UNIVERSITY OF CAMBRIDGE

UCI POLICY EVIDENCE UNIT
UNIVERSITIES | COMMERCIALISATION | INNOVATION

National Centre for Universities and Business

TOMAS COATES ULRICHSEN | LEONARD KELLEHER

Through crisis to recovery

The ongoing effects of the COVID-19 pandemic on universities and their ability to drive innovation

July 2022

UNIVERSITIES | COMMERCIALISATION | INNOVATION

Citation
Please cite this work as: Ulrichsen, T. & Kelleher, L. (2022). Through Crisis to Recovery: The ongoing effects of the COVID-19 pandemic on universities and their ability to drive innovation. Cambridge: Policy Evidence Unit for University Commercialisation and Innovation (UCI), University of Cambridge and the National Centre for Universities and Business (NCUB).

Contact us
For more information, contact Tomas Coates Ulrichsen (UCI) at tc267@cam.ac.uk and Leonard Kelleher (UCI) at lk491@cam.ac.uk.

About UCI
The University Commercialisation and Innovation Policy Evidence Unit (UCI) is based at the University of Cambridge and aims to support governments and university leaders in delivering a step change in the contributions universities make to innovation and economic prosperity – nationally and locally – through their commercialisation and other innovation-focused activities and partnerships.

UCI seeks to improve the evidence base and tools available to key decision makers in public policy and university practice as they develop new approaches for strengthening university research-to-innovation and commercialisation pathways. To do so it draws on the latest advances and insights from both academic research and policy practice, as well as lessons learned from experiences in the UK and internationally.

The Policy Evidence Unit is funded through a generous grant from the Research England Development Fund. It is based at the Institute for Manufacturing (IfM) at the University of Cambridge and is being developed in partnership with the IfM's Centre for Science, Technology, and Innovation Policy (CSTI) and the UK National Centre for Universities and Business (NCUB).

Find more about our work: UCI Policy Evidence Unit

About NCUB
The National Centre for Universities and Business (NCUB) is a strategic leadership network that provides a collective voice on the future of collaboration between universities and business. Driven by data and shaped by ideas, NCUB seeks to inform, influence and shape the future of collaboration. Our members share a commitment to working together to tackle some of the UK's biggest challenges, from adapting our education and training systems to developing the talent needed in the future, to transforming lives and opportunities through research and innovation.

Published by the UCI Policy Evidence Unit, Institute for Manufacturing, University of Cambridge and the National Centre for Universities and Business (NCUB).

Acknowledgements
The Policy Evidence Unit for University Commercialisation and Innovation (UCI) and the National Centre for Universities and Business (NCUB) would first and foremost like to thank the many senior leaders and managers within UK universities who invested their time and effort to respond to our survey. The information they gathered and provided underpins the evidence we present in this report. We are also grateful for those individuals who reviewed and commented on the survey questionnaire and on the draft report. Finally, we would like to thank the policy community within the UK Department for Business, Energy and Industrial Strategy, Research England, and UK Research and Innovation more widely, for their continued endorsement of, and engagement with, this project.

Contents

Executive summary

This report investigates the ongoing effects of the COVID-19 pandemic on the ability of universities to contribute to innovation over the period between August 2020 – July 2021 – the 'Ongoing Crisis' period. It also explores how universities are responding to the 'shock' of the pandemic, and the implications of this for their roles in contributing to the post-crisis economic recovery. It builds on earlier reports by the University Commercialisation and Innovation Policy Evidence Unit (UCI) at the University of Cambridge and the National Centre for Universities and Business (NCUB), which revealed the scale of disruption to UK university innovation focused activities (Ulrichsen, 2021) and R&D activities of businesses operating in the UK (NCUB and UCI, 2021) during the early phase of the pandemic between March-July 2020.

The COVID-19 pandemic has caused a hugely disruptive and sudden shock to societies and economies around the world. Its evolution has proved to be highly uncertain. In the UK, following the first wave and national lockdown, additional waves of COVID infection emerged along with national lockdowns attempting to control the spread of the virus and its devastating effects on health and health systems. The ongoing disruption will undoubtedly have had continued effects on universities. In order to add to the evidential baseline established in our first report (Ulrichsen, 2021), **the first aim of this report is to explore the scale and nature of the effects of the ongoing crisis on the innovation-focused activities of universities and their ability to initiate and deliver them.**

The pandemic, and our responses to it, catalysed an unprecedented mobilisation of science and innovation systems which successfully developed, manufactured, and distributed a range of innovations to tackle various COVID-induced problems. These included COVID countermeasures –diagnostics, treatments, medical devices such as ventilators – as well as innovations to support struggling businesses, and to improve the resilience of hospitals under extreme pressure.

Universities, often working in close collaboration with a range of private sector firms and investors, public sector agencies and departments, hospitals, and third sector organisations, have made a major contribution to this global effort. In order to learn lessons from how this mobilisation was delivered, both to inform future crisis planning and strategies for economic recovery, **the second aim of this report is to investigate how universities adapted and responded to the challenges of the pandemic to continue to support innovation** – i.e. how they developed a degree of organisational resilience during the crisis.

As we move through the crisis, governments around the world have been developing strategies for the economic recovery. Many of these strategies seek a step-change in all aspects of innovation, from discovery through development to adoption, and to promote managed transitions to a more sustainable, equitable and resilient future. Realising the ambitions of these strategies is predicated on a strong and resilient system of universities, working in close partnership with the public, private and third sectors. To investigate whether universities are able to adapt and reconfigure through the pandemic to help deliver this innovation step-change, **the third aim of this report is to explore the drivers and factors shaping universities' strategic agility and how these are influencing their strategic priorities for contributing to the recovery.**

Finally, governments are keen to understand the effectiveness of policy interventions in supporting innovation-focused activities during the pandemic. Understanding what worked in terms of how the government invested to support the system through the pandemic will hold lessons for developing more effective responses to future crises and innovation policy more generally. Consequently, **the fourth aim of this report is to explore the effectiveness of policy interventions made during the pandemic and capture the views of universities on what further policy interventions could be made to enable universities to more fully contribute to an innovation-led recovery.**

Key findings of the report are captured below.

Ongoing effects of the pandemic on university innovation-focused activities

Level of innovation-focused activities with different sectors

The report reveals that universities saw a 7% decrease in levels of innovation-focused activities across their portfolio over the Ongoing Crisis period (August 2020 – July 2021). This is on top of a 6% drop during the First Lockdown period (March-July 2020). This varied across sectors, with the worst affected – automotive, other transport and machinery manufacturing – seeing around a 20% decrease.

It also varied across universities, with some seeing increased activity levels in sectors where the overall level of activity had decreased, and vice versa. This reinforces the evidence that universities find themselves in the 'same storm, but in very different boats' as they navigate the turbulence of the pandemic.

FIGURE X.1 **Change in the level of innovation-focused activity with universities' top sectors during the Ongoing Crisis period**

† Mean change estimated by taking the following points in each category: Collapsed (-51%); significantly decreased (-35%); slightly decreased (-13%); about the same (0%); slightly increased (13%); significantly increased (21%).

Level of innovation-focused activities with different types of partner

There was also variation across different types of partner, with activities involving the third sector, and small and medium enterprises seeing the most significant decreases. Activities with strategic partners remained largely stable, and those with the public health system increased.

The report's findings suggest a disproportionate effect of the pandemic on smaller universities with less research activity. Unless addressed, this could lead to a growing exclusion of these institutions from the innovation system as we move into the recovery period.

FIGURE X.2 **Change in the level of innovation-focused activity with different types of external partner during the Ongoing Crisis period**

† Mean change estimated by taking the following points in each category: Collapsed (-51%); significantly decreased (-35%); slightly decreased (-13%); about the same (0%); slightly increased (13%); significantly increased (21%).

Nature of changes to innovation-focused activities

While universities continued to experience significant disruptions to their innovation-focused projects and activities over the Ongoing Crisis period, disruptions for many were starting to abate. The evidence suggests growing efforts among partners to find ways of keeping their relationships with universities going through the crisis.

Challenges for initiating and delivering activities

Many universities continued to find it hard to ensure the availability of key resources and support to initiate and deliver innovation-focused activities. Particularly challenging were ensuring staff were able to dedicate sufficient time to projects; recruiting and retaining project staff; accessing facilities, equipment and data; and covering the full economic costs of projects.

Large, research-intensive universities found it more difficult than other university types to recruit and retain staff to work on innovation-focused projects.

University resilience during the pandemic

Effectiveness of university response

Most universities rated their response to the pandemic – in terms of overcoming challenges and pursuing innovation opportunities while attempting to ensure staff welfare – as highly or moderately effective.

University resilience during the pandemic

However, universities' approaches to building resilience – i.e. how they attempted to anticipate, prepare for, respond and adapt to change and sudden disruptions to survive and prosper – relied more on defensive measures to 'bounce back' from disruptions rather than progressive measures to 'bounce forward' towards future growth and new opportunities.

Lasting impacts of university innovative responses

In response to the challenges of the pandemic, most universities introduced new or significantly improved ways of working, and many sought new opportunities with partners during the period between March 2020 – July 2021.

Of those universities that made changes, most believed the changes to ways of working had at least a moderately positive lasting impact on the university. Concerningly, fewer universities reported that their efforts to build new opportunities with existing or new partners had lasting positive impacts.

Trends and drivers shaping the strategic priorities of universities for innovation

Trends and drivers shaping university strategic priorities

University strategies, and their implementation, are being shaped by a range of external and internal drivers, in addition to COVID.

These include the evolution of the pandemic; changes in the global order and international relations; changing societal preferences and values; the scale and distribution of socio-economic impacts; the pace and direction of technological innovation; and pressure on universities to become more entrepreneurial and engaged.

Factors affecting the strategic agility of universities to respond to the pandemic

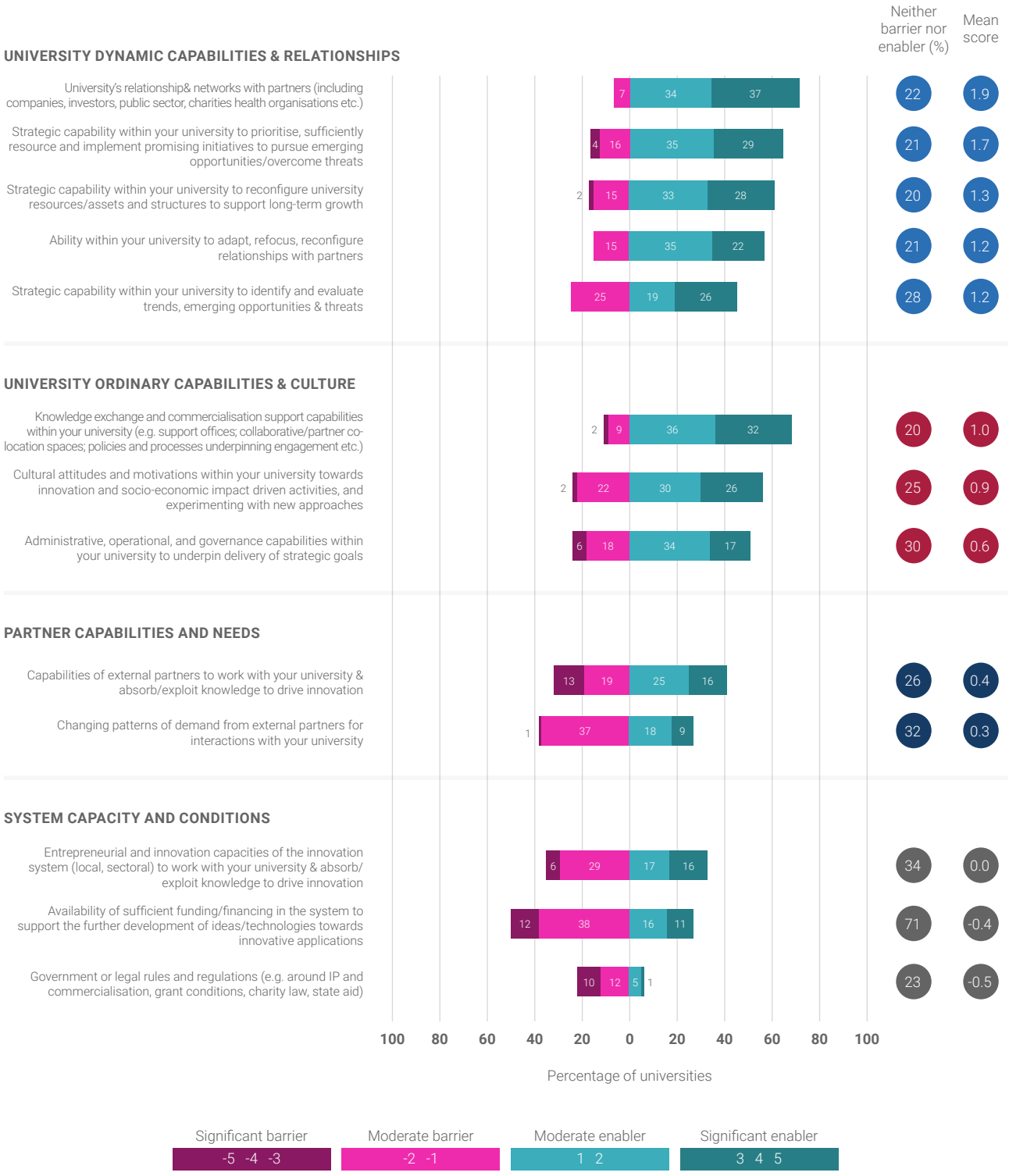
Factors affecting strategic agility

The ability of universities to respond to the challenges of the pandemic and pursue new opportunities is shaped by a mix of internal and external factors. Overall, universities saw their strategic capabilities around 'seizing' opportunities and 'transforming' their organisations to pursue long-term growth, as well as the strength and flexibility of their relationships with partners, as particularly enabling of their response to the hugely disruptive COVID shock. Their capabilities to support knowledge exchange and commercialisation activity were also seen as a key enabler.

The capabilities and changing needs of their partners, and the capacity and conditions of the innovation system within which they operate to drive innovation, were much more likely to be seen by university leaders as hindering their response than other factors.

Our findings suggest that capability gaps within universities may exist that affect their strategic agility – their flexible, mindful responses to the changing external environment following the COVID shock. In particular, their capability to identify and evaluate trends, opportunities and threats ('sensing') was regarded as a comparatively weak enabler of strategic agility. This capability is likely to be crucial for universities to navigate a still highly uncertain, post-crisis landscape.

FIGURE X.3 **Barriers and enablers to university strategic agility to pursue emerging innovation-related opportunities and overcome major challenges over the Pandemic period**



Looking to an innovation-led recovery

Strategic priorities for universities for the Recovery

Universities roles in contributing to innovation may be categorised within three main functions:

- R&D activities to generate new knowledge, ideas and technologies that form the basis of new innovations
- Applying their existing knowledge base and resources to support partners in delivering their innovation activities
- Developing and strengthening the capabilities of the system to better enable organisations to innovate and for innovations to be introduced and diffused.

Looking to the recovery, most universities saw applied research, use-inspired basic research, and challenge-driven programmes as R&D activities of particular strategic importance for helping to meet the innovation needs of their partners. Both basic research and prototype development, design and demonstration were regarded as particularly important by less than half of universities.

Beyond R&D, universities of all types are placing significant strategic importance on a variety of roles to support partners to help them tackle their specific innovation challenges and needs. Particularly important were building networks, helping partners identify new innovation directions and opportunities, and helping them to identify/adopt new technologies.

A majority of universities also place significant strategic importance on building both tangible and intangible infrastructure and conditions of the innovation system that underpin the ability of organisations to innovate. Of particular importance were efforts to raise the innovation and entrepreneurial culture of innovation systems and the quality of life of their local areas.

Emerging and viable strategic opportunities

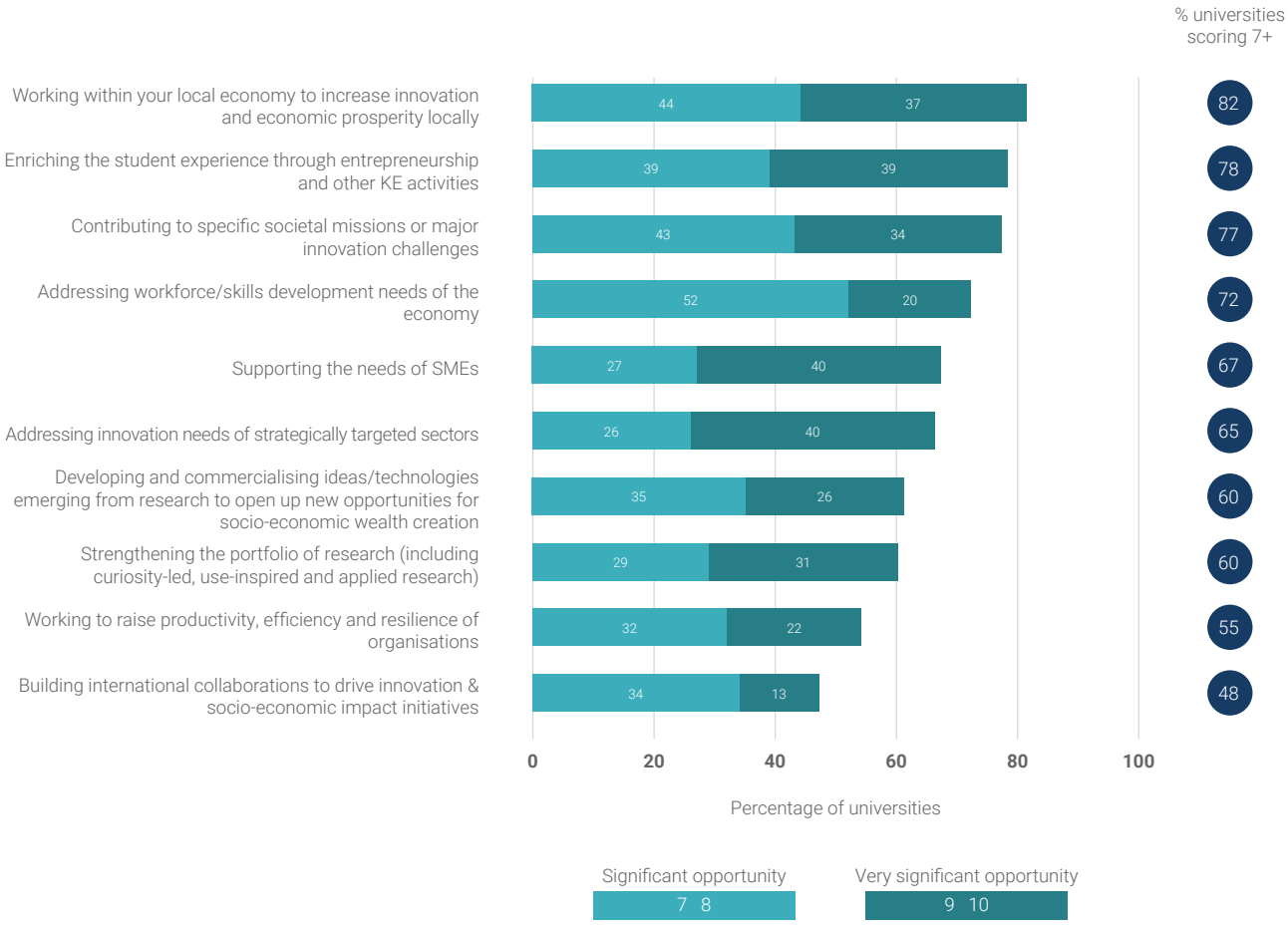
Because the resources and capabilities of universities can be mobilised in many different areas, it is crucial that policy ambitions for an innovation-led economic recovery translate into recognisable strategic opportunities if they are to be delivered.

The area most commonly seen by universities as offering significant and viable strategic opportunities for the recovery period is working within the local economy to increase innovation and economic prosperity. Enriching student experience through entrepreneurship/KE activities, and working to deliver on specific societal missions and innovation challenges are also seen as offering significant opportunities.

Worryingly for post-Brexit ambitions to build Global Britain, fewer universities saw viable strategic opportunities around building international innovation-focused collaborations. Also striking were the relatively fewer universities seeing opportunities to work with partners to raise productivity, efficiency, and resilience of organisations. Additional policy incentives may be needed in these areas.

