:<br>➢ **Reducing the time to market** of inventions, research results and innovative technologies; e.g. the IECEx certification[11] provides a single international certificate of conformity to a standard for equipment to be used in explosive atmospheres, making it easier for manufacturers to sell their products globally (Choi et al., 2010).<br>➢ **Helping to build focus, cohesion and critical mass** in the formative stages of a market by limiting the variety of available options (therefore helping to focus on specific technologies), e.g. the World Wide Web Consortium (W3C), the Bluetooth Wireless communication standard, and the USB standard were developed under policies requiring all essential IP rights to be licensed royalty-free to implementers (Baron et al., 2018).<br>➢ **Adding credibility,** e.g. by promoting trust in innovative products through meeting the requirements for health and safety aspects; by allowing producers to prove to the customer that products are as innovative as claimed; and more generally by reflecting user needs and therefore making them more likely to purchase. |

[11] International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres

| Key findings |
| --- |
| **In which contexts have they been found to work?** |
| • Technology standards play an essential role in **industries where compatibility is key**, including in **information and communication technologies** (Swann, 2010), but also in other sectors/technology areas. For example, ensuring the compatibility of electric vehicle batteries and charging stations across multiple models will provide critical infrastructure, making it attractive for consumers to switch from internal combustion engine vehicles to electric. |
| • An Ernst & Young et al. (2014) report refers to a study on the Australian oil and gas industry by Ford et al. (2014) which found that firms often go beyond the regulatory requirements and exceed compliance. This is explained by the concept of a "social licence" – a level of acceptance or approval granted by consumers as resulting from a socially acceptable norm. This suggests that **environmental standards are likely to be effective** in encouraging firms towards more environmentally friendly practices beyond the traditional governmental roles. |
| • The use of standards in **public procurement** facilitates positive spillover effects in the private sector and help to diffuse innovations (Blind, 2013). |
| **Are there particular barriers/enablers to their use?** |
| • Blind (2013) identifies challenges related to the adoption of standards in the context of academic research. One of these relates to standardisation processes being time consuming meaning that the decision to engage involves weighing up the **opportunity cost** (e.g. less time for writing scientific papers). The other challenge is around standardisation leading to being **restricted in commercialising the research results.** |

*Source: SQW evidence review*

## Implications

**5.17** The UK has a perceived diffusion gap, and this chapter has identified some important implications through three key inter-related areas:

- **Technical advisory services can have positive effects on businesses, and this includes through the adoption of process improvements.** However, the evidence base is relatively limited, and requires strengthening. The workshop feedback also highlighted the perceived gaps in provision in this area.
- **Various people-related factors are important for adoption and diffusion, including leadership and management skills, workforce skills and workforce practices.** There are questions over the extent to which interventions in this area have a focus on innovation-related issues that could prompt wider adoption of innovative practices.
- **Finally, networks can have important positive effects on the diffusion of practices and innovations, as shown by academic research.** This raises implications for how technical advisory and practice-related initiatives could be best delivered themselves, or the complementary initiatives that could encourage them – e.g. through peer-to-peer or networking schemes.

**5.18** **A final point to highlight from this chapter is the role for demand-side interventions.** The evidence review focused on standards, and highlighted some contexts where these can

work. It is important to note that there are varying types of standards and significant growth in 'soft' standards. There are also key challenges around bringing together the relevant actors to the standard-setting process, including professional associations, trade bodies, intermediaries such as Catapults and businesses themselves. UKRI could have a key convening role in this respect, and bringing in a wider group of SMEs may also help aggregate the voice of business and encourage wider adoption. There are also links to other types of demand-side initiatives, including regulations and public procurement.

# 6. Intersections, synergies and interactions: thinking about levers from a systems perspective

**6.1** This chapter sets out the issues to be considered and the potential benefits when taking systems-based approaches to analysing R&I levers and interventions. It draws on stakeholder feedback from the workshops, and builds on the evidence and findings from the previous chapters in relation to examples within the R&I system. The chapter is split into three parts. First, we set out key contextual issues when taking a systems-based view. Second, we discuss some of the key tensions and opportunities in the R&I system. Third, we identify the implications for UKRI and other actors in the system by using examples to show how a systems-based approach could add to more traditional approaches of evaluating 'what works'.

**6.2** Systems approaches provide a set of tools for exploring problem spaces as (parts of) complex adaptive systems. This point of view appreciates that much of the social world in which we operate consists of systems (for R&I, this can be seen as the constellation of institutions, interventions, processes and contexts, and how they interact or could interact) characterised by complexity (Meadows, 2008). Complexity is a term used to describe systemic attributes such as interdependence between elements that exhibit nonlinear dynamics, emergent behaviour and path dependence (Cairney, 2012). In short, this approach views problem spaces as embedded in broader contexts and specifically seeks to explain observed outcomes by searching out interdependencies, interactions, feedback loops and bottlenecks in order to better design (and experiment with) policy. This provides an opportunity to better understand the inter-relationships between some of the many interventions and factors reported on in previous chapters.

## The R&I system context

**6.3** As was noted in chapter 2, the landscape of institutions and governance in R&I is complicated and has evolved over many years. The resulting landscape is multi-layered in various ways:

- Geographically, there are different levels, including the UK level, the nations within the UK, and various local levels (e.g. local authorities, combined authorities, city-regions and pan-local/regional spatial entities such as the Midlands Engine and Northern Powerhouse). In addition, across this, certain policy domains related to R&I are devolved. For example, business support is (largely) devolved in the nations; there are national HE funding councils; and different types of business, innovation and skills support are (or are expected to be) devolved to various extents locally within England. However, there are also some blurred edges in relation to this, e.g. with a UK-wide Help to Grow business support programme in addition to devolution of business support and locally-based Growth Hubs.