An important finding in relation to the government's Levelling Up strategy is that universities based in less prosperous parts of the UK were much more likely than others to see opportunities in working with their local economy; working to raise productivity and efficiency of partners; working to address the innovation needs of SMEs and of specifically targeted sectors; and working to develop workforce skills.

FIGURE X.4 **Viable strategic opportunities for the Recovery Period, driven by unmet needs, identified by universities as significant (score of 7-8) and very significant (score of 9-10)**



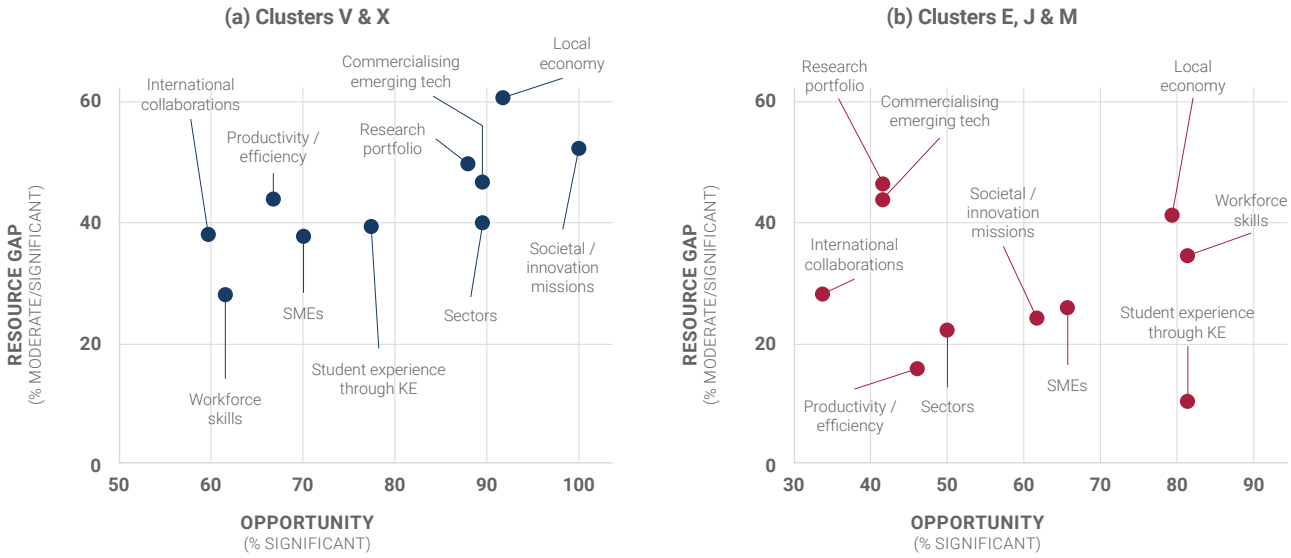
Note: sum of data points may not equal total % of universities scoring 7+ due to rounding

Resource gaps hindering pursuit of emerging strategic opportunities

Significant resource gaps (including finance and other resources) are hindering universities' pursuit of otherwise viable opportunities for driving innovation in the recovery period. The areas with the greatest resource gaps vary by type of university. Larger, research-intensive universities see both working within the local economy to drive innovation, and contributing to key societal missions and innovation challenges as offering the significant strategic opportunities but are hampered by significant resource gaps.

For smaller, less research-intensive universities, the most significant opportunities coupled with large resource gaps are around working within the local economy to drive local innovation, and addressing workforce/skills development needs of the economy. Crucially, universities in less economically prosperous regions were more likely than those in more prosperous areas to identify significant resource gaps for pursuing opportunities in areas that will be important for mobilising the university base to deliver on the Levelling Up strategy.

FIGURE X.5 **Comparison of the scale of opportunity and resource gaps for each area, for different types of university**



Government support for navigating the crisis and recovery

Government support schemes have been effective in supporting innovation-focused activities

Funding programmes that enabled flexibility and decentralised decision-making at the university or department level were regarded as most effective in enabling universities and academics to rapidly respond, adapt, and reconfigure to overcome major challenges thrown up by the pandemic, drive research translation, and purse new opportunities. Few universities found the BEIS/UKRI Sustaining University Research Expertise Fund to have had much of an effect in helping them to continue to initiate and deliver innovation-focused activities.

More could be done to enable universities to contribute to the recovery

Universities also identified a number of government actions that could help to enable the university system in the UK to contribute fully to an innovation-led recovery.

More funding to effectively and efficiently generate innovations

Universities called for higher levels of flexible funding for research and KE (such as QR funding and core KE funding) to enable them to become more responsive to long-term opportunities to both create breakthroughs that will drive technologies and innovations, and leverage their existing knowledge bases and resources to help their partners innovate.

More mission and challenge-led funding

Universities also called for additional resources to enable them to actively engage in addressing innovation-related endeavours to tackle major societal problems, exploit technological opportunities and contribute to local and regional development.

Improved coordination of funding

A variety of timing-related issues associated with the coordination of funding allocations were identified by universities that would benefit from being addressed. This includes the short notice of funding calls; extended duration of HEIF allocation decisions in recent years (in England); mismatched funder/university expectations for the time needed for impact realisation; and funding sequencing issues.

The need to improve coordination and coherence between funding programmes and incentives across different levels (e.g. regional vs national) and areas of policy; across different government departments, and between the strategic intention of policies and their implementation was also highlighted.

Improving self-governance of the innovation system

There were calls for greater involvement of a range of actors in the self-governance of innovation systems. Also emphasized by universities was the need to improve monitoring, anticipation, evaluation, and impact assessment systems to aid decision-making.

Strengthening the 'demand side' for innovation-focused KE

Universities also called for targeted action to help innovation-focused SMEs, third sector organisations and those sectors badly affected by the pandemic to recover. They also highlighted the need for greater funding to help SMEs build the necessary capabilities to engage in innovation, and to support mechanisms to promote the value of research and innovation diffusion in regions of low innovation maturity.

Building capabilities to drive innovation and collaboration

Respondents also called for additional support to build capabilities to collaborate and innovate within the innovation system, including within the university (recognising the challenges of recruiting and retaining highly skilled professionals to support KE and commercialisation), and to build entrepreneurial and workforce skills within the wider economy.

Creating/strengthening network links

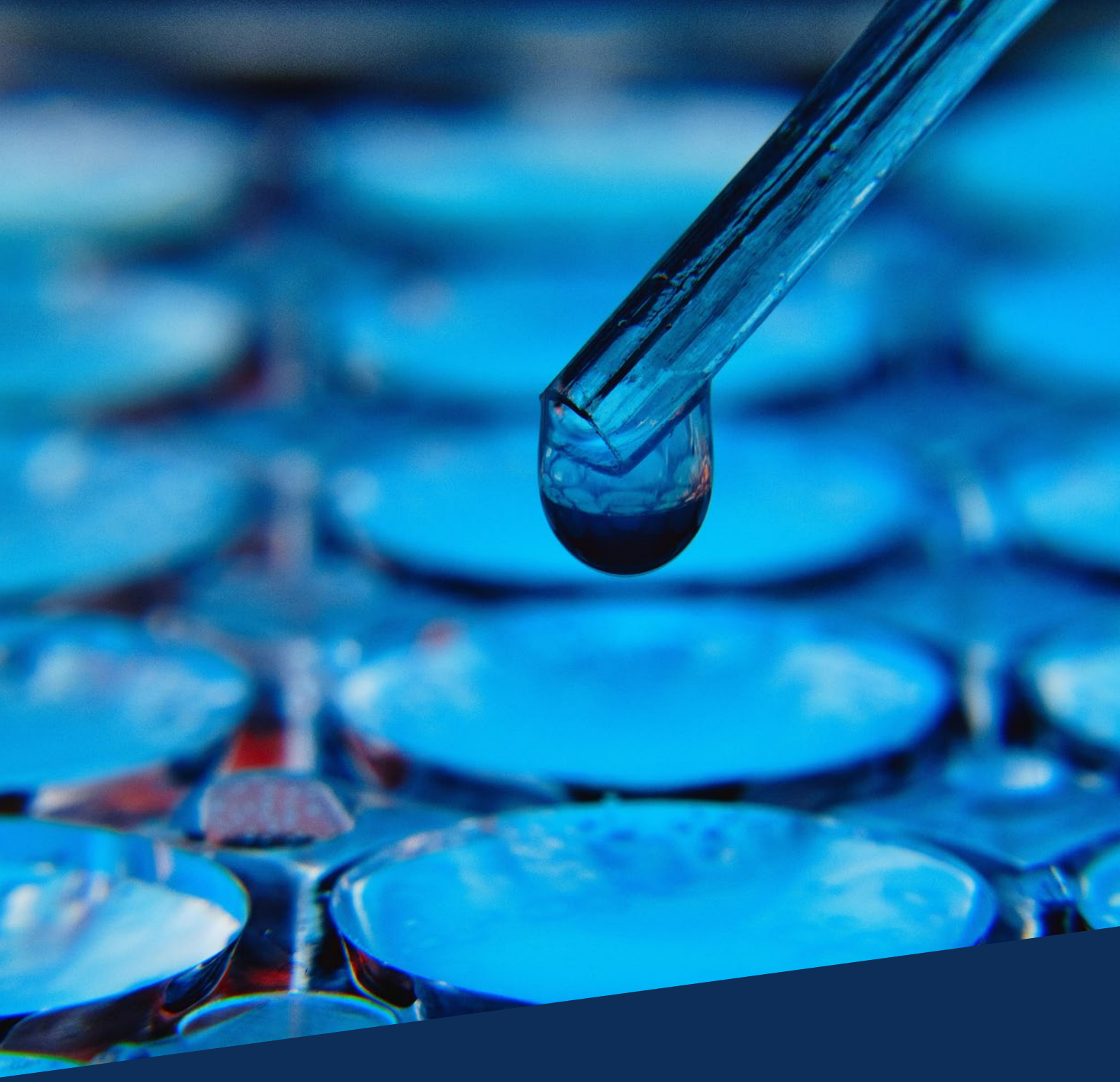
Finally, universities called for greater efforts to help them build and strengthen networks to facilitate innovation and platforms to drive collaborations, such as pre-competitive R&D consortia, regional technology clusters, and international research and innovation platforms.

While our evidence base is wide-ranging on the nature and scale of the effects of the pandemic on universities and their ability to contribute to innovation through the crisis and into the recovery, we highlight three key implications for policymakers. First, the pandemic has had continuing, detrimental impacts on university innovation-focused activities over the Ongoing Crisis period. Experience from previous pandemics suggests that the effects on innovation are expected to continue well beyond the crisis phase of the pandemic (Wang, Zhang and Verousis, 2021). Consequently, additional public funding may be needed to enable universities to maintain capabilities and infrastructure through a prolonged recessionary period of depressed demand for R&D, KE, and innovation activities in order to foster long-term growth (OECD, 2009, p.28).

Second, universities may need to be supported to build resilience capabilities as preparation for future crises, particularly to enable them to 'bounce forward' to new growth during times of turbulence.

Third, university leaders identified key resource gaps hindering their pursuit of a range of significant, viable strategic opportunities for their institutions to fully contribute to an innovation-led economic recovery. Further work is needed to better understand the nature and scale of these resource gaps and whether additional public funding and incentives may be needed to enable universities to contribute fully to the delivery of key government ambitions for the recovery.

Overall, the pandemic continues to hugely disrupt the university system and its ability to contribute to innovation. We need to continue to invest through the crisis and into the recovery to enable universities to overcome the many challenges they face in this area and help them adapt and reconfigure to pursue new opportunities to contribute to innovation. This will give us the greatest chance of positioning them at the heart of the innovation-led recovery and renewal that our country so desperately needs.



1 Introduction

The COVID-19 pandemic constitutes the worst global public health emergency in living memory, and has resulted in a global recession (IMF, 2021). In our previous report, we explored the disruption to innovation-focused activities at UK universities during the early phase of the pandemic and the UK's first national lockdown (Ulrichsen, 2021). Given the pandemic's persistence, there is now a need to build on our earlier findings to explore its ongoing effects on universities and their innovation activities. In this report, we investigate these ongoing effects, as well as the 'organisational resilience' of universities which enabled flexible and purposeful responses through the pandemic, and their 'strategic agility' to adapt and pivot as they attempt to navigate through the crisis to drive efforts for an innovation-led economic recovery within a changed, post-crisis landscape.

By July 2020 (immediately after the first national lockdown), UK universities had experienced a 6% decrease in the level of innovation-focused activities (Ulrichsen, 2021). Despite this, many university leaders were optimistic, anticipating a rebound in activities over the short-term.

However, the evolution of the pandemic has proved to be (and remains) highly uncertain. The period between August 2020 and July 2021 saw subsequent COVID waves and two further national lockdowns, which cast doubt on whether a short-term rebound would take place.

Consequently, the first aim of this study is to examine the ongoing effects of the pandemic on university innovation-focused activities. This, together with our earlier report (Ulrichsen, 2021), helps to establish an evidential baseline for investigating how the roles of universities are changing as we move through the crisis into the economic recovery.

One positive development since our last report has been the rollout of vaccines, which emerged from the unprecedented science and innovation response to the pandemic. That universities acted as a major driver of this response was not a given, but rather a critical pivot point where different outcomes could have played out.

An area of interest for policy makers is how universities managed to combine efforts to 'bounce back' from the public health and economic effects of the pandemic with those to simultaneously 'bounce forward' and drive the science and innovation response. **The second aim of this study is to explore this topic, known as 'organisational resilience', to inform future crisis planning.**

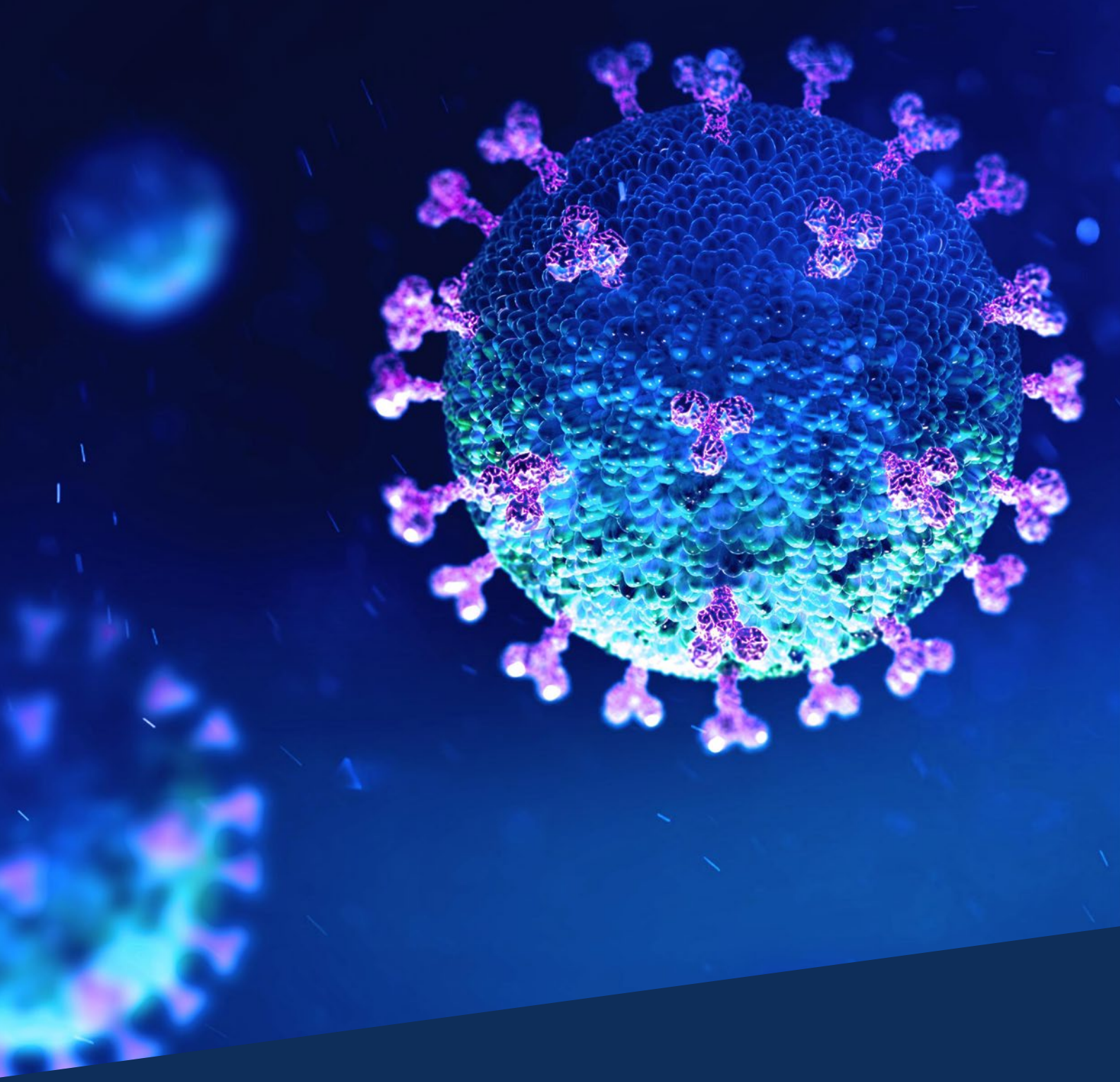
The vaccine rollout has offered a pathway out of the crisis phase of the pandemic, enabling many governments to develop strategies for economic recovery and managed transition to more sustainable, equitable and resilient futures. These strategies are premised on a step-change in all aspects of innovation, from discovery through development to adoption.

The extent to which the ambitions of strategies for an innovation-led economic recovery are realised is a second critical pivot point, which will be influenced by the ability of universities to adjust to changes in the emerging post-pandemic landscape and lead this step-change in innovation. **The third aim of this study is to explore this topic, known as 'strategic agility', to inform the implementation of innovation strategy for recovery.**

To enable the science and innovation pandemic response, governments performed roles which deviated quite dramatically from pre-pandemic approaches to innovation policy. Consequently, policy makers are keen to learn lessons from this effort and apply them moving forward into the recovery. **The fourth aim of this study is to explore how effective policy interventions were during the crisis and identify what further support could be provided to accelerate an innovation-led economic recovery.**

This report presents the findings of a survey of UK university leaders and senior managers with strategic decision-making authority in innovation, knowledge exchange, enterprise, business engagement or equivalent, on a variety of topics relating to ongoing disruption to the sector and the extent of university strategic agility to meet the opportunities and challenges of the post-pandemic landscape.

The survey was developed by the Research England-funded University Commercialisation and Innovation (UCI) Policy Evidence Unit at the University of Cambridge in cooperation with the UK's National Centre for Universities and Business (NCUB). The survey was conducted between August and December 2021.



2 Universities, innovation and COVID recovery

To guide our exploration of the ongoing effects of the pandemic on universities, and their ability to adapt strategically to the post-crisis landscape and pivot to pursue new opportunities and overcome major challenges, we first reviewed relevant academic and practitioner literatures to build a baseline of what is known of these key topics and develop analytical frameworks to guide our thinking and evidence gathering. Insight into these topics is structured in this section as shown below.

Insight into these topics is structured in this section as shown below.

- **Universities' roles and functions in innovation processes, systems and the economy (Section 2.1)**
- **Innovating during the COVID crisis: policy responses and effects on science and innovation (Section 2.2)**
- **Innovating for recovery: emerging policy priorities (Section 2.3)**
- **Universities' resilience and strategic agility for navigating the pandemic (Section 2.4)**

For a discussion of findings, proceed to Sections 4 - 9.

2.1 Universities' roles and functions in innovation processes, systems and the economy

Innovation tends to be a collective process (Lazonick and Mazzucato, 2013), involving the integration of the skills and efforts of a variety of people and organisations (e.g. universities, private sector firms and investors, public sector agencies and government departments, third sector organisations) through a network of institutions and relationships along strongly coupled and interactive chains of activities (from discovery through conception, design, testing, to adoption) (Caraça, Lundvall and Mendonça, 2009; Kline and Rosenberg, 1986). In many countries, policymakers are positioning universities and other research performing organisations alongside private enterprise as crucially important for realising the ambitions of national and regional innovation policy.

Arguably, the most established and recognised roles of universities lie upstream in the innovation chain. Through their basic, use-inspired and applied research, universities generate new ideas, technologies and approaches (Stokes, 1997). These are diffused through varied pathways of knowledge exchange (KE), ranging from commercialisation (e.g. patenting, licencing, entrepreneurship) to more engaged and people-centric modes (e.g. collaborative or contract research, consulting, providing ad hoc advice, networking with practitioners). Through these interactions, universities contribute to a wide range of impacts, from ground-breaking innovations that transform the world to incremental innovations that help to drive efficiency and productivity improvements (Cohen, Nelson and Walsh, 2002; Hughes and Kitson, 2014; Lee, 2000; Perkmann et al., 2013, 2021).

Universities' research and KE extend far beyond contributions to technological advances, although this is sometimes overlooked due to an excessive focus on technology transfer (Hughes and Kitson, 2012). Amongst other things, university research and KE activities help to drive new business models and organisational practices to create and capture value; new ways of producing and supplying products and services in more efficient and sustainable ways; individual and population behavioural insights concerning responses and adaptation to new technologies; public policies, standards and regulations; and ethical frameworks that guide the development and diffusion of innovations (Hughes and Kitson, 2014; Jacobsson and Vico, 2010).

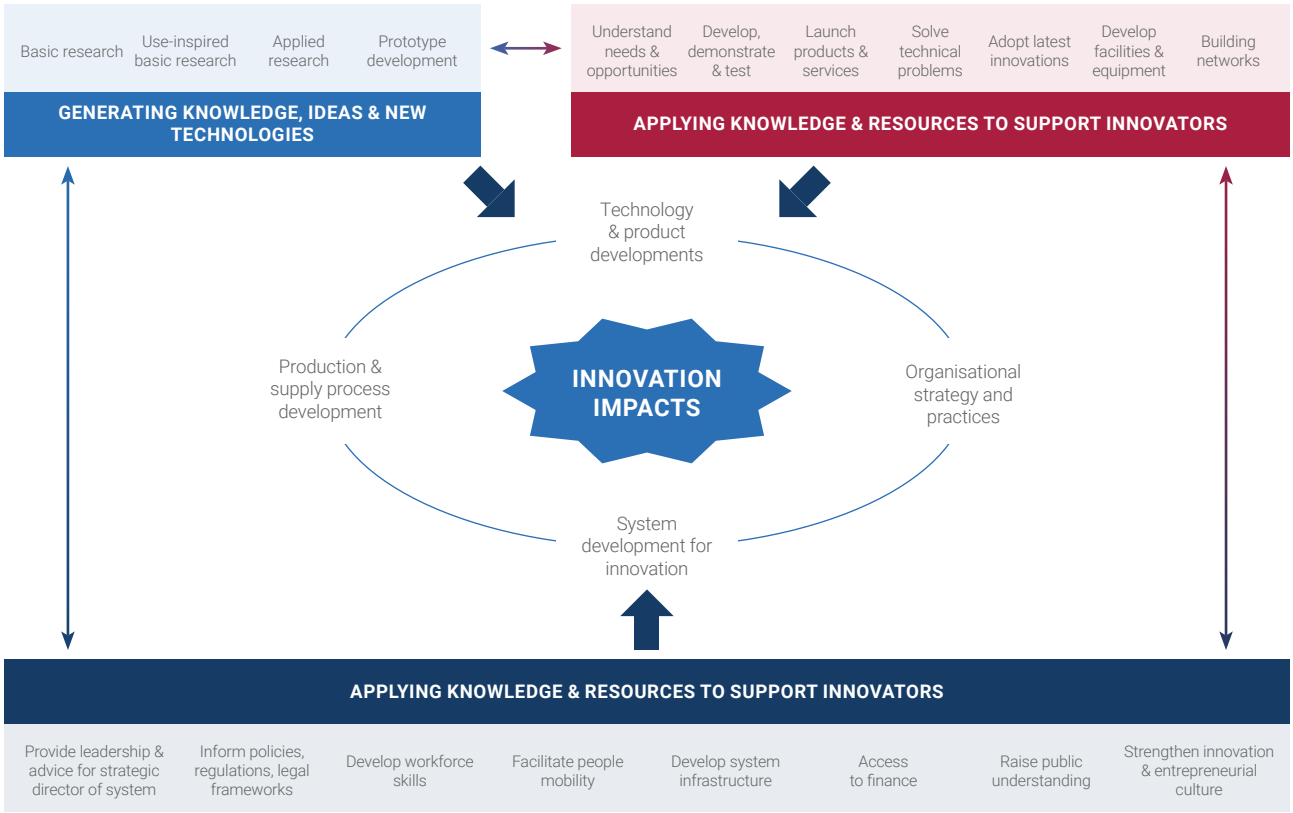
Research has also shown that universities contribute to innovation much further downstream in the innovation chain than previously thought, leveraging their expertise and infrastructure to support partners in delivering their innovation activities. This includes providing a range of services that apply existing knowledge bases and resources (e.g. facilities) to support their partners in the private, public and third sectors to: develop, demonstrate and test new technologies, processes and products/services; identify routes to market; provide technical problem-solving services; and help them to adopt the latest innovations and technologies to drive efficiency and productivity gains (Bercovitz and Feldman, 2007; Betz, 1997; Hughes et al., 2016; Lee, 2000; Lester, 2005; Youtie and Shapira, 2008). Additionally, universities have been shown to help partners understand the need for innovations and identify new opportunities for innovation.

As well as these roles along the innovation chain, the past few decades have seen a growing evidence base on the strategic role that universities can play in stimulating economic growth by strengthening capabilities and conditions of the wider innovation system that shape the ability of organisations to collaborate and innovate, and for innovations to be introduced and diffused (Breznitz and Feldman, 2012; Gunasekara, 2006; Hughes and Kitson, 2012; Kitson et al., 2009; Lester, 2005; Uyarra, 2010; Youtie and Shapira, 2008).

Examples of their roles in this area include providing strategic insights and intelligence to inform regional and national sector and technology strategies; providing regional leadership alongside key stakeholders; building workforce technical and managerial skills; investing in physical infrastructure to support experimentation with new innovative ideas and very early-stage company growth; attracting inward investment; building research and innovation networks; facilitating knowledge spillovers that stimulate innovation in proximity to the university; and raising public understanding of the potential opportunities and societal implications of emerging technologies and innovations.

Finally, with the evolution of innovation policy to include the promotion of transformative change towards more sustainable futures (Schot and Steinmueller, 2018; Wanzenböck et al., 2020), new 'transformative university' or 'development university' models are emerging (Cuesta-Claros et al., 2021; Guzmán-Valenzuela, 2016; Trencher et al., 2014) which sees the university as having a role in shaping not only the pace, but also the direction of innovation along corridors of 'acceptable' development paths (Weber and Rohracher, 2012). Activities of these types of universities include engagement with a broadened range of stakeholders involved in social change; critique of problems to understand their socio-political dimensions; management of the knowledge required to drive transformative change; socio-technical experimentation and demonstration in real-world settings; and reform of built and natural environment (Parker and Lundgren, 2022; Trencher et al., 2014).

FIGURE 1 **Understanding how universities contribute to innovation**



These diverse roles are brought together under three broad types of function universities serve in the development and deployment of new innovations and the functioning of the innovation system (Figure 1): (i) generating new knowledge, ideas and technologies that form the basis of new innovations; (ii) applying their existing knowledge base and resources (such as their physical infrastructure and social networks) to support partners in delivering their innovation activities; and (iii) developing and strengthening the capabilities of the system to better enable organisations to innovate and for innovations to be introduced and diffused.

It also aims to recognise the different types of innovations these functions support, from developing new technologies and products to ways of producing and supplying them, organisational strategies and practices, and the development of the system that underpins organisations' ability to innovate.

While innovation is often understood in terms of technological inventions, and linked back to advances and activities in STEM disciplines (science, technology, engineering and mathematics), it must be stressed that the social sciences and arts and humanities are known to actively engage in delivering many of these contributions (Hughes et al., 2011; Paunov, Planes-Satorra and Moriguchi, 2017), and their participation is increasingly important in the area of responsible research and innovation (Stilgoe, Owen and Macnaghten, 2013; Ulrichsen, 2019).

2.2 Innovating during the COVID crisis: policy responses and effects on science and innovation

In our previous reports, we investigated the effects of COVID-19 on university innovation-focused activities between March and July 2020 (Ulrichsen, 2021) and on R&D activities of businesses operating in the UK between March and September 2020 (NCUB and UCI, 2021). Key findings from both reports are included in Table 1. In particular:

- Universities reported a 6% decrease in innovation-focused activities with partners, particularly small and medium enterprises (SMEs), across most sectors apart from pharmaceutical and biotechnology, human health and social work, and agriculture and fishing.
- Many reported increased difficulties in starting or continuing innovation-focused projects.
- Expectations for short-term recovery in innovation-focused activities were mixed, though recovery in activities with SMEs and start-ups/spin-offs was expected to lag behind those with strategic partners.
- Most firms reported some disruption to their R&D and innovation activities and university collaborations, in particular affecting product/service demonstration, testing and trial production. However, back in September 2020, while R&D strategies were disrupted, many firms planned to increase R&D activities in the short term.

These findings are consistent with existing and emerging evidence on innovation during a crisis, explored in a recent report by Kelleher and Ulrichsen (2022). Key insights are summarised below:

- **Innovating during major crises differs from that in normal times** in terms of the large social returns on R&D investment and the need to act quickly, while the objective of innovation also shifts from non-specific, broad technological advance to finding solutions to acute challenges thrown up by the crisis (Gross and Sampat, 2021). One effect of this is that crises can affect the direction of innovation, inducing firms to develop easier, lower-value and less promising inventions (Bryan, Lemus and Marshall, 2020; Laperche, Lefebvre and Langlet, 2011).
- **Major crises enable a more active role for government in innovation than would be justified under market-based approaches to innovation policy.** In particular, innovation policies take on key additional importance and roles during a crisis, including prioritising applied research to address crisis needs, prioritising short-term results; coordinating innovation efforts and knowledge flows; funding overlapping and parallel R&D efforts; and focusing on development, demonstration and diffusion of innovations (Gross and Sampat, 2021). The successful mobilisation of innovation systems to combat COVID, catalysed by these types of crisis innovation policy interventions, has provided lessons for innovation policy for the recovery (OECD, 2021; Stiglitz, 2021).

TABLE 1 **Key findings from explorations of COVID impacts up to September 2020**

REPORT	FOCUS	KEY FINDINGS
 *Ulrichsen (2021) Innovating During a Crisis: the Effects of the Covid-19 Pandemic on how Universities Contribute to Innovation*	Universities	**Change in levels of innovation-focused activities with:** • External partners: 45% of universities reported moderate or significant decreases, 23% reported increases • SMEs: 55% of universities reported moderate or significant decreases or collapse • Strategic partners: 38% of universities reported moderate or significant increases. **Change in ability to deliver innovation-focused projects:** • Access to facilities: 82% reported this becoming moderately or significantly harder • Dedication of staff time: 69% reported this becoming moderately or significantly harder • Cover financial costs: 79% reported this becoming moderately or significantly harder • Assemble/recruit staff for new projects: 78% reported this becoming moderately or significantly harder. **Expected change in innovation activities by March 2021 with:** • External partners: 43% expected moderate or significant decline; 51% expected moderate or increase • SMEs: 46% expect moderate or significant decline; 32% expect moderate or significant increase • Strategic partners: 22% expect moderate or significant decline; 51% expect moderate or significant increase • Spin-offs/start-ups: 39% expect moderate or significant decline; 30% expect moderate or significant increase.
 *NCUB and UCI (2021) Innovation and Resilience in a crisis: The impact of Covid-19 on UK business R&D*	Firms	**Change in levels of R&D and innovation activities:** • 91% reported some disruption of their R&D and innovation activities • 96% reported some disruption of their university collaborations. **Change in focus of R&D and innovation activities:** • Product/service demonstration, testing and trial production faced the greatest disruption. **Change in planned R&D and innovation activities over next 12 months:** • 19% planned decreases, 44% planned increases.

- **Crises may disincentivise business innovation, disrupt R&D strategies and lead to a drop in R&D investments** (known as procyclicality) through weakened financial resources, market volatility, weak market demand, and uncertainty-related precautionary behaviour – i.e. where people behave in such ways as to enable them to respond to unknowable contingencies, such as by reducing R&D spending and instead holding financial resources (Roper and Turner, 2020; Stiglitz, 2021; Stiglitz and Guzman, 2021). Procyclicality may persist for years after a pandemic has been controlled (Wang, Zhang and Verousis, 2021), weakening the potential for innovation in the longer run and harming long-term competitiveness of both businesses and nations.

- **Conversely, crises may incentivise business innovation and lead to an increase in R&D investments** (known as counter-cyclicality), particularly in innovations designed to counter the crisis. Firms which continued R&D-based innovation investments during a crisis (drawing on the experiences of the 2008 financial crash) were more likely to survive (Jung, Hwang and Kim, 2018), to emerge more competitive (Antonioli et al., 2013; Soininen et al., 2012) and with enhanced financial performance (Castillejo, Barrachina and Sanchis-Ilopis, 2019; Flammer and Ioannou, 2021; Spescha and Woerter, 2019).

- **The pandemic has had asymmetric impacts across sectors** (Bloom et al., 2020, p.17). Some sectors have experienced creative destruction (Schumpeter, 1942), where a small group of firms maintain innovative activities throughout the crisis and higher productivity firms replace lower productivity firms, resulting in a more innovative and competitive economy overall. Other sectors have seen destruction – i.e. the shrinking of lower productivity industries with limited offsetting expansion of other industries.

- **Science and innovation played critical roles in responding to the COVID crisis,** through understanding the virus, shaping virus containment policies through scientific advice, developing effective vaccines and therapeutics, and enabling continuity in many industries and education (OECD, 2021). Key to these efforts were a proliferation of open science initiatives (Paunov and Planes-Satorra, 2021a), strong public-private collaborations and open innovation (Chesbrough, 2020; Patrucco et al., 2022), and international collaborations, governance models and coordinating mechanisms (Collins and Stoffels, 2020).

- **Universities played critical roles in enabling the science and innovation COVID response,** including:

  - Prioritising applied research in response to urgent COVID needs while shuttering many non-COVID projects (Barrero, Bloom and Davis, 2020). Public research institutions (including universities) were a main driver of the pandemic R&D response (Paunov and Planes-Satorra, 2021b), for example being 10% more likely than private firms to conduct COVID clinical trials (Agarwal and Gaule, 2021).

  - Focusing on short-term results by accelerating R&D, translation and commercialisation activities to the extent that the time between identifying a new innovation need and innovation launch (i.e. market introduction or public communication of an innovation) was about the same for innovations undertaken by universities as for incumbent firms (Ebersberger and Kuckertz, 2021).

  - Coordinating research efforts and knowledge flows, for example by launching open innovation competitions (Chesbrough, 2020) and through participation in national and international coordination initiatives (Paunov and Planes-Satorra, 2021b).

  - Focusing on the development, demonstration and diffusion of innovations, including through public-private partnerships and consortia (Tietze et al., 2020), adopting new ways of working with external partners to increase agility, responsiveness, flexibility and accessibility (Ulrichsen, 2021), reducing appropriability barriers for COVID-related technologies (Contreras, 2021), and engaging in non-traditional downstream innovation activities, such as using 3D printing facilities to produce personal protective equipment (Johnstone and McLeish, 2020).

- **Universities and researchers also experienced negative impacts during the pandemic**, including reductions in research productivity as a result of limited access to research infrastructures, a diversion of efforts away from non-COVID-projects, financial challenges and restricted researcher mobility, which has impacted collaborations and the career development of early career researchers (Paunov and Planes-Satorra, 2021b, pp.27–31).

2.3 Innovating for recovery: emerging policy trends

2.3.1 Post-pandemic trends in innovation policy

The pandemic presented policymakers with two main challenges: 'to fight the crisis today and build a better tomorrow' (Georgieva, 2020). In the previous section, we discussed how crisis innovation policy took on additional roles to mobilise the innovation system response to the pandemic, roles that would not be justified in normal times. In this section, we explore how governments have attempted to learn lessons from this mobilisation, and apply them within innovation policy for economic recovery. We also explore the signals for emerging priorities within the UK innovation strategy for the recovery.

What is striking about emerging innovation strategies for recovery, such as those from the UK, US, EU and China (CSET, 2021; EC, 2020; HM Government, 2020; US Congress, 2021) is that they do not emphasise a return to business as usual with a 'growth at all costs' approach to economic development (Crisp and Waite, 2020). Instead, policymakers have, to varying degrees, adopted the 'build back better' imperative (Martin, 2021; OECD, 2020; Schwab and Malleret, 2020; Stern et al., 2020) and are attempting to strengthen innovation policies to drive transformational change in key areas of societal importance (OECD, 2021, p.45). These promote a managed transition to more sustainable, equitable and resilient forms of growth, as shown in Table 2. Indeed, COVID itself is being characterised in ways which justify the 'build back better' approach, which are summarised in Table 3.

TABLE 2 **Types of growth targeted within recovery innovation strategies**

TYPE	DESCRIPTION	REFERENCE
Investment-led growth	Strong public funding for R&D and innovation to boost demand and reduce unemployment in the short term, and support emerging or breakthrough technologies and industries of the future in the long term	(Griffith-Jones and Cozzi, 2016)
Innovation-led sustainable growth	Growth that is environmentally sustainable, driven by a zero-carbon transition that increases underlying strength and productivity across assets and can be sustained in the long term	(Stern and Valero, 2021; Zenghelis, 2016)
Inclusive growth	Reducing social and spatial barriers to increase both participation in growth (e.g. raising the overall level of R&D and innovation, boosting productivity) and distribution of the benefits of growth (e.g. 'levelling up' socio-economic prosperity).	Crisp and Waite, 2020; Stiglitz, 2016)

TABLE 3 Characterisations of COVID shaping innovation strategies

CHARACTERISATION	DESCRIPTION	POLICY IMPLICATION
COVID as a 'landscape shock'	A 'landscape shock' is a major short-term, difficult to foresee disturbance in the social, technical and ecological environment which substantially disrupts organisations, presenting as opportunities, threats, crises, or catastrophes (Geels and Schot, 2007; Meyer, 1982).	As a landscape shock (Schot, 2020), COVID provides an impetus to tilt the playing field across a range of organising systems, resetting the economy towards sustainable and inclusive growth.
COVID as a 'normal accident'	A 'normal accident' is an event with small beginnings but catastrophic outcomes, made inevitable because of cascading and unanticipated failures within complex, tightly coupled societal and economic organising systems (Perrow, 1984).	As a normal accident (Schot, 2020), COVID justifies efforts not only to reduce the likelihood of future crises (e.g. through sustainable and inclusive growth), but also to enable rapid recovery from crises that do occur (through resilience, reducing reliance on global supply chains, and recognising the strategic value of basic research and other techno-scientific capabilities which together provide the stock of knowledge and resources necessary to counter future crises).
COVID as a 'grey rhino'	A 'grey rhino' is a highly probable, high impact threat which is anticipated but neglected until its impacts are being felt (Wucker, 2017).	Here, COVID is regarded not as a failure of planning and anticipation, but of execution and collaboration. Consequently, mechanisms which worked well in the COVID response are being emulated in innovation strategies for recovery. These include portfolio approaches to de-risk public investment in innovation (Mazzucato, Kattel and Ryan-Collins, 2020); public-private partnerships (Lynch et al., 2021); public procurement policies to support market creation (Edler and Georghiou, 2007) and project schedule compression (Winch et al., 2021)

2.3.2 Emerging UK policy priorities

We see a number of these policy trends emerging in the UK as it develops its own innovation strategy and associated plans for the recovery (BEIS, 2021; HM Government, 2020, 2021; HM Treasury, 2021; Science and Technology Select Committee, 2021). In particular, the innovation strategy identifies a challenge to learn from the success of COVID-related innovation 'in order to improve how government departments, public organisations and industry can work together and deliver a step-change in innovation across the country' (BEIS, 2021, p.19).