- There is a wide mix of institutions and roles – as was discussed in chapter 2. These include those involved in policy direction and agenda-setting, policy and programme design, policy and programme implementation, connectors or influencers, and those undertaking R&I. Different institutions may be involved in one or more of these roles, e.g. Catapults can help to connect and also undertake R&I, and UKRI itself has a role in setting policy direction and is also involved in implementation and, to some extent, connecting.

- Different actors have different goals, which are specific to an organisation, and may be more or less aligned with economic growth. Moreover, there are actors that represent different communities, e.g. sectors, technology areas, geographies etc.

6.4 **The result is a complicated landscape, with lots of blurring around the edges of the remits of different actors.** This results in overlaps and messiness. As highlighted by stakeholders in the workshops held for the study, this can have perceived negative effects due to duplication, lack of alignment and fragmentation from the perspective of actors trying to navigate the landscape. However, there are also benefits in terms of the diversity of actors, and their perspectives, foci and ability to respond to changes in the wider R&I system.

6.5 Moving beyond the actors in the landscape, chapters 3-5 have described and assessed evidence on different policy interventions, and also the ways in which processes and contexts can affect R&I performance. Bringing these issues together, the R&I system cannot be understood simply by looking at component parts, as these are often interdependent and interrelated. A systems perspective or systems thinking is therefore important in enabling an understanding of how this constellation of institutions, interventions, processes and contexts (including within R&I and influences from outside) interact or could interact. This can enable management and coordination of the 'messiness' as an alternative to institutional reform.

6.6 A note of caution is important at this point. There can be a tendency to try to think about the whole R&I system and strive to understand and/or coordinate everything. However, it is important to be realistic, assessing in depth particular sub-systems by setting the boundaries of analysis. This can also facilitate responsiveness to what is a dynamic environment.

## Sources of tensions and opportunities

6.7 The stakeholder workshops identified a series of different tensions and opportunities within the R&I system. These provide an important backdrop to future systems-based analyses, and cover institutional, temporal, geographical and informational tensions or gaps:

- **The landscape is fragmented with variation in the capabilities and capacities of different actors.** In relation to the research base, for example, universities have competing priorities; whilst they are intrinsically linked to place and can play key roles in the place agenda, the capacity, capability and willingness to engage is variable and dependent on a range of factors.

- **There is fragmentation across innovation and business support in related areas** such as advice, financial support and fiscal incentives, leading to tensions and a lack of signposting between schemes. This would benefit from managing through alignment and join-up, and also through consideration of the incentives (and disincentives) created by targets and performance indicators. There are also opportunities from the fragmentation, for instance in seeking to expand innovation to wider audiences.
- **The policy and budget cycle creates competition for funding and churn, which can cause challenges.** For instance, at the time of Spending Reviews, normally collaborative relationships can become more defensive. There are related issues associated with the well-documented churn in the landscape, in terms of institutions and the cycle of programmes and policies, and the turnover of people that can erode corporate memory and make it difficult to build relationships between actors (Cook et al., 2019).
- **There are issues of bounded rationality in a complicated landscape**, including for businesses (in understanding and navigating the landscape) and for other organisations. This can engender a focus on what or who people and organisations already know, and so prevent new relationships and opportunities. This points to a key role for connectors to educate and signpost, as well as levers and interventions that can encourage more open mindsets.
- **There are some gaps (if not tensions) in having common understanding, definitions or frameworks in certain key areas**, including innovation and its different forms, and in relation to research and innovation skills (as noted in chapter 3).

## Implications for systems-based approaches

6.8 There can be a tendency to try to understand all implications and roles for UKRI (or other actors) and this is not practical. **There is a need to think about parts of the system that may be more important to focus on.** This might be because they are more relevant to key outcomes in the pathways to economic growth, and/or because there are identified issues where taking a systems-based view may be beneficial in developing a deeper understanding of the issues at play in relation to the links to growth. In developing this understanding, it is important to be humble in how much can be fully understood, and in how far the system can be shifted. Key points are to be able to accept and manage the ambiguity, and to find the aspects that can be influenced and so have wider desirable effects (whilst being alert to unintended consequences).

6.9 This sub-section looks at three different examples where UKRI and other actors could consider systems-based issues. These are examples, drawing on findings from earlier in the report, and in no way exhaustive of the potential areas to examine. The examples are different in their nature, covering different types of levers:

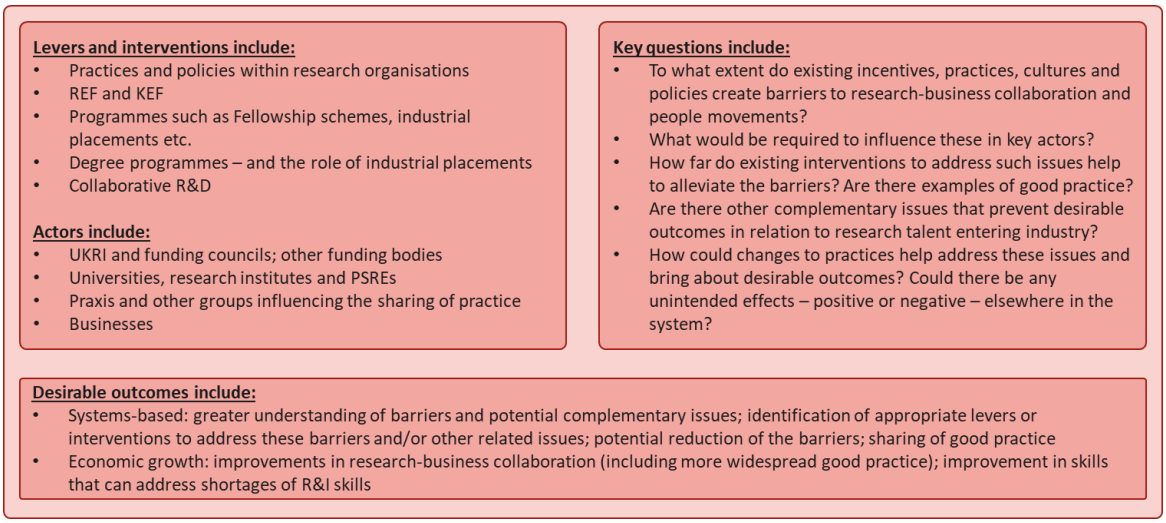
- **influencing/incentivising actors**, and how such a lever could change practices to address existing barriers or enable desirable effects on the routes to growth – this uses the influence of research collaborations as an example
- **convening actors** to seek better alignment, through taking a systems approach to developing a better understanding of how a range of inter-related programmes and actors co-exist – this draws on the example of the stages of funding and expertise required through concept, commercialisation and scaling innovations
- **investing in R&I** support, by taking a systems perspective to an area where there are identified gaps or bottlenecks – this draws on the perceived diffusion gap in the UK as an example.