Looking across the various strategies and plans, a number of policy priorities are emerging in which universities have the potential to play a central and driving role. These include:

- **Mission-led and challenge-led programmes** to address complex societal and industrial innovation challenges and the shift to net-zero
- Strengthening the **ability to develop and commercialise emerging technologies and deep tech to drive industries of the future**, with a focus on seven key technology families (advanced materials and manufacturing; AI, digital and advanced computing; bioinformatics and genomics; engineering biology; electronics, photonics and quantum; energy and environment technologies; and robotics and smart machines)
- Emphasising not just research excellence but the ability of the UK innovation system to **translate R&D into innovative applications and commercialise them to open up new opportunities for economic wealth creation**
- **Attracting, retaining and developing the skills necessary in the economy to drive R&D and innovation in the future**, to underpin the ability of the UK to become a 'global science superpower' by 2030 and a 'global hub for innovation' by 2035
- Providing **greater support to companies for their R&D and innovation activities and to raise productivity**, for example through the adoption of latest technologies/processes, in particular digital

- **Supporting R&D and innovation infrastructure** within the system that underpins the ability of organisations to innovate
- **Investing and intervening through a place-based lens**, with a tailored approach to support the development of (i) high potential international R&D clusters of the future; (ii) areas with emerging R&D strengths; and (iii) to encourage technology adoption and diffusion in areas of low innovation maturity.

2.4 Universities' resilience and strategic agility for navigating the pandemic

The pandemic is laden with key uncertainties comprised of 'critical pivot points' – where developments may play out in different ways (OECD, 2021, pp.32–45). Here, we identify two critical pivot points which, we argue, are important in understanding both the ongoing effects on university innovation-focused activities and university strategic adaptation to lead economic recovery:

- The response of universities during the pandemic to drive innovation-focused activities which has facilitated a way out of the crisis. We see this as an outcome of universities' **organisational resilience.**
- The adjustment of universities to changes in the emerging post-pandemic landscape to lead efforts for an innovation-led economic recovery. We see this as an outcome of universities' **strategic agility.**

2.4.1 Organisational resilience

The unprecedented science and innovation response to the crisis in the UK was driven in large part by universities (Section 2.2). This was not a given, rather it was a critical pivot point which may have gone differently under different circumstances.

An important factor which influenced universities' responses during the pandemic was their organisational resilience – i.e. their ability to anticipate, prepare for, respond and adapt to incremental change and sudden disruptions in order to survive and prosper (Denyer, 2017).

Understanding the forms of resilience universities displayed is important to understand both the pandemic's ongoing effects on university innovation-focused activities, and also for future crisis planning. To explore what universities did to achieve resilience during the crisis phase of the pandemic, we use a framework developed by Denyer (2017), which identifies five different perspectives (in order of increasing maturity of thinking about resilience):

- **Preventative control:** Resilience is achieved by means of risk management, erecting physical barriers, using redundant/spare capacity, systems back-ups and deploying standardised procedures, which protect the organisation from threats and allow it to 'bounce back' from disruptions to restore a stable state.
- **Mindful action:** Resilience is produced by empowering staff, who notice and react to threats and respond effectively to unfamiliar or challenging situations.
- **Performance optimisation:** Resilience is formed by continually improving, refining, and extending existing competencies, enhancing ways of working and exploiting current technologies to serve existing customers, stakeholders, or markets.
- **Adaptive innovation:** Resilience is built through creating, inventing, and exploring new markets and new technologies.
- **Paradoxical thinking:** Resilience is achieved by balancing and managing the inherent tensions between the different approaches above, namely preventative control, mindful action, performance optimisation and adaptive innovation.

2.4.2 Strategic agility

The extent to which the ambitions of government for an innovation-led economic recovery are realised will be influenced by the ability of universities to adjust to changes in the emerging post-pandemic landscape and lead a step-change in innovation. This represents a second critical pivot point, about which little is currently known.

A key consideration for this pivot point is strategic agility – i.e. their ability to respond flexibly and purposefully to the constantly changing external environment (Lewis, Andriopoulos and Smith, 2014).

To guide our exploration of universities' strategic agility, we constructed a simplified model of university strategic agility following a landscape shock (Figure 2). In this model, universities are seen as already responding to various landscape pressures in the form of unchanging or slowly changing long-term trends, such as climate change and digitalisation (van Driel and Schot, 2005). COVID, as a landscape shock, created a new and very sudden additional external pressure for change.

The new and sudden shock of COVID induced universities to respond to overcome major threats and challenges and to pursue new opportunities. Their ability to respond is seen as influenced by a range of internal and external influencing factors. In Table 4, we identify a number of these factors drawing upon insights into organisational responses to landscape shocks (van Mossel, van Rijnsoever and Hekkert, 2018). These factors can be experienced as either barriers or enablers to a university's strategic agility and ability to respond to the crisis. As a consequence of a university's response to the COVID shock, some change in its innovation-focused activities may be expected.

FIGURE 2 **Simplified analytical model of university strategic agility following a landscape shock**

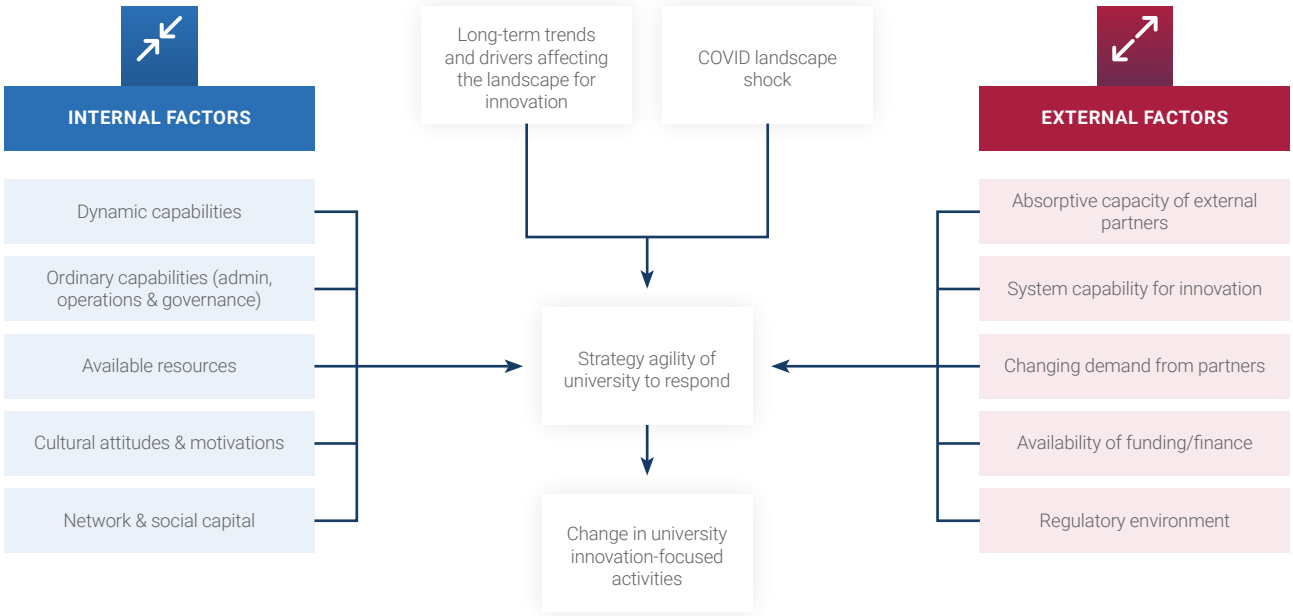


TABLE 4 Factors influencing strategic agility

FACTOR	DESCRIPTION
INTERNAL FACTORS	
Dynamic capabilities	Activities that contribute to the reconfiguration of a university's resources in alignment with the changing needs of stakeholders and conditions in the external environment (Teece, 2018). Dynamic capabilities can be disaggregated into those enabling organisations to: • 'Sense' (identification, development, co-development, and assessment of technological opportunities in relation to customer needs) • 'Seize' (mobilisation of resources to address needs and opportunities, and to capture value from doing so) • 'Transform' (continued renewal of existing operations to support opportunity seizing)
Ordinary capabilities	Capabilities in administration, operations, and governance which enable the effective operational delivery of tasks (Teece, 2018).
Slack resources	Excess capacity maintained by an organisation which is available to absorb the change and engage in solution searching
Cultural attitudes and motivations	The attitudes and motivations towards innovation which enable the development of new business models and ways of working more suited to a changed landscape
Social and network capital	Network links based on sociability and trust (social capital) and on calculation of economic returns (network capital) (Huggins, 2010).
EXTERNAL FACTORS	
Absorptive capacity of external partners	The ability of organisations to identify, assimilate, and exploit knowledge from the environment (Cohen and Levinthal, 1989)
Capability and capacity for innovation and entrepreneurship	The ability of the local/sectoral/technological innovation systems to conceive, develop, and/or produce new products and services, to deploy new production processes, and to improve on those that already exist (Lester, 2005) and to develop and scale new ventures to drive new wealth creating opportunities
Availability of funding/finance	The financial resources and incentives available for organisations to undertake innovation-focused activities
Regulatory environment	Established practices and rules that regulate the relations and interactions between individuals, groups and organisations (Boschma, 2005)

3 Definitions, survey method and data

To gather evidence on how the ongoing COVID-19 pandemic and related economic crisis has affected universities and their ability to engage in innovation-focused activities with external partners, we developed and distributed a survey to senior leaders and managers of UK universities with strategic decision-making influence over their institution's innovation and KE activities.

The survey covers the period August 2020 – July 2021 (the 'Ongoing Crisis period'), including the second (November 2020) and third (January – March 2021) UK national lockdowns. Together with our earlier report covering the period March 2020-July 2020 (the 'First Lockdown period') (Ulrichsen, 2021), this helps to establish an evidential baseline for investigating how the roles of universities are changing as we move through the crisis into the economic recovery.

3.1 Definitions

In this section, we define a number of key terms used in the survey. These definitions were presented to respondents at the beginning of the survey to help standardise the interpretation of the questions.

Innovation: Innovation covers all types, from product/service, to process and production, and organisational. Innovation is not limited to the private sector and can take place in any type of organisation, including in public and charitable sector organisations. Universities can contribute to innovation in different ways, most obviously through their research activities, but also through for example, their contributions to innovation-related skills development, competency building, and the provision of key infrastructure for innovation.

Innovation-focused activities: Activities of academics and the university, beyond core research and education, aimed at contributing directly to the innovation process or the strengthening of the underlying conditions enabling innovation to take place. Activities could include R&D partnerships, collaborations, industry-sponsored research, academic entrepreneurship, technology licensing, workforce development etc.

External partners: Any type of non-academic organisation involved in the innovation process or developing the underlying conditions for innovation. Could include industry partners (large companies, SMEs, start-ups), investors, public sector agencies, hospitals, charities etc.

University strategies for innovation and wider socio-economic impact: The strategic priorities of universities in how they, as institutions, seek to contribute to unlock the value of their knowledge to drive innovation and socio-economic impacts. These priorities may form a standalone strategy or may be part of a wider plan.

Local economy: The city, combined authority or local authority – whichever is the largest relevant geographic area – in which a university is based.

Basic research: Theoretical, empirical or experimental work, undertaken primarily to acquire new knowledge about the underlying foundation of phenomena or observable facts, without any particular application or use in view.

User-inspired basic research: Theoretical, empirical or experimental work, undertaken primarily to acquire new knowledge about the underlying foundation of phenomena or observable facts, but also inspired by considerations of use.

Applied research: Original investigation undertaken in order to acquire new knowledge directed towards an individual, group or societal need or use.

Time periods:
- Pandemic period: March 2020 – July 2021
- Pre-COVID period: up to March 2020
- First Lockdown period: from March – July 2020
- Ongoing Crisis period: from August 2020 – July 2021
- Immediate Recovery period: from August 2021 – July 2022

3.2 Survey instrument

The survey instrument was developed to gather information on a range of topics relevant to our study of the ongoing effects of the pandemic on the innovation activities of universities and their ability to respond to overcome major challenges and pursue emerging opportunities.

It adopted a broad definition of innovation to include not just new or significantly improved products, services, processes, and enabling platform technologies, but also new or significantly improved business models and organisational practices, ways of delivering and distributing products and services, and public policies and other elements of institutional frameworks that shape innovation activities.

The development of the questionnaire was informed by literature reviews of how universities contribute to innovation (Section 2.1), known impacts of the pandemic on science and innovation during its crisis phase (Section 2.2), emerging policy priorities for the recovery period (Section 2.3) and factors influencing strategic agility following a landscape shock (Section 2.4). It was also shaped through discussions with key experts on, and selected senior university practitioners involved in developing university innovation-related activities with external partners and their experiences during the COVID-19 pandemic.

Key topics explored in the survey are shown in Table 5.

TABLE 5 **Aims and areas of focus explored in the survey**

FACTOR	RESULTS SECTION IN REPORT	AREAS OF FOCUS
Explore the ongoing effects of the pandemic on university innovation-focused activities	4.1	Effects on levels of innovation-focused activities with different sectors
	4.2	Effects on levels of innovation-focused activities with different types of partner
	4.3	Nature of changes made to innovation-focused activities
	4.4	Ease of initiating and delivering university innovation-focused activities
Explore university resilience during the pandemic	5.1	Effectiveness of university response during the pandemic
	5.2	University resilience during the pandemic
	5.3	Lasting impacts of innovative responses initiated by universities during the pandemic
Explore university strategic directions and strategic agility in the Immediate Recovery period	6	Trends and drivers shaping university strategic priorities
	7	Factors affecting the strategic agility of universities in response to the COVID landscape shock
	8.1	Strategic priorities for universities for the Immediate Recovery period
	8.2	Emerging strategic opportunities for university innovation-focused activities
	8.3	Resource gaps hindering the pursuit of emerging strategic opportunities
Key areas for government support for navigating the crisis and recovery	9.1	Effectiveness of government support schemes on university innovation activities during the pandemic
	9.2	Further policy support to enable universities to contribute fully to the economic recovery

1 KE clusters are available at https://www.ukri.org/publications/knowledge-exchange-framework-clustering-and-narrative-templates/ accessed on 24th February 2022.
2 The KE cluster descriptions and membership are provided in Appendix A to this report.

3.3 Sample

The survey was targeted at all 162 UK universities across all UK nations and regions and types of institution based on their membership of their 'KE cluster'. The KE clusters were developed to identify groups of English universities with broadly similar structural characteristics that are likely to affect how they engage with external partners to develop, exchange and deploy knowledge (Ulrichsen, 2018)[1,2]. These clusters now underpin the Knowledge Exchange Framework (KEF) for English universities. To support this study, we extended the clusters to incorporate Scottish, Welsh and Northern Irish universities.

The survey was distributed in early August 2021 and was open for approximately four months. The survey was distributed to university leaders and senior managers with strategic decision making authority in innovation, knowledge exchange, enterprise, business engagement or equivalent through a number of channels, including the membership network of NCUB as well as through the Pro-Vice-Chancellor networks of key university mission groups. Following the initial distribution, prompts were sent at regular intervals to increase participation. The contact names, positions and email addresses of those invited to participate were collected from the public websites of each university. Details of the distribution of the target sample across regions and types of institution, along with the achieved sample (responses and response rates) are provided in Table 6 and Table 7.

As with our previous survey, we received no responses from the specialist arts universities. Given that specialist arts universities are quite different from other universities in how they contribute to R&D and innovation in the UK, we decided to exclude these universities from both our target and achieved samples. This resulted in a target population of non-arts specialist universities of 140.

TABLE 6 **Target survey sample: Breakdown by UK region/nation**

REGION/NATION (AGGREGATE)	REGION/NATION	POPULATION		RESPONSES	RESPONSE RATE (%)
		ALL	EXC SPECIALIST ARTS INSTITUTIONS		
North	North East	5	5	3	60
	North West	15	13	6	46
	Yorkshire and the Humber	12	10	3	30
NORTH: SUB-TOTAL		**32**	**28**	**12**	**43**
Midlands & South West	East Midlands	9	9	2	22
	West Midlands	12	12	3	25
	South West	15	13	4	31
MIDLANDS & SOUTH WEST: SUB-TOTAL		**36**	**34**	**9**	**26**
Greater South East	East of England	10	9	3	33
	London	37	26	12	46
	South East	19	17	6	35
GREATER SOUTH EAST: SUB-TOTAL		**66**	**52**	**21**	**40**
Scotland, Wales & Northern Ireland	Scotland	18	16	5	31
	Wales	8	8	2	25
	Northern Ireland	2	2	2	100
SCOTLAND, WALES & NORTHERN IRELAND: SUB-TOTAL		**28**	**26**	**9**	**35**

TABLE 7 **Target survey sample: Breakdown by KE cluster**

	KE CLUSTER	NUMBER OF UNIVERSITIES	RESPONSES (NUMBER)	RESPONSE (RATE)
V	Very large, very high research-intensive universities with broad discipline portfolios including in clinical medicine, and large numbers of research postgraduates	22	13	59
X	Large, high research-intensive universities with broad discipline portfolios with limited activity in clinical medicine, and large proportion of taught postgraduates in student population	29	12	41
E	Large universities with broad discipline portfolios across both STEM and non- STEM, generating mid-level amounts of world-leading research, and large numbers of part-time undergraduates	35	9	26
J & M	Small and mid-sized universities with limited funded research activity, but academic activity across STEM and non- STEM	41	12	29
Specialise: STEM		13	5	39
Specialise: Arts		22	0	0
TOTAL		**162**	**51**	**31.5**
TOTAL (EXCLUDING ARTS SPECIALISTS)		**140**	**51**	**36.4**

The survey generated 51 responses in total, representing a 36.4% response rate of the 140 non-arts specialist universities in the UK.

The sample is, however, biased towards the research-active universities, with 59% of universities in KE cluster V responding, 41% of those in cluster X, 26% of those in cluster E, and 29% of universities in clusters J and M.

To help correct for the non-response biases resulting from differential response rates from different types of universities, a set of post-stratification weights were calculated and applied to the analysis[3].

We analysed the data arising from the survey for the sample as a whole, and then examined differences across the KE clusters described above. To test for the statistical significance of any differences we observed, we primarily used the non-parametric Kruskal-Wallis test. Wherever the Kruskal-Wallis test showed a statistically significant variation, we supplemented it with the Dunn test, which carries out pairwise tests of the several groups to identify which groups are statistically significant from each other.

3 The post-stratification weights were calculated using the statistical software Stata v16.1 as part of the survey estimation commands. The method followed by Stata is based on Levy and Lemeshow (2008) and is set out in detail in the Stata manual on post-stratification available at https://www.stata.com/manuals/svypoststratification.pdf. The method stratifies both the population and realised sample based on the type of university (proxied by their membership in a particular KE cluster) and compares the composition of the responses to that of the population.

4 Ongoing effects of the pandemic on university innovation-focused activities

The report now turns to present the findings from the survey. In this section we address the first aim of this study, namely the ongoing effects of the pandemic on the innovation-focused activities of universities during the period August 2020 – July 2021. This period saw a second wave of COVID infections and two further national lockdowns. Where possible we provide comparisons with evidence from our earlier report on the effects of the initial national lockdown on these activities.