## Influencing and incentivising

6.10 In relation to the role of research in the pathways to growth, chapter 3 identified a range of issues with respect to how structures and incentives in key actors can act as barriers or enablers to research-business collaboration and in the movements of people between research organisations and industry. These issues are critical to the transfer of ideas from the research base to practice, and in talent pipelines that have knock-on effects in other parts of the system.

6.11 Figure 6-1 sets out some of the issues that would frame a systems-based approach to better understand some of these issues and how they inter-relate. This includes key questions relating to existing incentives and practices, the scope to influence these, and the role of different interventions and actors in addressing key barriers. It also sets out the outcomes that could be focused on (and achieved if there are improvements in the system).

**Figure 6-1: Key issues to frame systems approach on influencing research collaborations and talent flows**

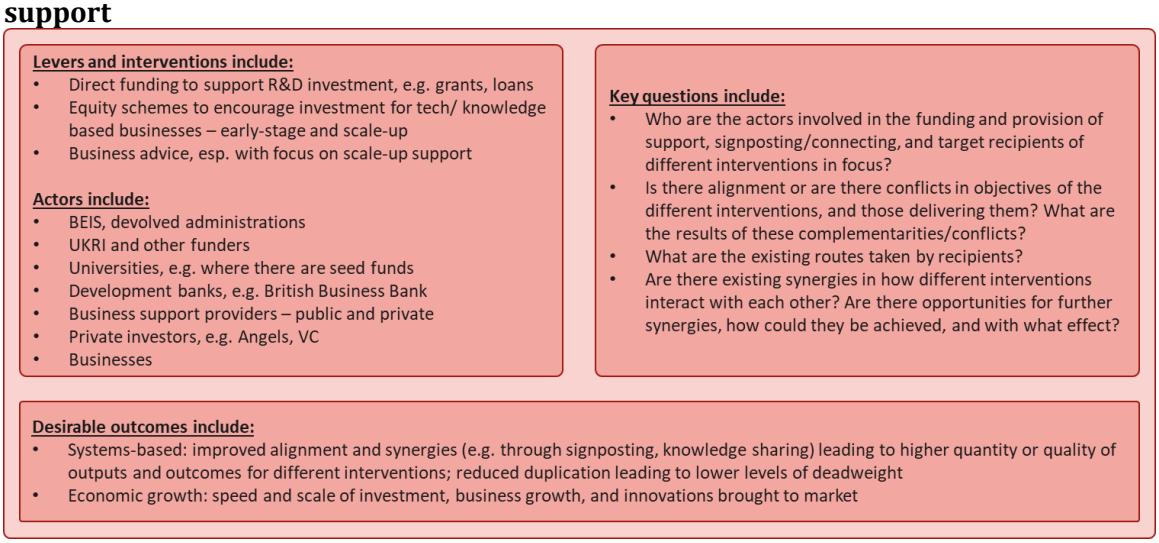


## Understanding alignment and connections

**6.12** In chapter 3, in the context of private sector investment in R&D, a key point was made in relation to the alignment between different instruments that enable businesses to be able to move through stages of funding. Related to this, in chapter 4, we saw that the complementarities between access to finance and access to expertise are key to success of firms in being able to scale up through commercial success of their innovations. This is an example of where a systems approach can be used to delve deeper into where there are evidence gaps. There is some good evidence on the effectiveness of individual interventions, but gaps are acknowledged in the complementarities between interventions and what these mean for the overall effectiveness of policy.

**6.13** There are a range of key issues to consider, and taking a systems-based approach could help to identify where *interventions could be made to work better with each other* to improve upon desired outcomes in the pursuit of growth. Figure 6-2 sets out some of the issues that would frame an approach, including key questions relating to alignment, conflicts and potential synergies, the interventions and actors involved, and the outcomes that could be focused on (and achieved if there are improvements in the system).