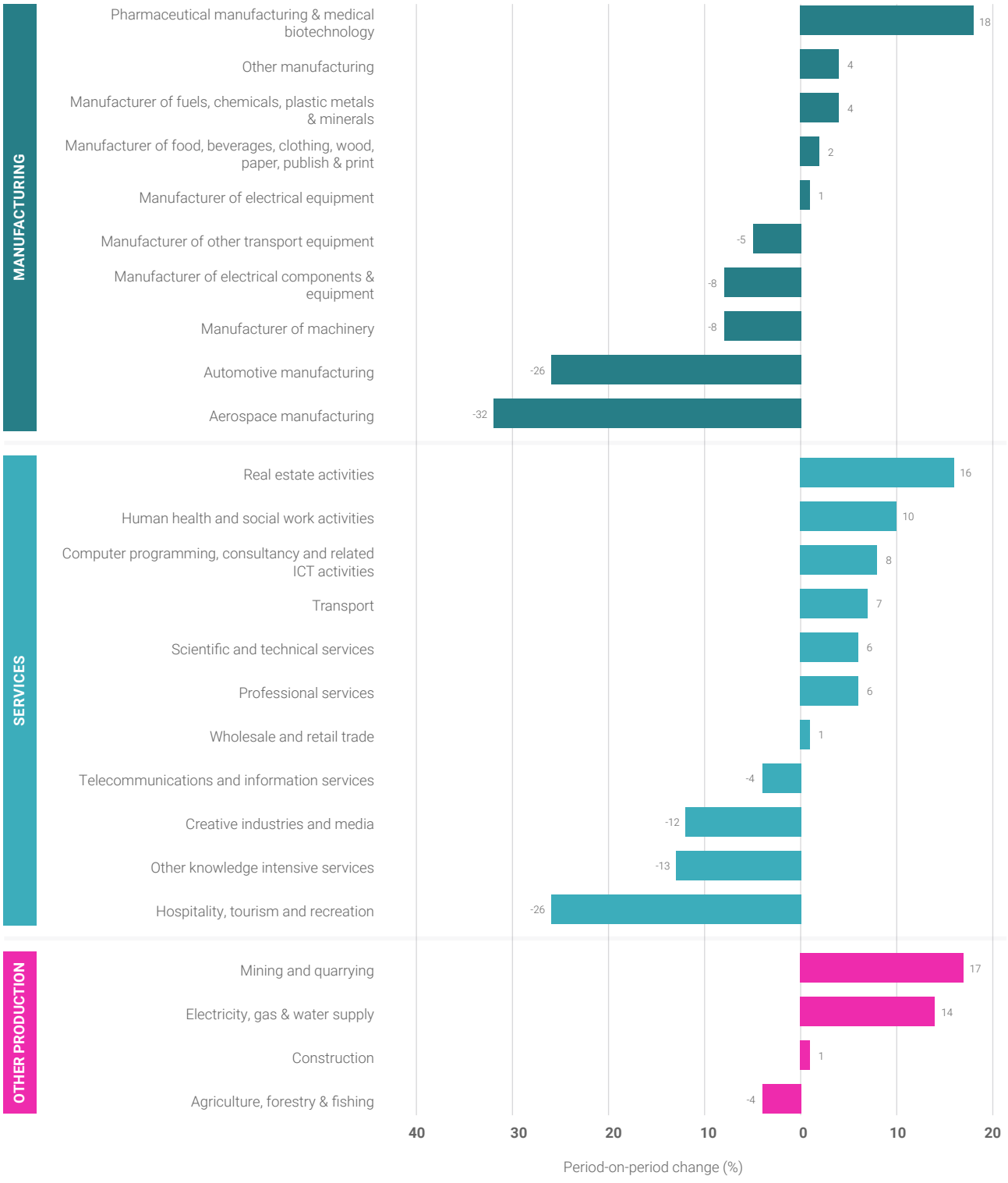
This section examines in detail how the ongoing crisis has affected universities' innovation-focused activities, in terms of:

- **The level of innovation-focused activities with different sectors (Section 4.1) and different types of partner (Section 4.2)**
- **The nature of changes made to innovation-focused activities (Section 4.3)**
- **The ability of universities to initiate and deliver innovation-focused activities (Section 4.4)**

4.1 Effects on levels of innovation-focused activities with different sectors

We know from wider industrial economic performance data that the pandemic shock has had varied effects across different sectors of the economy (Bloom et al., 2020). In our earlier report, we showed that outputs decreased across almost all sectors during the First Lockdown period (Ulrichsen, 2021, p.30). Swift and unprecedented policy responses over the Pandemic period have helped to reverse these decreases in some sectors, while they have continued within others (Figure 3).

FIGURE 3 **Percentage change in sector output between Quarter 2 2019 and Quarter 2 2021**



Sources: ONS Index of Production; ONS Index of Services, ONS Output in the Construction Industry

Given these varying pressures on sectors caused by the pandemic, our first area of interest is how levels of university partnerships, commercialisation and other KE activities with different sectors were affected during the Ongoing Crisis period (Figure 4). Respondents were asked to indicate the extent of change in activity levels with partners in their top three sectors for innovation-focused activities, on a scale ranging from collapsed (decrease of 51% or more) to significantly increased (>20% increase).

FIGURE 4 **Change in the level of innovation-focused activity with universities' top sectors during the Ongoing Crisis period**

† Mean change estimated by taking the following points in each category: Collapsed (-51%); significantly decreased (-35%); slightly decreased (-13%); about the same (0%); slightly increased (13%); significantly increased (21%).

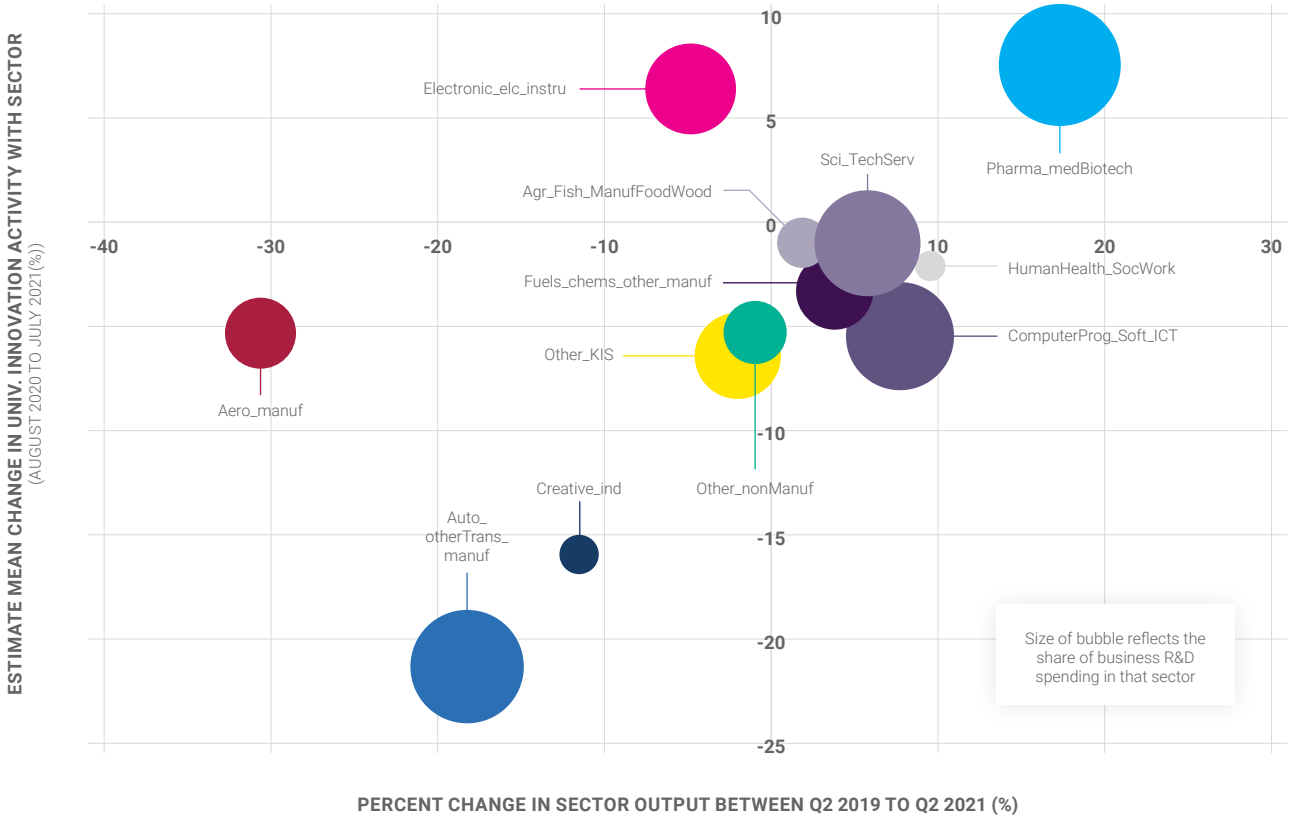
Using the mid-points from each category, we estimate that activity levels saw increases of 7% with partners in pharmaceutical manufacturing and medical biotechnology, and of 6% with partners in electronic and electrical manufacturing. Activities involving all other sectors saw decreases of typically 1-6%, but up to 20% for automotive, transport and machinery manufacturing partners and 15% for the creative industries and media partners.

These effects varied across universities, with substantial numbers reporting increased activities with sectors such as computer programming, consultancy, and related ICT activities; other knowledge intensive services; and human health and social work, despite overall decreases.

Having established that university innovation-focused activity levels varied across sectors, we next sought to understand the relationship between activity levels and sector output performance. In our earlier report, we showed that the pandemic-induced change in sector output had consistently fed through to innovation-focused activities between universities and partners in those sectors (Ulrichsen, 2021, p.32). Figure 5 repeats this analysis to look at whether the changes universities experienced to their innovation activities during the Ongoing Crisis period are correlated with the level of disruption experienced by the sector through the crisis.

Once again there is a fairly strong linear relationship between the scale of disruption the pandemic has caused to a sector and the change in levels of innovation-focused activities universities experienced with the sector during the Ongoing Crisis period (Figure 5). There were two exceptions to this, both of which suggest a degree of 'bounce back' in innovation-focused activity levels as partners within certain sectors invested in R&D during the crisis ('counter-cyclicality'). The 5% decrease in activity levels with aerospace manufacturing occurred despite of a 32% decrease in sectoral output, and is much smaller than the drop during the First Lockdown period. Similarly, activity levels with electronic & electrical components, equipments & instruments manufacturing saw a 5% increase despite a 6% decrease in sectoral outputs, reversing a 6% decrease in innovation activity levels during the First Lockdown period.

FIGURE 5 **Relationship between change in the sector output and the change in level of innovation activity between universities and partners in the sector**



Notes: (i) change in sector output for other knowledge intensive services (Other_KIS) excludes financial and insurance services. (ii) mean change estimated by taking the following points in each category Collapsed (-51%); significantly decreased (-35%); slightly decreased (-13%); about the same (0%); slightly increased (13%); significantly increased (21%).

Sources: ONS Index of Production; ONS Index of Services, ONS Output in the Construction Industry

Our survey also highlights the very different sectoral focus of universities. Table 8 shows the top sectors (in terms of the level of innovation-focused engagements) identified by universities in each KE cluster. We see that most universities in KE cluster V (very large, very highly research intensive HEIs with a broad discipline base often including a medical school) identified pharmaceutical manufacturing and medical biotechnology; and electronic and electrical manufacturing as key sectors. Similarly, key sectors for clusters X (large, high research-intensive universities with broad discipline portfolios) and cluster E (large universities with broad discipline portfolios across both STEM and non-STEM, generating mid-level amounts of world-leading research) included human health & social work; and computer programming, consultancy and related ICT. It is likely that the exposure of universities to different sectors of the economy will be driving at least some of the differences in the scale of disruption to their overall level of innovation-focused activities with partners during the Ongoing Crisis period.

TABLE 8 **Top sectors for universities' innovation-focused engagements during the Ongoing Crisis period, by KE cluster**

KE CLUSTER	KEY SECTORS	PROPORTION OF CLUSTER (%)	CHANGE IN SECTOR OUTPUT (%) †
Cluster V	Pharmaceutical manufacturing & medical biotechnology	92	+18
	Aerospace manufacturing	62	-32
	Manufacture of electronic and electrical components & equipments, instruments	46	-8
	Other knowledge-intensive services	38	-13
Cluster X	Human health and social work activities	50	+10
	Other knowledge-intensive services	33	-13
	Computer programming, consultancy and related ICT activities	25	+8
	Pharmaceutical manufacturing & medical biotechnology	25	+18
Cluster E	Human health and social work activities	67	+10
	Other knowledge-intensive services	44	-13
	Computer programming, consultancy and related ICT activities	33	+8
	Creative industries and media	33	-12
Cluster JM	Human health and social work activities	67	+10
	Other knowledge-intensive services	58	-13
	Creative industries and media	42	-12
	Scientific and technical services	25	+6

† Change in sector output between Quarter 2 2019 and Quarter 2 2021

4.2 Effects on levels of innovation-focused activities with different types of partner

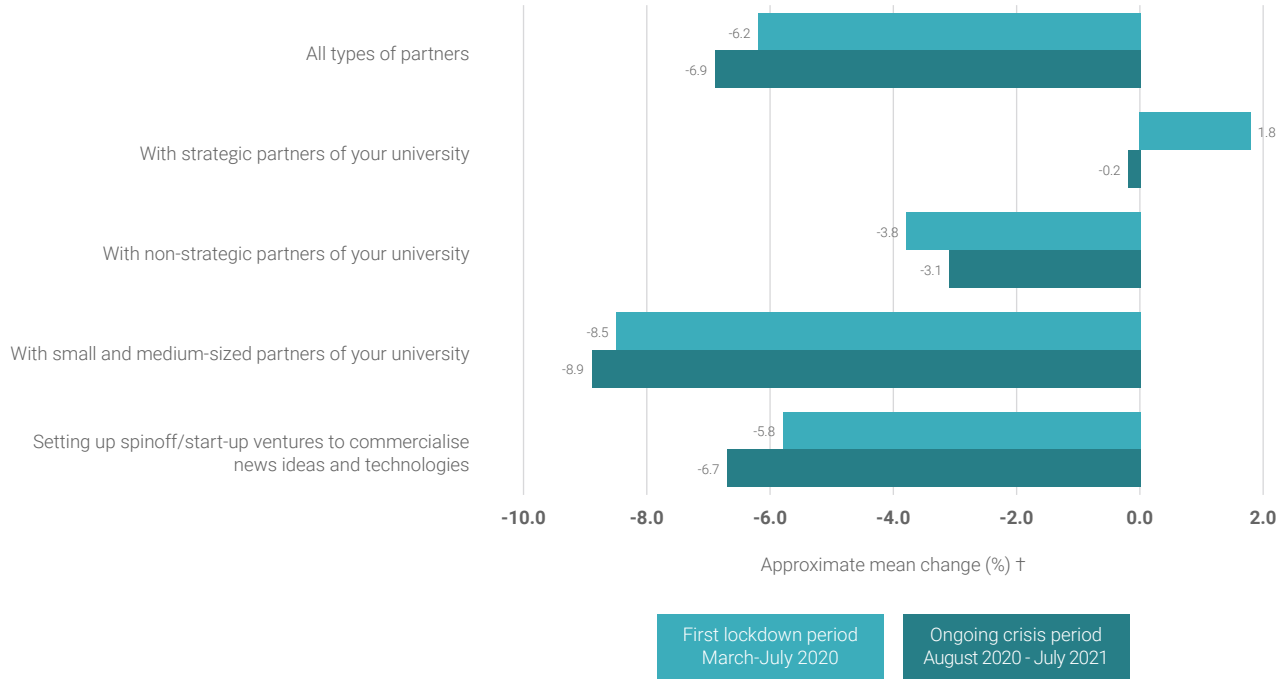
We next explored how the pandemic has affected levels of university innovation-focused activities with different types of partners during the Ongoing Crisis period (Figure 6). Respondents were asked to indicate the extent of change in activity levels, on a scale ranging from collapsed (greater than 51% decrease) to significantly increased (>20% increase).

FIGURE 6 **Change in the level of innovation-focused activity with different types of external partner during the Ongoing Crisis period**

† Mean change estimated by taking the following points in each category: Collapsed (-51%); significantly decreased (-35%); slightly decreased (-13%); about the same (0%); slightly increased (13%); significantly increased (21%).

Using the mid-points from each category, we estimate that innovation-focused activities between universities and all external partners fell by around 7% during this period. This is on top of a 6% drop during the First Lockdown period (Figure 7). This is consistent with expected and prolonged decreases in R&D investment by partners during the crisis – known as 'procyclicality' (see Section 2.2).

FIGURE 7 **Comparing the approximate mean change (%) in the level of innovation-focused activities with different types of external partner during the First Lockdown and Ongoing crisis**



Note: Data for First Lockdown period taken from our earlier report (Ulrichsen, 2021, p.28).
† Mean change estimated by taking the following points in each category: Collapsed (-51%); significantly decreased (-35%); slightly decreased (-13%); about the same (0%); slightly increased (13%); significantly increased (21%).

The overall decrease in activity with private sector partners varied across types of partner. Activities with small and medium enterprises (SMEs) saw a decrease of 8.9%; those to set up spinouts/start-up ventures decreased by 6.7%; and activities with large, non-strategic partners dropped by 3.1%. Activities with strategic partners remained largely unchanged, with just a 0.2% decrease.

Pandemic effects on activities with public and third sector partners was more varied. Activities with charitable organisations saw the largest decrease of 10.2%, which is expected as charitable income was been badly hit during the pandemic (Thomas and Nanda, 2021). Activities with central government departments & agencies dropped by 1.7%, while those with public sector research establishments (PSREs), independent research institutes, and technology development & innovation organisations saw a decrease of 2%.

By contrast, activity levels with health authorities, hospitals and other publicly funded healthcare organisations increased by 3.2%, while activities with local/regional government agencies or economic development bodies increased by 1.8%. This reinforced universities' civic role as they pivoted their efforts to address COVID-related health and local socioeconomic needs during the Ongoing Crisis period.

These system-level changes hide important asymmetries in the experiences of different universities; while some universities are being hugely disrupted by the pandemic, others are proving more resilient. Our findings show that while 47% of universities reported their innovation-focused activities with all partners had decreased during the Ongoing Crisis period, 26% of universities reported increases. This pattern of asymmetry is repeated across all forms of private sector partners: SMEs (51% decrease versus 27% increase); setting up spinout/start-up ventures (51% decrease versus 31% increase); and large strategic partners (28% decrease versus 30% increase). Similarly with public and third sector partners: PSREs and other research organisations (26% decrease versus 32% increase); central government departments and agencies (29% decrease versus 28% increase); local and regional government agencies and economic development boards (29% decrease versus 50% increase); and health authorities, hospitals and other publicly funded healthcare organisations (24% decrease versus 55% increase).

In the case of private sector organisations, these findings suggest that some partners are continuing to invest in their innovation-focused links with universities during the crisis, suggesting some degree of 'counter-cyclicality' at play (see Section 2.2). While this was expected in the case of large organisations with sufficient financial resources to weather the crisis, it was more surprising in the case of SMEs, which typically tend to reduce investments in R&D and innovation until the crisis has passed (Archibugi, Filippetti and Frenz, 2013a, 2013b).

Comparing the mean change in activity levels with private sector partners with those reported in our earlier study (Ulrichsen, 2021, p.45), we find that levels have continued to decline with all partner types over the First Lockdown period (Figure 7). Interestingly, the relatively insignificant decrease in activities with strategic partners (0.2%) suggests that the 1.8% increase seen during the First Lockdown period has been largely sustained over the Ongoing Crisis period.

The breakdown of the mean percentage change in activity by KE cluster, shown in Table 9, reveals that the decrease in activities in the smaller and less research-intensive universities of KE cluster JM was more significant across almost all partner types than changes in other KE clusters. This finding is supported by pairwise testing (see Technical Annex[4], Table B.1). This suggests a disproportionate exclusion of cluster JM universities from innovation-focused activities during the Ongoing Crisis period. Such an exclusion is consistent with a characteristic feature of innovation during a crisis, whereby the need to deliver results quickly favours institutions with large staffs and specialist resources over other cost or distributional concerns (Gross and Sampat, 2021).

TABLE 9 **Mean change in the level of innovation-focused activities with different types of partners during the Ongoing Crisis period, by KE cluster**

PARTNER TYPE	CLUSTER					N	VARIATION ACROSS CLUSTERS ‡
	KE_V	KE_X	KE_E	KE_JM	KE_STEM		
All partners	0	-7	-2	-15	-3	42	
With strategic partners of your university	3	2	3	-8	5	46	*
With non-strategic large partners of your university	4	-3	-2	-10	3	46	**
With small and medium-sized partners of your university	-9	-8	0	-20	2	44	†
Setting up spinoff/start-up ventures to commercialise new ideas and technologies	8	-2	1	-24	-7	37	**
Public sector research establishments, independent research institutes, and technology development & innovation organisations	1	0	2	-13	11	39	*
Central government departments & agencies	-2	0	0	-9	12	40	*
Local/regional government agencies or economic development bodies	1	6	5	-6	9	45	
Health authorities, hospitals and other publicly funded healthcare organisations	4	10	6	-7	11	45	
Charitable organisations	-17	1	-11	-18	3	41	†

*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%; † 15%.*

4 The Technical Annex is published as a separate document alongside this report.

4.3 Nature of changes made to innovation-focused activities

Our earlier study revealed that universities experienced significant disruptions to their innovation-focused activities during the First Lockdown period (Ulrichsen, 2021, p.33). All universities surveyed reported project deadline/milestone extensions; 88% experienced delayed project start dates; 56% saw partners renegotiating contract terms; 48% reduced project scale; 44% saw projects being refocused on short-term partner needs and 36% reported project cancellations.

In order to explore whether this situation had stabilised during the Ongoing Crisis period, we again explored the nature of changes being made to university innovation-focused activities with external partners. Respondents were asked to identify changes that affected a significant proportion (at least 10%) of their engagements (Figure 8).

This revealed a similar picture to that of the First Lockdown period. The proportion of universities experiencing project deadline/milestone extensions and delayed start dates remained high at 83 and 81% respectively. Project scale reductions, project cancellations, and projects being refocused on short-term partner needs were reported by 38-42% of universities, again broadly similar to our earlier findings. The proportion of universities experiencing renegotiation of contract terms was substantially lower than before, at 24%. Finally, just 9% of respondents reported partners seeking to rationalise of the number of university partners they work with.

FIGURE 8 **Scale of changes being made to innovation-focused activities and projects with external partners during the Ongoing Crisis period**

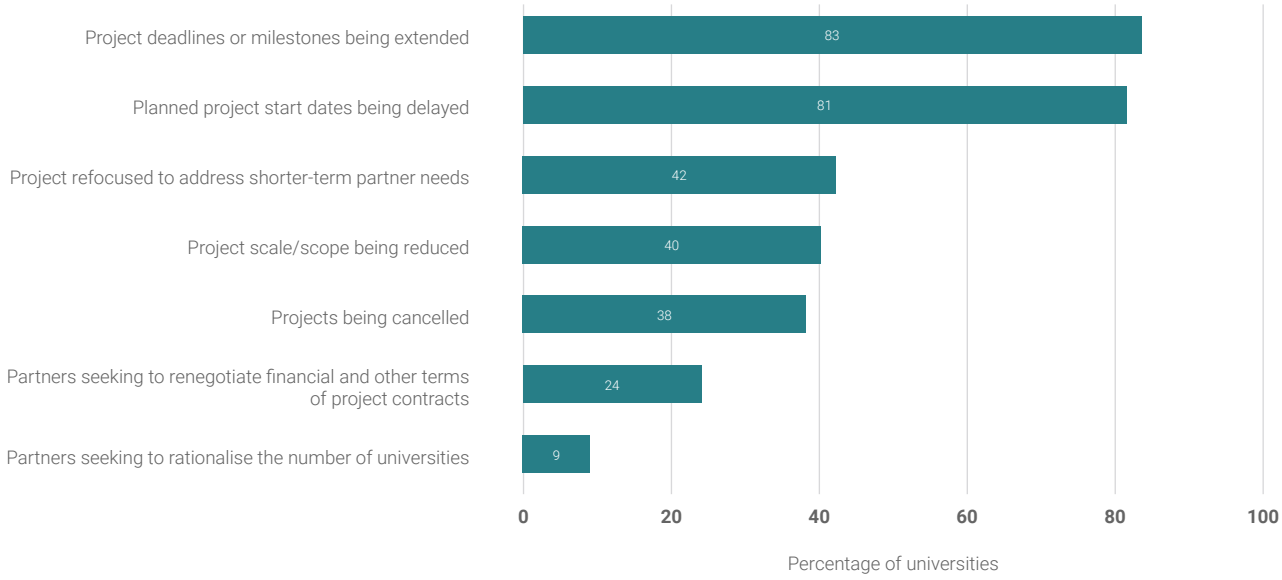
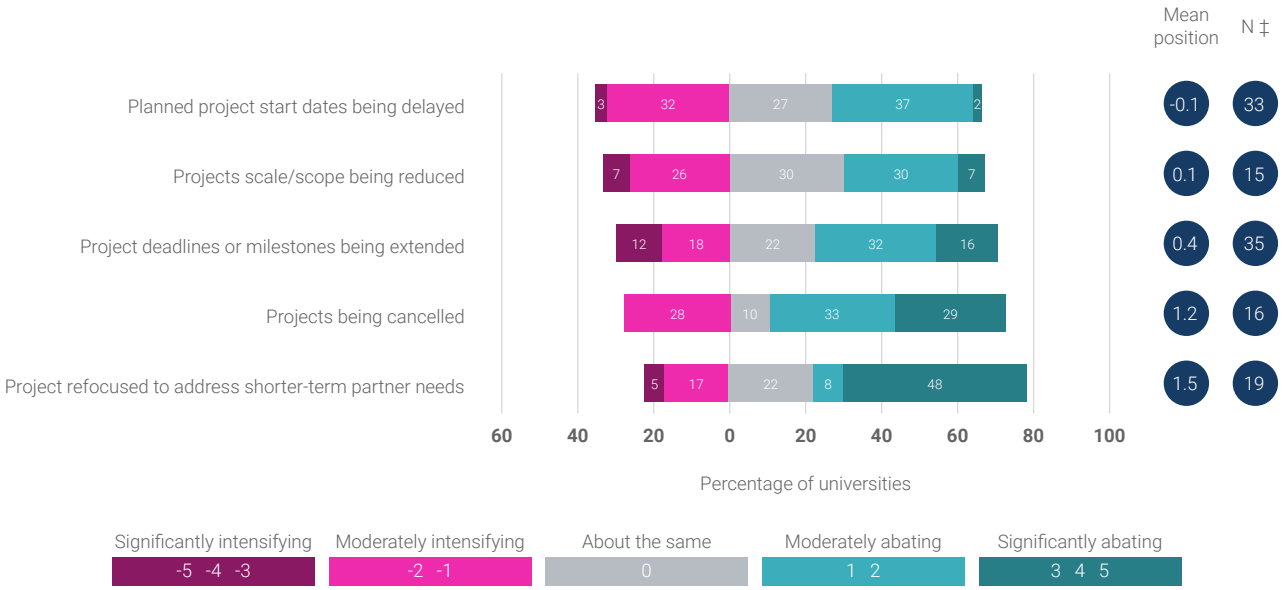


FIGURE 9 **Intensification in the nature of changes being made to innovation-focused activities and projects with external partners in the summer of 2021**



Note: The items 'partners seeking to rationalise the number of universities they work with', and 'partners seeking to renegotiate financial and other terms of project contracts' are not represented due to small sample sizes.
‡ N is the number of responses.

In order to gain a deeper understanding of the direction of travel of these types of disruptions to projects, we asked respondents to indicate whether, as of summer 2021 (the time of the survey), each type of change was either abating or intensifying (Figure 9). It shows that the scale of 'projects being refocused on short-term partner needs', 'project cancellations', and (to a lesser extent) 'project deadlines/milestones being extended' were moderately abating at this time. By contrast, the number of partners looking to reduce the scale/scope of projects or delay start dates has stayed broadly the same.

Once again, these average positions hide significant asymmetric effects across different universities. For example, significant proportions of universities reported intensification of projects being refocused on short-term partner needs and project cancellations despite an overall abatement (22 and 28% respectively). Similarly, while 48% of universities saw an abatement in project deadline/milestone extensions, 30% saw intensification. This was repeated for project scale/scope reductions (37% abatement; 33% intensification) and delayed project start dates (39% abatement; 35% intensification).

On breaking down these findings by KE cluster, we find no significant statistical variation across clusters (see Technical Annex, Table B.2).

Overall, these findings show that universities continued to experience significant disruptions to their innovation-focused activities during the Ongoing Crisis period, in particular project deadline/milestone extensions and delayed start dates. However, as of summer 2021 the moderate abatements in project cancellations and projects being refocused to short-term partner needs are encouraging in that they signal that partners are seeking both to maintain activity with universities, and to shift the focus of these activities away from immediate pandemic-related needs and towards more long-term objectives. This suggests a reduction in partners' precautionary behaviour and a greater willingness to strategically invest in R&D (Stiglitz and Guzman, 2021).

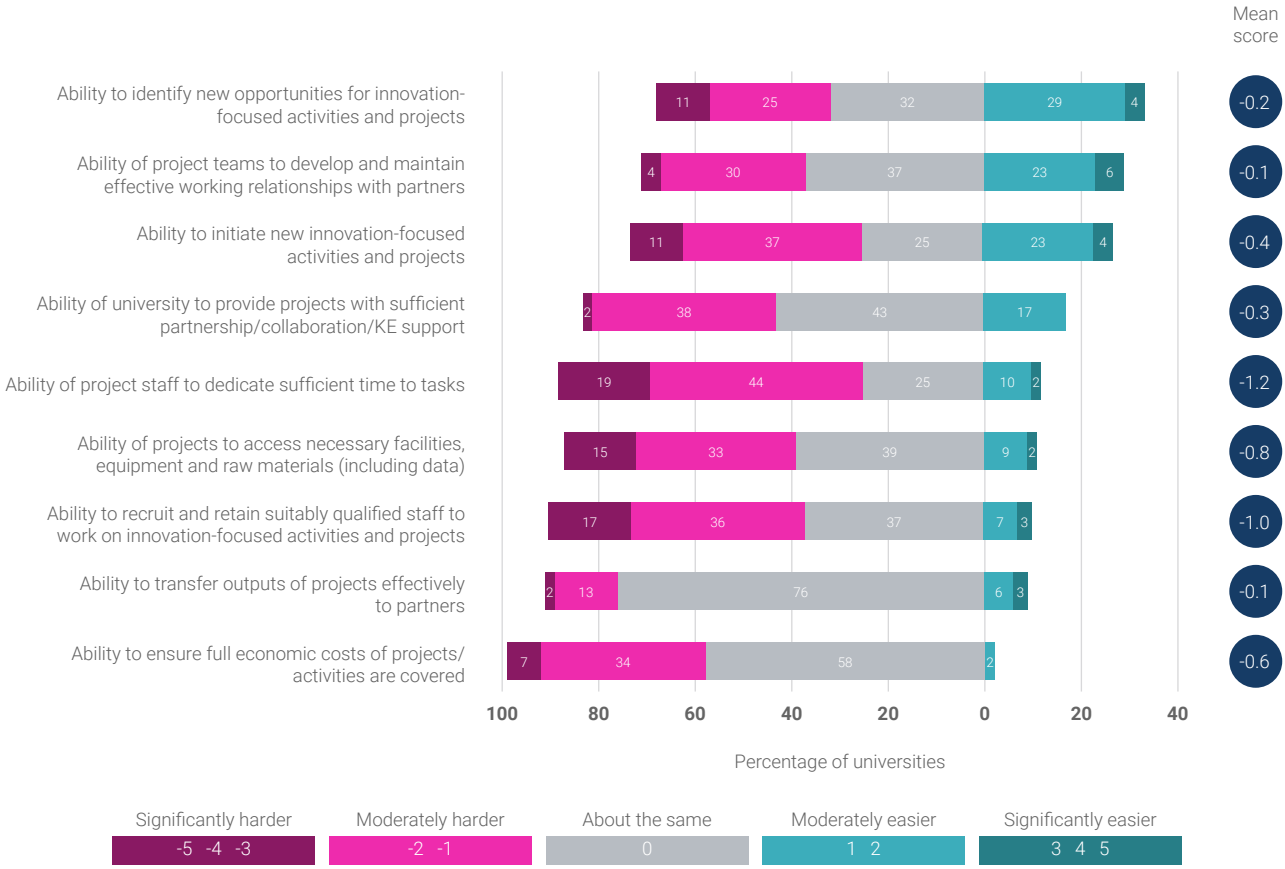
4.4 Ease of initiating and delivering university innovation-focused activities

Section 2.2 outlined how universities played critical roles in the pandemic response, even as their ability to continue to provide their core 'services' – including initiating and progressing existing innovation-focused projects and activities for external partners – was dramatically impacted by national lockdowns and other public health measures.

The survey explored the extent to which the Ongoing Crisis period continued to affect the ability of universities to ensure a range of key resources and support were available to initiate and deliver innovation-focused projects and activities with external partners.

The results show that, for most universities across the UK, their ability to ensure key resources and support were available to initiate and deliver innovation-focused activities continued to be negatively affected by the disruptions during the Ongoing Crisis period (Figure 10). Across all types of resources and support studied, most universities saw either no change in availability, or found it harder to ensure that they were available to initiate and deliver innovation-focused projects and activities with partners. In particular, many universities found their ability to dedicate sufficient staff time to projects; recruit and retain project staff; access facilities, equipment and data; and cover project economic costs continued to get harder during this period.

FIGURE 10 **Ability of universities to ensure necessary resources and support are available to initiate and deliver innovation-focused projects and activities for external partners during the Ongoing Crisis period**



Again, there are exceptions to this overall picture. Some universities indeed found it easier to ensure different resources and support were available for innovation-related activities, in particular, around developing and maintaining effective working relationships with partners (29%); identifying new opportunities (33%); and initiating new projects (27%).

The breakdown of findings by KE cluster group shows that the more research-intensive cluster V and X universities found it more difficult than both the less research-intensive cluster E and JM universities, as well as the STEM universities to recruit and retain staff to work on projects (see Technical Annex, Table B.3). This finding is supported by pairwise testing (see Technical Annex, Table B.4).

Summary of key findings

We estimate that universities saw a 7% decrease in levels of innovation-focused activities overall over the Ongoing Crisis period. This is on top of a 6% drop during the First Lockdown period. This suggests expected and prolonged decreases in R&D investment by partners during the crisis – known as 'procyclicality'.

Effects on levels of innovation-focused activities with different sectors – The Ongoing Crisis period (August 2020 – July 2021) saw some sectors continuing to bear the brunt of the pandemic in terms of ongoing decreases in sectoral output, while others enjoyed a bounce back in outputs from the disruption of the First Lockdown period (March-July 2020). These asymmetric effects continued to feed through into changes in levels of innovation-focused activities universities have with these sectors. Crucially, these effects varied across universities, with some seeing increased activities in sectors where the overall level of activity had decreased, and vice versa. It is likely that the exposure to different sectors of the economy is driving at least some of the differences in the scale of the overall disruptions universities are facing to their innovation activities.

Effects on levels of innovation-focused activities with different types of partner – The ongoing pandemic's effects on the innovation activities of universities with different types of partner varied significantly. While activity levels with most private sector partner types continued to decline during this period, with the most significant decreases being associated with small and medium enterprises, activities with strategic partners were much more resilient with activity levels largely stable. The effects also varied significantly across universities, with over a quarter reporting increases in activities with all private sector partner types. This suggests that some partners – even SMEs – are finding ways to continue to invest in R&D and innovation partnerships through the crisis – known as 'counter-cyclicality'.

Work with many types of public and third sector partners saw overall decreases as the pandemic continued through 2020-21. Worst affected were activities with charitable organisations. However, activities with health authorities, hospitals and other publicly funded healthcare organisations; and with local/regional government agencies or economic development bodies actually increased by 2-3% overall, with some universities seeing quite significant increases.

At the university level, our findings suggest a disproportionate exclusion of small and mid-sized universities with limited funded research activity from innovation-focused activities during the Ongoing Crisis period. This is consistent with a characteristic feature of innovation during a crisis, whereby the need to deliver results quickly favours institutions with large staffs and specialist resources over other cost or distributional concerns.

Nature of changes made to innovation-focused activities – As with the First Lockdown period, universities continued to experience significant disruptions to their innovation-focused activities over the Ongoing Crisis period. The most common disruptions were project deadline/milestone extensions; delayed project start dates; and partners renegotiating contract terms.

However, the intensity of disruptions has changed. In particular, the number of projects being refocused on short-term partner needs; project cancellations; and (to a lesser extent) partners seeking project deadline/milestone extensions have all abated. This suggests a reduction in partners' precautionary behaviour – i.e. where people behave in ways so as to enable them to respond to unknowable contingencies – and a greater willingness to strategically invest in R&D.

Ease of initiating and delivering innovation-focused activities – Many universities continued to find it hard to ensure the availability of key resources and support to initiate and deliver innovation-focused activities during the Ongoing Crisis period. Particularly challenging were ensuring staff were able to dedicated sufficient time to projects; recruiting and retaining project staff; accessing facilities, equipment and data; and covering the full economic costs of projects.

Large, research-intensive universities found it more difficult than other university types to recruit and retain staff to work on innovation-focused projects.

5 University resilience during the pandemic

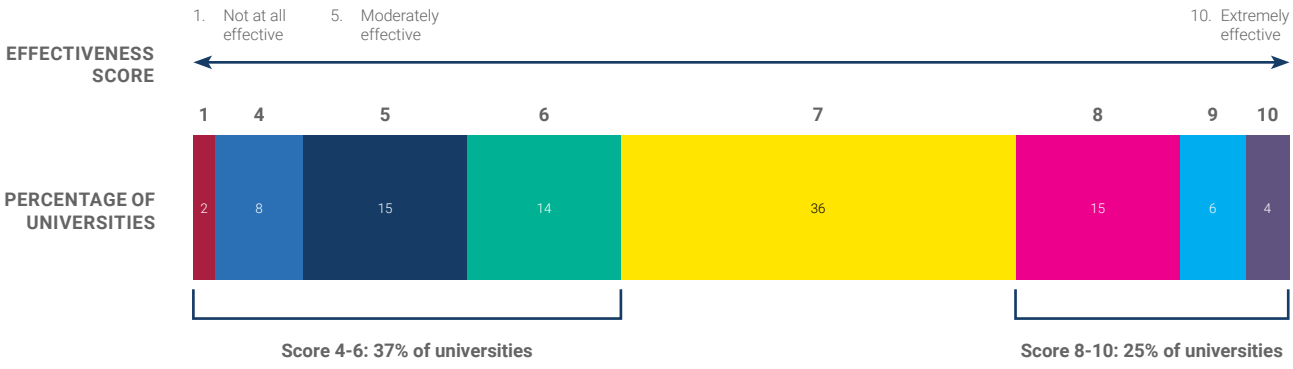
The unprecedented science and innovation response to the crisis in the UK was driven in large part by universities. An important factor which influenced their contribution was their ability to adapt and reconfigure resources and assets to overcome the unprecedented disruptions they were facing while finding ways of contributing to the fight against COVID-19 and pursuing other innovation opportunities. We also know from our previous report (Ulrichsen, 2021) that the sheer scale of disruption caused by the first lockdown induced many universities to innovate in how they operated and delivered their innovation-focused activities. These innovations were believed at the time to offer the potential for lasting and positive impacts.

In this section, we explore how university leaders and managers perceived the effectiveness of their institution's response to the crisis (Section 5.1). We then look at the level of organisational resilience universities exhibited during the pandemic – i.e. how they attempted to anticipate, prepare for, respond and adapt to change and sudden disruptions to survive and prosper (Section 5.2). We finish the section examining the extent to which the organisational innovations introduced early in the pandemic have indeed led to lasting and positive impacts on the university and its ability to contribute to innovation (Section 5.3).

5.1 Effectiveness of university response during the pandemic

Before considering the organisational resilience of universities, the survey first explored how respondents perceived the effectiveness of their university's response to the pandemic in terms of overcoming major challenges and pursuing new innovation opportunities, while attempting to ensure staff welfare. It asked respondents to rate their organisation's effectiveness on a scale from 1 (not at all effective) to 10 (highly effective). Figure 11 shows that 25% of respondents believed their university's response to the pandemic had been highly effective (score of 8+). A further 36% rated it a score of 7 on the scale, while 37% rated it a score of 4-6 (moderately effective). We found no significant statistical variation across the KE clusters of universities (see Technical Annex, Table B.5).