**Figure 6-2: Key issues to frame systems approach on aligning finance and scale-up support**



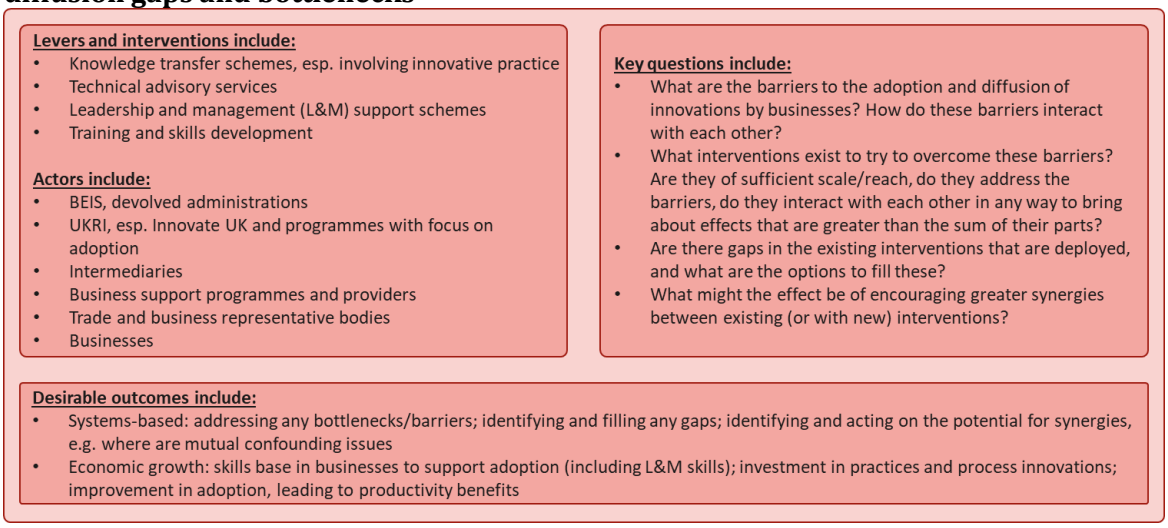

## Gaps and bottlenecks

**6.14** In chapter 5, it was reported that there is a perceived diffusion gap in the UK, with absorptive capacity, which is key to diffusion, being low according to the Global Innovation Index (GII) (Dutta et al., 2020). There are different issues involved here, including relatively low levels of research talent working in businesses, weaknesses in ICT services, and, from workshop feedback, gaps and piecemeal levels of advisory services for businesses. Evidence on individual types of levers and interventions include that reported on skills and talent pipelines from research (chapter 3), the role of intermediaries (chapter 4) and technical advisory services (chapter 5) – though it is acknowledged that there are evidence gaps. A

systems-based perspective could be used to consider the different factors influencing the diffusion gap and/or hone in on particular areas.

**6.15** Figure 6-3 sets out some of the issues that would frame an approach, including key questions relating to improving the understanding of barriers, bottlenecks and gaps (and the potential for synergies), the interventions and actors involved, and the outcomes that could be focused on (and achieved if there are improvements in the system).

**Figure 6-3: Key issues to frame systems approach on addressing adoption and diffusion gaps and bottlenecks**



# 7. Conclusions and implications

**7.1** This final chapter presents the concluding findings from the study. It summarises the key evidence of 'what works' for different interventions where summative findings are clear. It then provides observations on three sets of implications: specific implications for levers and interventions and how they can be deployed; evidence gaps that could provide the basis of part of a future research agenda; and the case for systems-based approaches to help better understand R&I levers and how they interact.

## Synthesis of evidence on interventions

**7.2** Table 7-1 sets out a selection of key evidence on interventions that have been reviewed in some detail as part of the study. The table comprises evidence on the key findings on outcomes, and the implications that this can have for how the interventions can contribute to pathways to growth. Below the table we examine some of the implications from this evidence.

**Table 7-1: Selection of key evidence on interventions, outcomes and growth**

| Intervention | Evidence on outcomes/impacts | Implications for growth |
|---|---|---|
| **Intermediaries** (e.g. Catapults) | • Intermediaries can play a range of roles in supporting innovation and growth.<br>• Across different intermediaries, there are examples of impacts, including new product and process development, and business performance.<br>• Benefits vary in their nature, scale and contexts, and the evidence needs further development. | The evidence on impact needs to be considered carefully – it is less meaningful to quantify outcomes in terms of a growth contribution, but rather there are a mixture of outcomes relating to business performance, investment and the wider system. |
| **Grants and subsidies** | • Whilst there is mixed evidence on the effectiveness of grants/subsidies to firms in stimulating R&D spend, the majority of studies find a positive link.<br>• Numerous studies find self-reported outcomes for beneficiaries relating to innovation and business performance outcomes (e.g. product development, new markets, firm growth).<br>• Studies on collaborative R&D grants find a positive effect on a range of outcomes including level of collaboration and IP applications (and potentially spillovers). | Grants and subsidies can contribute to economic growth by helping to stimulate private sector R&D investment, which can lead to subsequent innovation and business growth outcomes. This is especially for SMEs and can be aided by long-term stability of instruments, and appropriate design (e.g. intervention rates). |
| **Tax incentives** | • There is mixed evidence with some studies finding a positive effect on R&D spending (especially for small firms) whilst another recent study questioned | The mixed evidence on the effect of tax incentives suggests uncertainty in the pathways to supporting economic growth. |

| Intervention | Evidence on outcomes/impacts | Implications for growth |
|---|---|---|
| | the additionality of the UK R&D Tax Credit scheme. | |
| **General and technical business support** | • Overall, there is a lack of conclusive evidence of how general business support affects innovation outcomes; and contribution to growth outcomes depends programme-to-programme.<br>• For technical advisory services, outcomes seem to vary by intensity of support and specific focus. | There is a gap in understanding the effects of business support innovation outcomes specifically, and therefore the specific pathways to stimulating economic growth. |
| **Standards** | • Evidence points to several ways in which standards can contribute to innovation, e.g. serving as framework conditions; levelling the playing field; and creating focus/cohesion.<br>• However, there are challenges relating to knowledge leakages to competitors; firms using their influence over standards to serve own interests; and the differences in impact between companies, sectors and more widely. | Whilst there is evidence on the routes through which standardisation can lead to economic growth, more evidence is required to understand how this varies when looking at: (i) different domains; (ii) different types of companies; and (iii) intersections with regulation. |

# Implications and actions

## Levers and interventions

**7.3** For interventions where research and evaluation evidence has been reviewed, **the evidence points to different conclusions and implications, highlighting that 'what works' may be context or programme-specific.** In other words, the effectiveness of different levers and interventions – i.e. 'what works – is dependent on various factors, including the 'who', 'where', 'when' and 'why'. This is also true when comparing across high quality evaluations. There are two overarching implications from the nature of the evidence.

**7.4** First, transferability of findings requires care, and should include consideration of implementation and contextual issues. Second, policy decisions may need to be informed by the 'balance' of evidence, with interventions subject to ongoing review and evaluation. The implications from the evidence on financial incentives, such as grants and tax incentives (as summarised in Table 7-1), illustrate these points. On balance, grants are effective in stimulating private investment in R&D, though this can vary by business type (e.g. size of firm); intervention rates and design features can also influence effectiveness. Incentives such as tax credits have been found to be effective, though this is challenged in other studies – interventions here particularly warrant ongoing assessment.

**7.5** Several other implications have been identified from the evidence in relation to levers and interventions:

- **If growth is a focus for UKRI, then the balance of basic and applied research could be considered.** This requires further evidence to examine the issues and routes to growth – see Table 7-2 below under evidence gaps. Depending on the evidence, there could be implications for levers that are available to UKRI in terms of incentivising actors such as universities and other research organisations to consider changes in the emphasis of different types of research, and in terms of convening actors to encourage the sharing of good practice.
- **Intermediaries play a range of key roles in the R&I system.** The study has particularly considered the evidence on Catapults and similar types of research and technology organisation where there has been a focus on their role in knowledge transfer between research and industry, collaborative R&D, and leveraging private investment. These remain relevant, and other roles may be important, such as in relation to skills development, informing standards, and equality, diversity and inclusion. Indeed, a key implication is that intermediaries may need to evolve in response to changing market and technology needs; evaluation of intermediaries also needs to respond to this in ways that are developmental and provide real time learning.
- **In order that business innovations, sometimes developed with the support of UKRI funding, can reach their full potential through scale-up, there are subsequent requirements for finance, advice and access to networks.** There is a range of actors involved in this process, but a perception that these stages are not well aligned or joined up. UKRI and other actors could work together to identify ways of making this journey from concept to scale-up clearer and easier to navigate.
- **The study has discussed the UK's 'diffusion gap', the perceived weakness in the UK in relation to the adoption and wider diffusion of innovations and innovative practice.** There are a range of interventions can contribute to improving performance here. These include inter-related options around skills (such as leadership and management skills and workforce skills provision), technical advisory services and the role of networks. Some interventions already exist in these areas, and there is a case for actors to consider how these can address the barriers to diffusion to a greater extent (e.g. leadership and management provision). There are also perceived gaps in advisory services, but also a deficit in quality evaluation evidence.
- **Demand-side interventions, such as standards and regulations, can play a role in encouraging innovation and their adoption.** This is a growing area of importance, especially for certain emerging technology areas and also to support wider transformation such as net zero transition. There are challenges around bringing together the relevant actors to inform effective policy here, e.g. the standard-setting process. This requires a range of actors including professional associations, trade bodies, intermediaries such as Catapults and businesses. UKRI itself could have a key convening role in this respect, including to bring in academic researchers and use links to draw in more businesses.

- Skills cut across the three pillars of the system, including many of these interventions. However, **there is lack of a clear framework for understanding different types of R&I skills, and where they are important in different parts of the R&I system.** This is an area where UKRI and other stakeholders could convene key actors, including employers, to agree and put into practice a framework from which skills needs/demands can be better understood and appropriate interventions identified. This can build on existing work to define R&I skills. Given the issues and how they cut across the three pillars of the R&I system, UKRI has a key opportunity to play a leading role in this area in coming years, building on the work that it has done, and is continuing to do, in this area.

7.6 **A final cross-cutting point is that effectiveness of interventions can be dependent on wider factors in the system**, including policy stability, and alignment with related interventions. This is more challenging to manage given the complicated and complex nature of the system, and we return to the related set of issues on this below.

## Gaps in evidence and understanding on levers and interventions

7.7 In addition to the evidence and perspectives on interventions summarised above, the study has reaffirmed the view that the evidence base is mixed in terms of its coverage, nature and quality. Evidence gaps have been identified throughout the report. There are different types of 'gaps', including:

- general lack of evidence in relation to an intervention or set of interventions
- mixed evidence, i.e. where different sources reach different conclusions, which can be due to context- or programme-specificity, and/or where the quality of the evidence base varies
- lack of granular level of detail, e.g. for different groups, contexts, stages of the R&I process.

7.8 Some of the more pertinent gaps in the evidence are highlighted in Table 7-2. Some of these may reflect the non-exhaustive nature of the study. These gaps could be further investigated through desk-research or future evaluations and research, therefore informing policy. There are two cross-cutting observations to make in this context:

- Many interventions in R&I have complicated and/or complex characteristics. This makes them challenging to research and evaluate using certain methods and/or in ways that lead to generalisable findings. In these cases, more developmental approaches to building the evidence base may be required.
- Table 7-2 identifies evidence gaps that are specific to discrete subjects or policy areas, but an important point relates to evidence gaps at a broader system/sub-system level – see the final sub-section in this chapter.