FIGURE 11 **Perceptions of the effectiveness of university responses to the crisis during the Pandemic period**



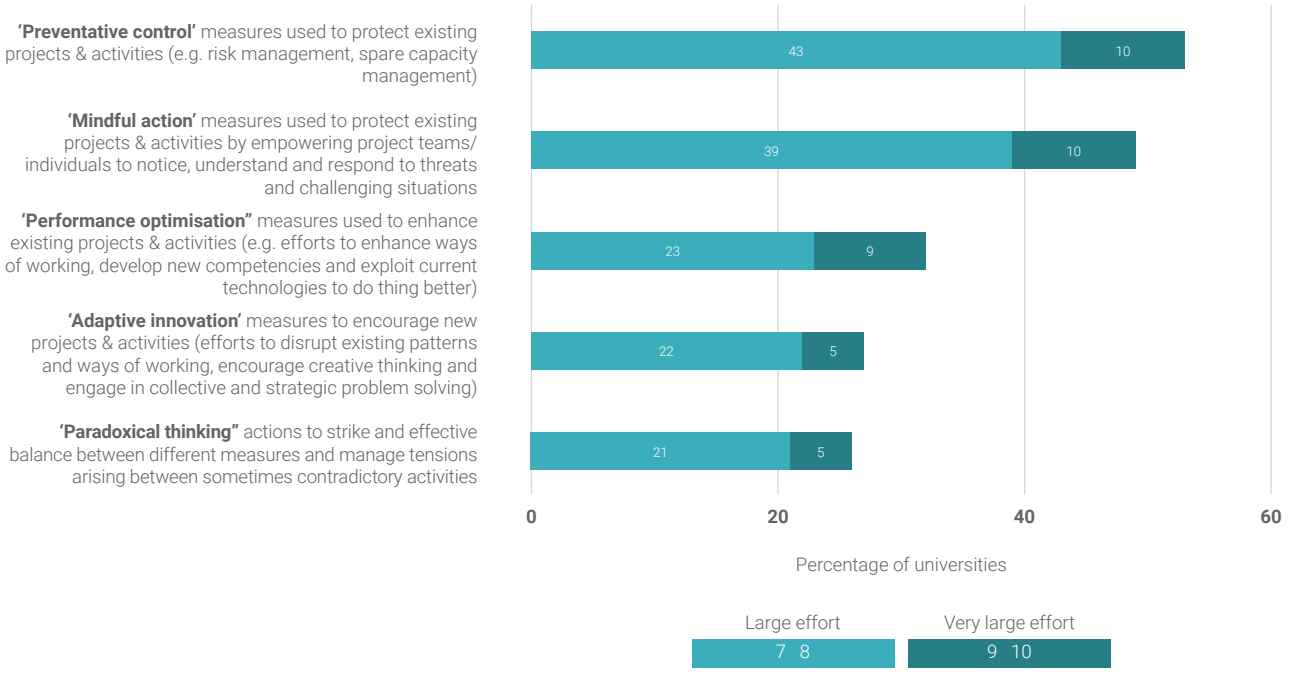
Note: no universities returned a score of 2 or 3 on the scale.

5.2 University resilience during the pandemic

In order to understand how universities responded to the pandemic, the survey investigated the degree of effort applied within universities to five key dimensions of resilience. These dimensions represent increasingly mature perspectives of what constitutes resilience and the activities necessary to achieve it (Section 2.4), namely:

- Preventative control: Resilience is achieved by means of risk management, physical barriers, redundant/spare capacity, systems back-ups and standardised procedures, which protect the organisation from threats and allow it to 'bounce back' from disruptions to restore a stable state
- Mindful action: Resilience is produced by empowered staff, who notice and react to threats and respond effectively to unfamiliar or challenging situations
- Performance optimisation: Resilience is formed by continually improving, refining and extending existing competencies, enhancing ways of working and exploiting current technologies to serve present customers, stakeholders or markets
- Adaptive innovation: Resilience is built through creating, inventing and exploring unknown markets and new technologies
- Paradoxical thinking: Resilience is achieved by balancing and managing the inherent tensions between preventative control, mindful action, performance optimisation and adaptive innovation.

FIGURE 12 **Level of effort invested by universities in measures to enhance organisational resilience during the Pandemic period (percentage of universities scoring 7-8 and 9-10 on the scale: 0 (no effort) to 10 (very high effort)**



The findings in Figure 12 indicate that universities' approaches to building resilience relied more on defensive measures (preventative control, mindful action) to 'bounce back' from disruptions rather than progressive measures (performance optimisation, adaptive innovation) to 'bounce forward' towards future growth. We found no significant statistical variation across the KE clusters of universities (see Technical Annex, Table B.6), suggesting that universities from all clusters applied effort within all resilience dimensions.

The comparatively low effort applied to progressive measures, and to managing inherent tensions between defensive and progressive measures reflects a potential need for capacity building in resilience, and in particular paradoxical leadership – where leaders can simultaneously attend to contradictory demands – as preparation for future crises (Lewis, Andriopoulos and Smith, 2014).

5.3 Lasting impacts of innovative responses initiated by universities during the pandemic

Both performance optimisation (enhancing existing ways of working) and adaptive innovation (disruption of existing patterns with new ways of working) are important for building resilience and enabling organisations to adapt to disruptive change. Furthermore, their importance is increasing for the recovery, with many governments, along with university and industry leaders, stressing the need to learn from the success of COVID-related innovations to improve how organisations work together to deliver an innovation step-change (OECD, 2021, p.19; Ulrichsen, 2022).

Our earlier report capturing the initial effects of the pandemic on universities revealed that the pandemic had forced many universities to introduce new and improved practices for supporting innovation-focused activities with partners (Ulrichsen, 2021, p.39), many of which had the potential for lasting and positive impacts on the ability of universities to work with partners to drive innovation. These included:

- Increasing accessibility to partners through digital technologies and reconfiguring of KE portfolios
- Stronger coordination with partners and more coherent internal academic support services through virtual collaboration tools
- Closer working relationships and goal alignment with partners and with regional assets
- New ways of translating intellectual property into practice
- Rapid starts to collaborations through digital technologies
- More rapid and flexible negotiations with partners
- Development of new or enhanced KE opportunities with new or existing partners
- New opportunities with geographically distant partners facilitated by on-line working
- New or improved ways of assembling resources and capabilities to deliver opportunities

Here, the survey explored whether these new or improved practices have been sustained over the Pandemic period and had indeed led to lasting positive impacts on the university.

Our findings (Figure 13) show that most universities engaged in various forms of performance optimisation and adaptive innovation. This included new/improved ways of assembling resources and capabilities to deliver opportunities (76%); developing new/enhanced opportunities with new partners (77%) and with existing partners (82%); developing new ways of working (86%) and improving existing ways of working (92%).

FIGURE 13 **Proportion of universities initiating innovative changes to support the delivery of their innovation-focused activities during the pandemic**

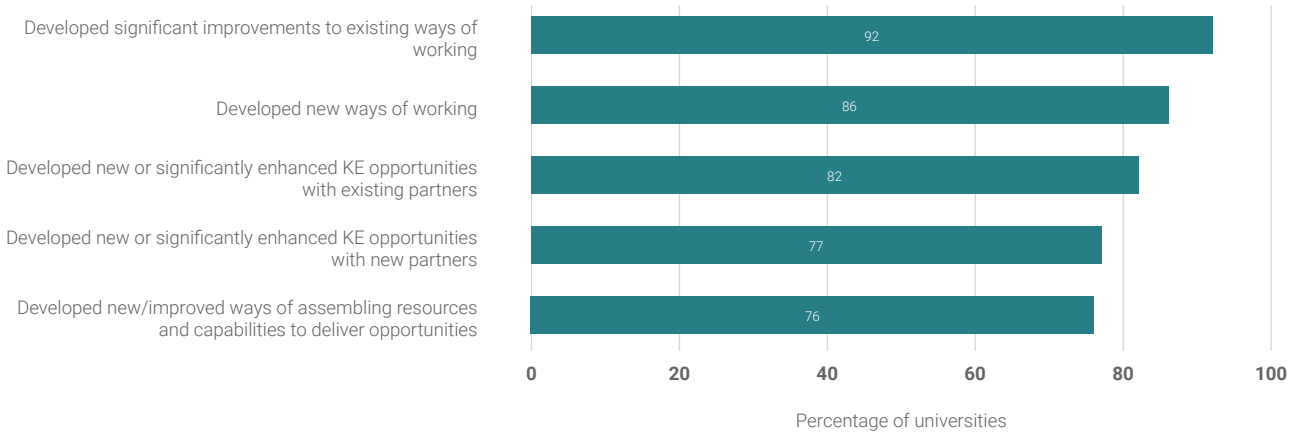
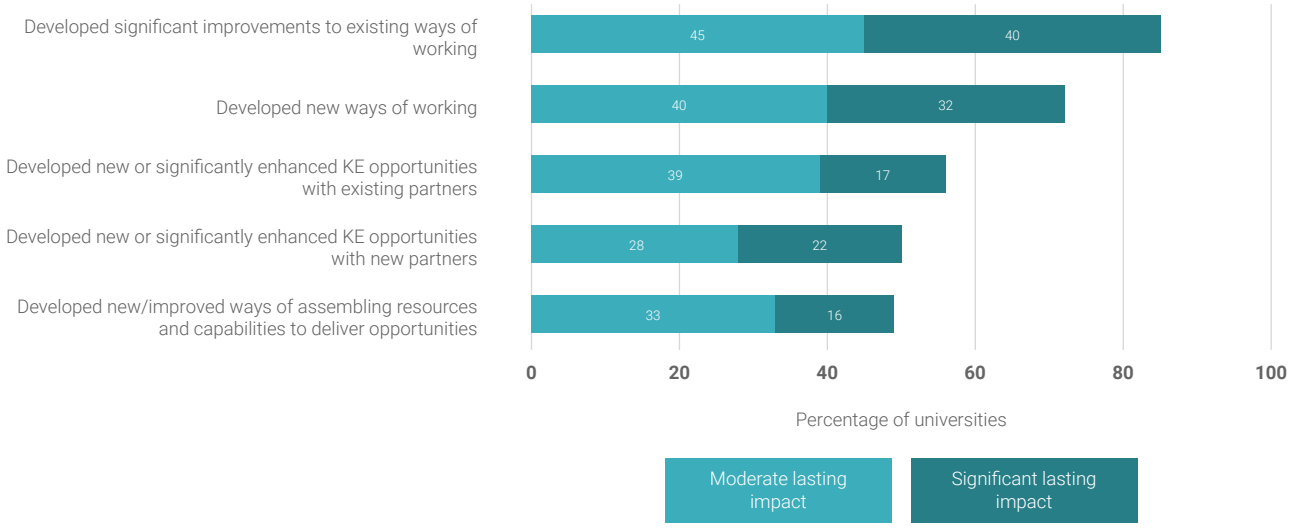


FIGURE 14 **Positive lasting impacts of innovative responses initiated by universities during the Pandemic period**



For those universities that introduced new or significantly improved ways of working to deliver innovation-focused activities, the effects appear to be positive and lasting (Figure 14). Where universities developed new or significantly enhanced KE opportunities with existing or new partners, these opportunities appear to be less 'sticky'. This could be due to resource constraints and disruptions to R&D and innovation in existing and potential partners, making this type of activity hard to fund and sustain during the crisis.

We found no significant statistical variation across KE clusters (see Technical Annex, Table B.7); universities from all KE clusters introduced new ways of working and sought to develop new opportunities in KE. Across all clusters, some universities have been successful in embedding these organisational innovations and emerging opportunities to create lasting impacts on their institutions, while others have had less been less successful.

Summary of key findings

Effectiveness of university response during the pandemic – A majority of respondents rated their university's response to the pandemic, in terms of overcoming major challenges and pursuing new innovation opportunities while attempting to ensure staff welfare, as either highly or moderately effective.

University resilience during the pandemic – Universities' approaches to building resilience – i.e. how they attempted to anticipate, prepare for, respond and adapt to change and sudden disruptions to survive and prosper – relied more on defensive measures to 'bounce back' from disruptions rather than progressive measures to 'bounce forward' towards future growth. As we look to preparing for future crises, it will be important to explore how to develop more progressive and proactive measures to drive resilience. This includes 'paradoxical leadership' where leaders are able to simultaneously attend to competing priorities that can appear in tension with each other.

Lasting impacts of innovative responses initiated by universities during the pandemic – The initial phase of the pandemic and the first national lockdown forced many universities to innovate in how they delivered their innovation activities with partners. In this study we show that most universities introduced new or significantly improved ways of working, and sought new opportunities with existing partners. Just over three quarters sought to develop new opportunities for engagement with new partners.

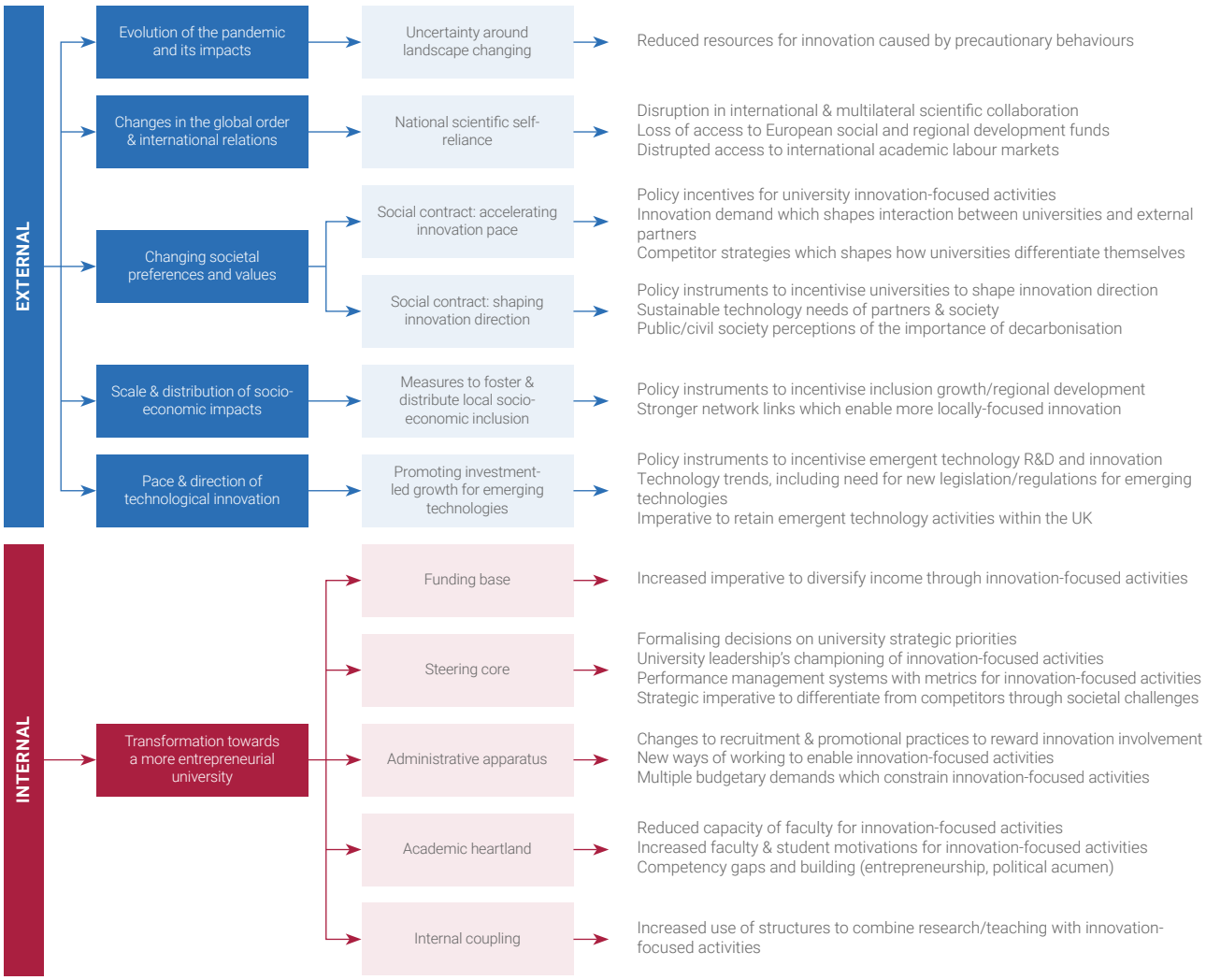
Of those that made changes, most universities believed the changes to ways of working had at least a moderately positive lasting impact on the university. By contrast, fewer universities reported that their efforts to build new opportunities with either existing or new partners had lasting positive impacts.

6 Trends and drivers shaping the strategic priorities of universities for innovation

While COVID-19 has acted as a hugely disruptive landscape shock, dominating discussions of how different types of organisations are being affected and are having to adapt to survive and thrive, it is not the only change which is buffeting them. There are a number of other long-term trends which appear to be reaching critical thresholds that are likely to force socio-political responses, such as climate change, rising inequality, and the digital revolution. Furthermore, internal conditions and priorities of organisations are changing. This section examines the range of major external and internal trends and drivers influencing the strategic priorities of universities in the summer of 2021.

Through the survey we asked respondents through an open question to tell us about what they saw as driving forces shaping their university's strategic priorities for contributing to innovation and delivering socio-economic impacts. These were coded to identify overarching drivers and trends, the contexts in which they are influential, and the mechanisms through which they are shaping university strategy[5]. Findings are presented in Figure 15.

FIGURE 15 **Drivers & trends shaping university strategic priorities**



5 *We used a grounded-based approach (Charmaz, 2006, p.24) to capture these views, informed by prior work on external (OECD, 2021, pp.35–43) and internal trends (Clark, 2004; Sánchez-Barrioluengo and Benneworth, 2019) influencing change in universities.*

6.1 External drivers & trends

Uncertain evolution of the COVID-19 pandemic and its impacts

A high level of uncertainty remains concerning the future evolution of the pandemic and its economic aftermath (OECD, 2021, p.35). Such uncertainty leads to precautionary behaviour – i.e. where people behave in ways so as to enable them to respond to unknowable contingencies, e.g. by delaying R&D spending to conserve financial resources (Section 2.2). Survey respondents described how uncertainties concerning the pandemic shaped strategic priorities by reducing the resources available for innovation-focused activities, such as cross-subsidies from student recruitment income and numbers of start-up venture partners:

> *"The main drivers are lack of clarity as to what kinds of workforces we have… going forward. For example, our accelerator occupancy fell by 30% overnight in March 2020. Will all these start-ups come back? Recovery indicators are that many, but not all, will return to the old normal." (Cluster J university)*

> *"Loss of income from student recruitment has limited all non-essential, non-core business initiatives." (Specialist STEM university)*

Changes in international relations and the global order

The years prior to the pandemic saw growing shifts in the global order, characterised by dissatisfaction with globalisation and multilateralism, which drove a rise in populism and ethno-nationalism generally. These shifts contributed to the withdrawal of the UK from the European Union (Foa et al., 2020), increased strategic competition between nations (OECD, 2021, p.42), and decreased public trust in science (Rohe, 2017). Despite emerging evidence suggesting that the pandemic has helped to reverse the rise of populism and boosted the legitimacy and authority of the scientific community (Foa et al., 2022), many countries have emphasised national scientific self-reliance as a policy aim for the pandemic recovery.

Respondents described how this change in the global order drove changes in university strategic priorities via three mechanisms: it disrupted international and multilateral scientific collaborations; led to a loss of access to European social and regional development funds; and also reduced access to international academic labour markets (although one respondent noted that COVID also presented an opportunity in accessing more diverse labour markets):

> *"Security concerns around new collaborations with non-UK partners." (Cluster V university)*

> *"With the loss of key economic and social development funding from EU, we will need to develop new approaches within the local Region and UK to offset the impact of these strategic funding mechanisms." (Cluster V university)*

> *"Potential to recruit from a more diverse and geographically dispersed talent pool." (Cluster X university)*

Changing societal preferences and values

The 'social contract' for science is the implicit agreement concerning the relationship between science and the state/society (Guston and Keniston, 1994). Since the 1980s, the contract has emphasised an expectation that science would accelerate the pace of innovation by meeting the needs of knowledge 'users' in the economy and society, and be explicitly accountable for funding received (Guston, 2000).

Respondents described how university strategic priorities were being shaped by three mechanisms underpinned by this interpretation of the social contract: policy instruments designed to incentivise universities to undertake innovation-focused activities; the innovation demands of external partners which shape interactions between universities and partners; and the behaviour of competitor universities which shapes how universities harness their core capabilities and differentiate themselves to external partners:

> *"KEF results [are] still being picked over, [and the] Concordat has driven some interesting internal discussions." (Cluster V university)*

> *"There is demand for our expertise from the data science sectors, and the health sectors, also our agriculture and human rights expertise has been more attractive recently." (Cluster X university)*

> *"Competitor behaviour – increased visibility and prominence of other universities drives a response within the University." (Cluster M university)*

More recently, changing societal preferences and values have led to an increased emphasis within the social contract on the role of science in shaping the direction of innovation to promote a managed transition to a more sustainable and equitable future. As discussed in Section 2.3, this shift has been accelerated by the pandemic.