**Table 7-2: Examples of key evidence gaps**

| Subject area | Potential research questions to strengthen the evidence base |
|---|---|
| **Basic and applied research** | • How do different types of research contribute to growth pathways, including through indirect routes such as industry engagement and to the flow of skills and people into industry and policy?<br>• How far can the relative scale and contribution to outcomes be assessed to inform decisions on the balance of focus, including for different research disciplines? |
| **Skills for research and innovation** | • How should research and innovation skills be defined?<br>• An agreed and consistent framework for this would enable mapping of the landscape, reviewing evidence on interventions, and identifying key gaps. Evidence is focused currently on STEM, the role of migration and university-industry research training. |
| **Grants and tax incentives for private investment in R&D** | • What outcomes exist for these interventions beyond investment in R&D itself, i.e. the effect on innovation and business growth?<br>• What are the effects of grants and tax incentives on investment, innovation and business growth for large companies?<br>• What is the effectiveness of grants and tax incentives on investment, innovation and business growth at different stages of the R&I process? |
| **Research-industry collaboration and engagement** | • Is there any transferable practice between different types/ contexts of institutions?<br>• What are the effects of intermediaries on business growth for their customers (recognising mutual combinations of factors)? |
| **General business support** | • There is evidence (albeit varying depending on programme/ context-specific factors) on business growth. What are the effects on innovation outcomes specifically, e.g. new product development and launches, process improvements, new business models? And how do these innovation effects relate to any subsequent business growth outcomes? |
| **Interventions to support adoption** | • What is the effectiveness of technical advisory services?<br>• What is the role of leadership and management support for firms in encouraging to innovation adoption?<br>• What is the role of networks and peer-to-peer sharing in encouraging adoption? |
| **Standards** | • What is the interface of standards with regulations?<br>• What is the effectiveness of different types of standards, e.g. flexible standards? |

## System level implications

7.9 **The R&I system is complex and requires various parts, processes, interventions and conditions to perform optimally.** The landscape of institutions and levers is inherently

complicated, having evolved over many years through influence from an array of public and private actors, and it continues to evolve with challenges associated with policy churn. There is blurring around the edges of the remits of different actors, and some competing objectives and behaviours. The reviews of evidence in chapters 3-5 highlight the complementarities between interventions and processes, potential conflicts and also likely missed opportunities.

**7.10** This results in overlaps and messiness. This can have perceived negative effects due to duplication, lack of alignment and fragmentation from the perspective of actors trying to navigate the landscape. However, there are also benefits in terms of the diversity of actors, and their perspectives, foci and ability to respond to changes in the wider R&I system.

**7.11** **Together, the findings suggest that the system cannot be understood simply by looking at component parts, as they are often interdependent and interrelated.** One aspect of the system alone does not lead to growth, rather it is the effect of complementary and simultaneous factors and interventions. A systems perspective is therefore important in enabling an understanding of how the constellation of actors and interventions across different scales and layers can interact. Improving this understanding could have important findings for policy-making and the levers used by UKRI and other actors.

**7.12** Chapter 6 advocates the use of systems approaches. These provide a set of tools for exploring systems such as the R&I system, which has complicated and complex characteristics. These approaches view problem spaces as embedded in broader contexts and specifically seek to explain observed outcomes by searching out interdependencies, interactions, feedback loops and bottlenecks in order to better design (and experiment with) policy. This provides an opportunity to better understand the inter-relationships between some of the many interventions and factors reported on in this study, and those that have not been covered due to the need to manage scope.

**7.13** There are numerous areas of potential inquiry from a systems perspective. Chapter 6 uses three examples to illustrate this, where systems approaches can be used to improve understanding and so inform potential policy actions in relation to:

- influencing and incentivising actors to change practices in ways that can help enable routes to growth, e.g. in relation to research-business collaboration and talent flows of research and innovation skills
- how existing interventions and actors co-exist, and the implications of seeking better alignment, e.g. in relation to the range of financial support and advice for early-stage innovations and scaling these up
- where there may be gaps or barriers in the R&I system, e.g. in relation to adoption and diffusion of innovations to address the 'diffusion gap' in the UK.

**7.14** In taking forward these types of approaches it is important to be realistic, assessing in depth particular sub-systems (rather than the whole) by setting the boundaries of analysis, whilst also accepting that there will be ambiguities and uncertainties.

# Annex A: Bibliography

Akcigit, U., Hanley, D., Serrano-Velarde, N. (2021) *Back to Basics: Basic Research Spillovers, Innovation Policy and Growth*. Review of Economic Studies, Oxford University Press, 88(1): 1-43.

Almeida, P. and Kogut, B. (1999) *Localization of Knowledge and the Mobility of Engineers in Regional Networks.* Management Science, 44(7): 905-917.

Andrews, D., Criscuolo, C. and Gal, P.N., (2016) *The best versus the rest: the global productivity slowdown, divergence across firms and the role of public policy* (No.5). OECD Publishing.

Åström, Tomas; Cristina Rosemberg Montes; Tobias Fridholm; Anders Håkansson and Annika ZikaViktorsson (2015). *Impact analysis of the technical-industrial research institutes in Norway*. Technopolis Sweden (Faugert & Co Utvärdering AB), April 2015.

Baron, J., Li, Q. and Nasirov, S. (2018) *Joining Standards Organizations: The Role of R&D Expenditures, Patents, and the Product-Market Position*

Becker, B. (2015) *Public R&D policies and private R&D investment: A survey of the empirical evidence*. Journal of Economic Surveys, 29(5): 917–942.

Becker, B., Roper, S., Love, J. (2016) *The effectiveness of regional, national and EU support for innovation in the UK and Spain.* ERC Research Paper No.52

BEIS (2021) *Catapult Network Review*.

BEIS (2021) *UK Innovation Strategy - Leading the Future by Creating It*.

Berlingieri, G., Blanchenay, P., and Criscuolo, C. (2017), *The Great Divergence(s).* OECD Science, Technology and Innovation Policy Papers, No. 39.

Berlinggieri, G., Calligaris, S., Criscuolo,C., Verlhac, R. (2020) *Laggard firms, technology diffusion and its structural policy determinants.* OECD Science, Technology and Industrial Policy Papers, No.86.

Blind (2013) *The Impact of Standardization and Standards on Innovation*. Nesta Working Paper No 13/15.

Blind, K., Petersen, S. and Riillo, C. (2017) *The impact of standards and regulation on innovation in uncertain markers*. Research policy

Blind, K. and Thumm, N. (2004) *Interrelation between patenting and standardisation strategies: Empirical evidence and policy implications*. Research Policy, 33(10):1583–1598.

Bloom, N., Reenen, J. and Williams, H. (2019) *A Toolkit of Policies to Promote Innovation*. Journal of Economic Perspectives, 33(4): 163-84

Breschi, S. and Lissoni, F. (2009) *Mobility of Skilled Workers and Co-Invention Networks: An Anatomy of Localized Knowledge Flows.* Journal of Economic Geography. 9(4): 439-468.

Cairney, P. (2012). *Complexity Theory in Political Science and Public Policy*. Political Studies Review, 10(3): 346-358.

Calzonetti, F., Miller, D., Reid, N. (2012) *Building both technology intensive and technology-limited clusters by emerging research universities: The Toledo Example.* Applied Geography, 34(1): 265-273.

Choi, D., Kang, B. and Kim, T. (2010) *Standardization: Fundamentals, Impact, and Business Strategy*. Asia-Pacific Economic Cooperation.

Connell, D. (2021) *Is the UK's flagship industrial policy a costly failure?*

Cook, J., Hardy, D. and Sprackling, I. (2019) Productivity Policy Review IN McCann, P. and Vorley, T. (2019) Productivity Perspectives, Edward Elgar

Cunningham, P. and Gok, A. (2012) *The Impact and Effectiveness of Policies to Support Collaboration for R&D and Innovation*. Nesta.

DIN (2000) *Economic Benefits of Standardisation.* Beuth Verlag: Berlin

Dowling, A. (2015) *The Dowling Review of Business-University Research Collaborations*. BIS.

DTZ (2007) *Evaluation of the Manufacturing Advisory Service.* DTZ Consulting and Research.

Dutta, S., Lanvin, B., and Wunsch-Vincent, S. (2020) *Global Innovation Index 2020*. Cornell University, INSEAD, and the World Intellectual Property Organization.

Dyer, J., Powell, B., Sakakibara, M., Wang, A. (2008) *The Determinants of success in R&D Alliances.* Academy of Management Annual Meeting Proceedings.

Edler, J. and Jan Fagerberg. (2017) *Innovation policy: what, why, and how*. Oxford Review of Economic Policy 33 (1):2-23.

Edler, J., Cunningham P., Gok, A., and Shapira, P. (2013) *Impacts of Innovation Policy: Synthesis and Conclusion*. Nesta Working Paper No. 13/2

Elsevier (2013) *International Comparative Performance of the UK Research Base*. Elsevier.

Ernst & Young, IFO Institute, Cambridge Economics, SQW, Capgemini (2014) *Innovation Demand-Side Monitoring System*. European Commission.

European Commission (2017a) *The Economic Rationale for Public R&I funding and its Impact*

European Commission (2017b) *European semester thematic factsheet - Research and Innovation*

Fleming, L., and Waguespack, D. M. (2007) *Brokerage, boundary spanning, and leadership in open innovation communities*. Organization Science, 18(2):165–180

Ford, J. A., Steen, J. and Verreynne, M. L. (2014), '*How environmental regulations affect innovation in the Australian oil and gas industry: going beyond the Porter hypothesis*'. Journal of Cleaner Production, 84: 204-213.

Gabriel, M. (2018) *Opportunity lost. How inventive potential is squandered and what to do about it*. NESTA.

Grove, L. (2017) *The effects of funding policies on academic research.* Doctoral Thesis, University College London.

Hall, B.H., Link A.N., Scott J.T. (2003) *Universities as research partners*. Review of Economics and Statistics 85: 485-491.

He, Z. L., and Wong, P.K. (2012) *Reaching out and Reaching Within: A Study of the Relationship between Innovation Collaboration and Innovation Performance.* Industry and Innovation, 19: 39–561.

Hill Dickinson LLP (2020) Commercialising university intellectual property. Available: https://www.lexology.com/library/detail.aspx?g=04a7586c-3650-4c60-94f9-93b6ea05be38

Hutschenreiter, G., Weber, J., and Rammer, C. (2019) *Innovation Support in the Enterprise Sector.* OECD.

Jessani, N., Valmeekanathan, A., Babcock, C.M., and Ling, B. (2020) *Academic incentives for enhancing faculty engagement with decision-makers - considerations and recommendations from one School of Public Health*. Humanities and Social Sciences Communications, 7, Article number: 148.

Jibril, H., Stanfield, C., Roper, S. (2020) *What drives productivity growth behind the frontier? A mixed-methods investigation into UK SMEs. ERC Research Paper No. 89*

Jones, B. and Grimshaw, D. (2012) *The Effects of Policies for Training and Skills on Improving Innovation Capabilities in Firms*. Nesta.

Kohler, C. Laredo, P. and Rammer, C. (2012) *The Impact and Effectiveness of Fiscal Incentives for R&D*. Nesta.

Kuhlmann, S., & Rip, A. (2018). *Next-Generation Innovation Policy and Grand Challenges*. Science and Public Policy, 45(4), 448-454.

McMillan T. (2016) *University Knowledge Exchange (KE) Framework: good practice in technology transfer*. McMillan group, HEFCE.

Meadows, D. (2008). *Thinking in Systems: A Primer*. White River Junction, VT: Chelsea Green Publishing

Migration Advisory Committee (2019). *Full review of the Shortage Occupation List*. HMG.

Migration Advisory Committee (2020) *Review of the Shortage Occupation List.* HMG

Mole, K.F., Hart, M., Roper, S, Saal, D.S. (2008) *Assessing the effectiveness of business support services in in England: evidence from a theory based evaluation.* Working Paper 93. Warwick Business School, Centre for Small and Medium Sized Enterprises.

OECD (2015) *The Impact of R&D Investment on Economic Performance: A Review of Econometric Evidence*

Okamuro, H., Nishimura, J., Colombo, M. and Stam, E. (2019) *Promoting SME R&D and Innovation*. T20 Japan 2019 Policy Brief.

Patton, M. (2010) *Developmental evaluation applying complexity concepts to enhance innovation and use*. New York, NY: Guilford Press.

Perkmann, M. and Walsh, K. (2007) *University-industry relationships and open innovation: Towards a research agenda*. International Journal of Management Reviews, 9(4): 259-280.

RAND and Deloitte (2017*) Research, innovation and economic growth – R&D policy reforms and strategies*

Roper, S. (2021) *Learning from the best: National innovation systems*. Enterprise Research Centre State of the Art Review.

Shapira, P. and Youtie, J. (2014) *Impact of Technology and Innovation Advisory Services.* Nesta.

Smith, E. and White, P. (2018) *The employment trajectories of Science Technology Engineering and Mathematics graduates*. Nuffield Foundation.

SQW (2016) Evaluation of the UK Futures Programme: conclusions and guidance. UKCES.

SQW (2017) *Evaluation Reviews*. Report for Innovate UK. Unpublished.

SQW (2019). *Mapping the landscape for innovation talent and skills*. Innovate UK (unpublished)

SQW (2020) UK Aerospace Technology Institute (ATI) Grant funding programme: Early Impact Evaluation. BEIS Research Paper 2021/002

Swann, P. (2010) *The Economics of Standardization: An Update*. Innovative Economics.

Syed, M. (2020) *Rebel Ideas: The Power of Diverse Thinking*. John Murray.

Thune, T. (2007) *University-industry collaboration: the network embeddedness approach*. Science and Public Policy, 34(3): 158-168.

Thune, T. (2009) Doctoral students on the university-industry interface: a review of the literature. Higher Education, 58(5): 637-651.

Thune, T. (2010) *The training of "triple helix workers" doctoral students in university-industry-government collaborations.* Minerva, 48(4): 463-483.

UK Visas and Immigration (2021) Skilled Worker visa: shortage occupations. GOV.UK. Available at: https://www.gov.uk/government/publications/skilled-worker-visa-shortage-occupations/skilled-worker-visa-shortage-occupations [Accessed August 2021]

UKRI (2020) *Corporate Plan 2020-21*

UKRI (2022) *UKRI Strategy 2022-2027*

Ulrichsen, T.C. (2019) *Developing University Spinouts in the UK*. A Technical Note for Research England

Vanino, E., Becker, B. and Roper, S. (2018) *Knowledge to money: Assessing the business performance effects of publicly-funded research and innovation grants.* ERC

Vilani, E., Rasnussen. E., Grimaldi, R. (2017) *How intermediary organizations facilitate university-industry technology transfer: A proximity approach.* Technological Forecasting and Social Change, Elsevier, 114(C): 86-102

Vries, E.D,W., Dolfsma, W., Van Der Windt, H,J., Gerkema, M., *Knowledge transfer in university–industry research partnerships: a review.* The Journal of Technology Transfer, 44(4).

Weresa, M., Poel, M., Cunningham, P. and Hertog, P. (2018) *Mutual Learning Exercise on Evaluation of Business R&D Grant Schemes: behavioural change, mixed-method approaches and big data.* European Commission

What Works Centre for Local Growth (2015) *Innovation: grants, loans and subsidies*

What Works Centre for Local Growth (2015) *Innovation: R&D tax credit*

What Works Centre for Local Growth (2016*) Evidence Review 2: Business Advice*

Wittmann, F., Hufnagl, M., Lindner, R., Roth, F., and Edler, J. (2021) *Governing varieties of mission-oriented innovation policies: A new typology*. Science and Public Policy, 48(5): 727-738.

Wolfe, D.A. (2009) *Embedded clusters in the global economy*. European Planning Studies 17:179-187

SQW

## Contact

For more information:

**Jonathan Cook**
*Director, SQW*
T: +44 (0)20 7391 4105
E: jcook@sqw.co.uk

2nd Floor
14-15 Mandela Street
London
NW1 0DU

**www.sqw.co.uk**

## About us

### SQW Group

SQW and Oxford Innovation are part of SQW Group.
**www.sqwgroup.com**

### SQW

SQW is a leading provider of research, analysis and advice on sustainable economic and social development for public, private and voluntary sector organisations across the UK and internationally. Core services include appraisal, economic impact assessment, and evaluation; demand assessment, feasibility and business planning; economic, social and environmental research and analysis; organisation and partnership development; policy development, strategy, and action planning. In 2019, BBP Regeneration became part of SQW, bringing to the business a RICS-accredited land and property team.
**www.sqw.co.uk**

### Oxford Innovation

Oxford Innovation is a leading operator of business and innovation centres that provide office and laboratory space to companies throughout the UK. The company also provides innovation services to entrepreneurs, including business planning advice, coaching and mentoring. Oxford Innovation also manages investment networks that link investors with entrepreneurs seeking funding from £20,000 to £2m.
**www.oxin.co.uk**