Respondents also described how mechanisms underpinned by this emerging interpretation of the social contract have shaped university strategic priorities. These mechanisms include policy instruments designed to incentivise universities to shape the direction of research and innovation along corridors of acceptable development (such as the transition to net zero); the sustainable technology development and adoption needs of partners and society; and public/civil society perceptions of the importance of decarbonisation.

> *"Changing perception around fossil fuels and changes to net zero emissions driving research futures and public perception." (Cluster V university)*

> *"AI is here but there is (an) absence of ethical considerations so we will focus on more on sociotechnical aspects of technological advances (i.e. ethics, social change, etc.)" (Cluster E university)*

Scale and distribution of socio-economic impacts

Socio-economic inclusion – i.e. the extent to which actors participate in society and the economy –influences the operation of science and innovation systems and the diffusion of new technologies (OECD, 2021, p.40). As discussed in Section 4, at an industry-level the pandemic has led to certain types of partner (e.g. SMEs) and certain sectors struggling to invest in innovation, and in R&D and innovation-driven partnerships with universities. This is leading to a growing exclusion across both industries and regions (Bailey et al., 2020).

Tackling this exclusion was seen by respondents as strongly shaping how universities perform innovation-focused activities, with many describing a strengthening of the university's civic role in fostering local recovery. This acted through three mechanisms, national and regional policy instruments to encourage inclusive growth; gaps in the local capacity for innovation; and local network links which have strengthened during the pandemic, enabling more locally-focused innovation activities.

> *"Focus in the local region on skills development, mismatch in labour market between jobs available and growing sectors, skills amongst those not working, and the need to retrain adults for current labour market. Desire to build local economy in certain areas, with focus on innovation involving local organisations/businesses, local councils and local HE." (Cluster M university)*

> *"Local authorities more interested to work with the University as a result of the closer relationship established during the pandemic." (Cluster J university)*

> *"Clarification on future (Strength in Places fund) is long overdue… Innovation strategy - clarification on specific opportunities for engagement." (Cluster V university)*

Pace and direction of technological innovation

The increased use of digital technologies, big-data analytics and AI during the pandemic led both to the adoption of new processes that affect productivity of science and innovation systems, such as remote working and virtual interactions, and increased demand for innovation-focused activities, including R&D for new waves of technological innovation, and services and support for technology adoption and diffusion (OECD, 2021, p.38; Ulrichsen, 2022). The UK Government seeks to further enable this demand during the recovery.

Respondents described how the pace and direction of technological innovation shaped university strategic priorities through mechanisms including policy instruments to incentivise universities to engage in emergent technology R&D and innovation; technology development trends, including the need for new legislation and regulations for emerging technologies; and the imperative to retain specific emergent technology activities within the UK.

> *"Our strategic priorities are informed by... political focus and associated government resource as well as emerging and evolving technology and innovation trends." (Specialist STEM university)*

> *"Technology and the potential for global transformation - Radical technological transformation and the need to negotiate and ideate new ethical, legislative and regulatory boundaries." (Cluster V university)*

> *"Retention of commercialising quantum tech activities remain in the region/UK – high risk." (Cluster X university)*

6.2 Internal drivers and trends

The overarching internal trend identified was for universities to become more entrepreneurial and enterprising by adjusting their goals and strategies, seizing new opportunities, and adapting to dynamic and competitive knowledge-based societies. Respondents addressed a number of pathways through which universities are seeking to become more entrepreneurial.

Funding base

The need for universities to diversify their sources of funding, be it through more effectively competing for public funding or broadening their range of innovation partners, is a key pathway by which they become more entrepreneurial and innovation-focused (Clark, 1998, p.6). Respondents identified an increased imperative to diversify their funding base as a driver for their strategic prioritisation.

> *"Increased focus on diversification of income through commercialisation." (Cluster J university)*

Steering core

A second pathway towards a more entrepreneurial university is a strong 'core' which steers the university towards quicker, more strategic and flexible responses to changing demands (Clark, 1998, p.5). This core sets strategic direction through articulating a shared vision and providing a platform for engagement (Sánchez-Barrioluengo and Benneworth, 2019).

Respondents described a number of mechanisms being used to strengthen this steering core, such as formalised strategies; university leadership's ability to champion faculty engagement in innovation-focused activities; the use of performance management systems with specific accountability-based metrics for innovation-focused activities; and a strategic imperative to identify areas in which a university's knowledge and skills could be leveraged to enable both innovation and research.

> *"Our new strategy…is an internal driver to our civic mission. It's core to what we do and now we have the justification for getting on with it." (Cluster E university)*

> *"The drive to deliver significant socio-economic added value from our significant innovation assets, Income targets." (Cluster V university)*

> *"In research, the focus is on challenges where were can secure high success rates and on developing signature research to avoid costly competition between universities." (Cluster E university)*

Various respondents also noted a shifting emphasis in their university strategies developed or launched during the pandemic, including:

- Increased strategic focus on applied research
- Increased strategic focus on KE, partner engagement and impact
- Depending on the type of university, an increased focus either on teaching, skills development and student experience, or research and innovation-focused activities
- Increased strategic focus on universities' civic role to support their local community and region
- Increased preferential focus on engagements with larger business partners.

Administrative apparatus

The extent to which innovation-focused activities are regarded as legitimate within the university's 'administrative apparatus' – i.e. its rules, procedures, decision-making and support/incentive structures (Sánchez-Barrioluengo and Benneworth, 2019) – may shape strategic priorities.

Respondents described changes to the administrative apparatus which acted as mechanisms to enable or inhibit innovation-focused activities, including recruitment and promotional practices which rewarded involvement with innovation-focused activities; new ways of working (e.g. hybrid working, new IT systems) which facilitated engagement in these activities; and multiple budgetary demands which constrained these activities.

> *"New academic career framework route for engagement and impact." (Cluster V university)*

> *"Hybrid models of working whilst seen as having long term benefit are fraught with challenges in a mixed working economy." (Cluster M university)*

> *"Economic restrictions as there are multiple demands on budgets." (Specialist STEM university)*

Academic heartland

The 'academic heartland' refers to the commitment to, and active engagement of, a core group of academics in innovation-focused activities, and the degree to which these academics are regarded as role models within the wider university, including by those academics who are not themselves engaged (Sánchez-Barrioluengo and Benneworth, 2019).

One mechanism shaping strategic priorities raised by many respondents across all university types was the COVID-induced reduction in the capacity of academics to engage in innovation-focused activities, be it through increased workload or wellbeing and career satisfaction concerns. Some respondents referred to increased motivations of both academics and students for innovation-focused activities following experiences during the pandemic. Finally, competency gaps and competency-building programmes were raised as shaping innovation-focused activities.

> *"Huge pressures on academic staff throughout the pandemic have had an impact on availability for external/ commercial work, and this will need to be redressed." (Cluster J university)*

> *"The need for academics to be more politically astute in how they operate." (Cluster V university)*

> *"Renewed emphasis and trajectory to enterprise education among staff and students. Focus on entrepreneurially aware student cohorts at all levels." (Cluster J university).*

Internal coupling

The degree to which innovation-focused activities and structures are coordinated with, and linked to, activities traditionally regarded as 'core' –¬ ¬i.e. research and teaching – so as to derive legitimacy and resources within the institution is known as 'internal coupling' (Sánchez-Barrioluengo and Benneworth, 2019).

Internal coupling was perceived as having shaped strategy through providing dual structures separately focussed on core or innovation-focused activities while being held together by a common strategic intent. This is known as structural ambidexterity (Ambos et al., 2008). Respondents described the increased provision of these structures following the pandemic. Examples included:

- Hybrid structures, such as research institutes and centres, to facilitate collaboration with external partners
- Internal networks to facilitate interdisciplinarity and challenge-driven research activities
- Large physical infrastructures and repurposed facilities to provide space for innovation-focused activities
- Informal innovation-related societal discourses
- Continuing professional development opportunities to build capacity of partners to engage with universities
- Dedicated innovation support capabilities, in particular strategic partnership building, management and support.

> *"Internally, we are focusing more on the external relations agenda to drive forward partner stewardship and development." (Specialist STEM university)*

> *"New opportunities for the use of space on campus to be used for innovation collaboration." (Cluster X university)*

> *"A new institute… is being developed to enable the university to interface and engage, and bring together our offer for (a specific) sector into a coherent message and opportunity, locally, national and globally." (Cluster X university)*

Summary of key findings

Trends and drivers shaping university strategic priorities – University strategies, and their implementation, are being shaped by a range of external and internal drivers. These include the evolution of the pandemic; changes in the global order and international relations; changing societal preferences and values; the scale and distribution of socio-economic impacts; the pace and direction of technological innovation; and pressure on universities to become more entrepreneurial and engaged.

7 Factors affecting the strategic agility of universities to respond to the pandemic

If universities are to play a full and active role in driving an innovation-led economic recovery after the COVID shock, they need to display strategic agility – an ability to respond flexibly and purposefully to the constantly changing external environment (Lewis, Andriopoulos and Smith, 2014). An important question for policymakers and university leaders alike is what factors constrain the ability of universities to respond to shocks. Insights on this issue will help to inform their understanding of what needs to be done to enable universities to adapt to the rapidly changing socio-economic and industrial innovation landscapes to support the economic recovery, as well as how to develop resilience in the system to future shocks.

To address this question, our survey explored the perceptions of university leaders and senior managers of the significance of a variety of internal and external factors in enabling or inhibiting the ability of their institutions to respond to the crisis to overcome major threats and challenges and pursue new opportunities. The factors were captured in our analytical framework in Figure 2. Participants rated these factors on a scale ranging from -5 (significant barrier) to 5 (significant enabler).

We first examined whether the factors group together in a particular way to help understand key categories of factor that influence the strategic agility of universities in responding to crises. To do this we undertook a process of 'dimension reduction' using principal component factor analysis to reduce the number of variables and identify key aggregate factors which shape strategic agility. Four such aggregate factors were identified (Table 10).

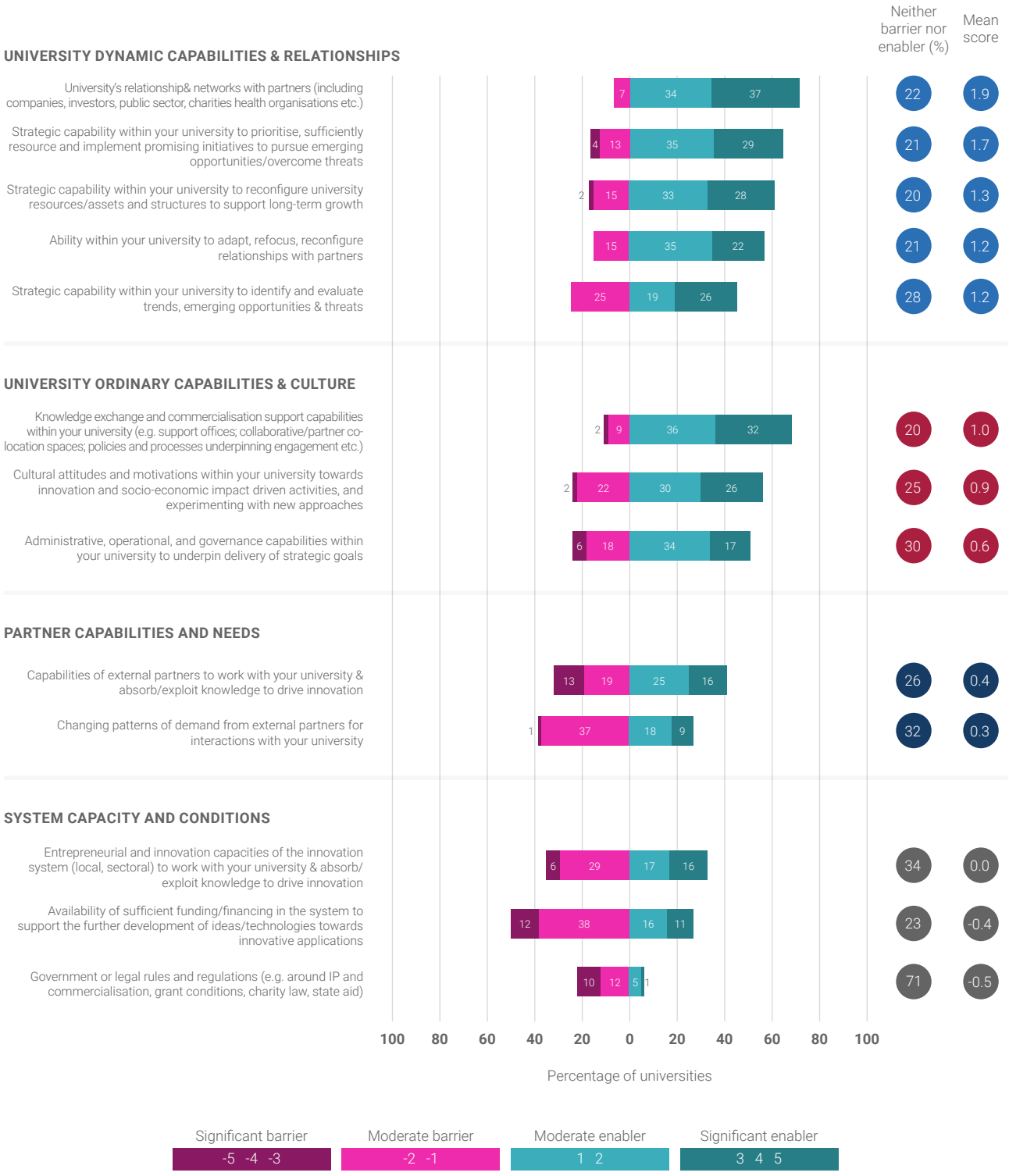
TABLE 10 **Key factors identified through a principal component factor analysis (rotated factor loadings)**

CATEGORY	VARIABLE	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4
University dynamic capabilities & relationships (Cronbach's α = 0.87)	Strategic capability within your university to identify and evaluate trends, emerging opportunities & threats	0.540			
	Strategic capability within your university to prioritise, sufficiently resource and implement promising initiatives to pursue emerging opportunities / overcome major threats	0.912			
	Strategic capability within your university to reconfigure university resources/assets and structures to support long-term growth	0.781			
	Your university's relationships & networks with partners (including companies, investors, public sector, charities health organisations etc.)	0.547			
	Ability within your university to adapt, refocus, reconfigure relationships with partners	0.791			
Ordinary capabilities & motivations (Cronbach's α = 0.83)	Administrative, operational, and governance capabilities within your university to underpin delivery of strategic goals		0.856		
	Cultural attitudes and motivations within your university towards innovation and socio-economic impact-driven activities, and experimenting with new approaches		0.826		
	Knowledge exchange and commercialisation support capabilities within your university (e.g. support offices; collaborative/ partner co-location spaces; policies and processes underpinning engagement, etc.)		0.623		
Partner capabilities and needs (Cronbach's α = 0.79)	Capabilities of external partners to work with your university & absorb/exploit knowledge to drive innovation				0.745
	Changing patterns of demand from external partners for interactions with your university				0.596
System capabilities and conditions (Cronbach's α = 0.75)	Availability of sufficient funding/financing in the system to support the further development of ideas / technologies towards innovative applications			0.745	
	Entrepreneurial and innovation capacities of the innovation system (local, sectoral) to work with your university & absorb/exploit knowledge to drive innovation			0.770	
	Government or legal rules and regulations (e.g. around IP and commercialisation, grant conditions, charity law, state aid)			0.838	
PROPORTION OF VARIANCE ACCOUNTED FOR:		**0.374**	**0.299**	**0.234**	**0.199**

Notes: Factors were rotated using the Promax oblique rotation method. We used Cronbach's alpha to assess scale reliability in terms of internal consistency of the different factors (i.e. are they measuring a similar construct), accepting values >0.75 as indicating strong reliability.

Full results can be found in the Technical Annex, Table B.8 & B.9.

FIGURE 16 **Barriers and enablers to university strategic agility to pursue emerging innovation-related opportunities and overcome major challenges over the Pandemic period**



University dynamic capabilities and relationships. Dynamic capabilities are about doing the right things at the right time to sustain university enterprise-level performance, based on prescient assessments of the external environment and technological opportunities; managerial orchestration processes; and a strong and change-oriented organisational culture (Teece, 2014). Dynamic capabilities include three enterprise-level capabilities:

- The strategic capability to identify and evaluate trends, emerging opportunities & threats ('sensing' capabilities)
- The strategic capability to prioritise, sufficiently resource, and implement promising initiatives to pursue emerging opportunities/overcome major threats ('seizing' capabilities)
- The strategic capability to reconfigure university resources, assets, and structures to support long-term growth ('transforming' capabilities)

Figure 16 shows that many universities found their dynamic capabilities around 'seizing' opportunities and 'transforming' organisations to pursue them as particularly strong enablers of their response to the crisis. Fewer identified their ability to identify and evaluate opportunities and threats as a key enabler, and a quarter of universities saw this as a barrier to their pandemic response. For some universities it may be that the opportunities and challenges thrown up by the pandemic – while hugely disruptive – were nevertheless relatively clear around preserving activities and relationships given lockdowns, solving clearly specific COVID-19 problems (e.g. developing vaccines and therapeutics, diagnostics, and ventilators), and supporting their local communities who were in dire need of help. For some they may lack the internal skills and tools to systematically sense challenges and opportunities.

These dynamic capabilities were strongly linked to the strength of relationships and networks universities have with their partners, and their ability to adapt, refocus and reconfigure them. Figure 16 shows that these relationships were, for most universities, a strong enabler of their crisis response. These external relationships can be seen as providing important links for knowledge to flow about external conditions and priorities, while also enabling universities to accelerate the practical development and deployment of solutions to innovation challenges in a crisis (perhaps demonstrated most visibly by the importance of such relationships for enabling the rapid development of the University Oxford-AstraZeneca COVID-19 vaccine, and the rapid development of breathing aids by University College London).

University ordinary capabilities & culture. Ordinary capabilities can be thought of as the capabilities which drive operational effectiveness and delivery. Our analysis suggests that these include not just the university's administrative, operational, and governance capabilities to underpin the delivery of strategic goals, but also the capabilities to support knowledge exchange and commercialisation. Also linked to this factor are the cultural attitudes and motivations within the university towards engaging in innovation and economic-impact driven activities and experimenting with new approaches.

Figure 16 shows that many universities believed their ordinary capabilities around KE and commercialisation support was particularly important in enabling their pandemic response (68% of universities). This reinforces the importance of KE support in enabling universities to develop the necessary relationships and projects to drive innovation. During the pandemic, these ordinary KE-focused capabilities were crucially important for enabling key partnerships to form between researchers and organisations that were able to develop and deploy (at scale) practical solutions to pandemic problems. Where more respondents saw barriers was around the wider administrative, operational and governance capabilities of universities (24% of universities).

Partners' capabilities and needs. This set of factors is about the roles that partners want universities to perform, and their own ability to take best advantage of these roles to drive their innovation efforts. This includes:

- Capabilities of external partners to work with your university & absorb/exploit knowledge to drive innovation
- Changing patterns of demand from external partners for interactions with your university

Figure 16 suggests that a third of universities found the uncertainty over demand created barriers to their ability to respond to the crisis. A third said the capabilities of partners also acted as a barrier. This compared with 41% of universities that said their partner capabilities were actually an enabler to change. This again suggests very different experiences across the sector in responding to the crisis.

System capacities and conditions. The final category focuses on the conditions and capacities of the wider system to innovate, within which universities and their partners operate and interact. These include the key factors of:

- Entrepreneurial and innovation capacities of the innovation system (local, sectoral) to work with universities & absorb/exploit knowledge to drive innovation
- Availability of sufficient funding/financing in the system to support the further development of ideas/technologies towards innovative applications
- Government or legal rules and regulations (e.g. around IP and commercialisation, grant conditions, charity law, state aid).

Figure 16 shows that these factors caused barriers for many universities: 50% of universities said that the availability of sufficient funding to support the development of ideas towards applications had hampered their ability to respond to the crisis. Interestingly, relatively few universities believed that government or legal rules and regulations influenced their ability to respond to the crisis, either as an enabling factor or as a barrier.

In examining the experiences of different types of universities while there was similarity across many factors, some important differences emerged (Table 11). In particular, the large research-intensive universities of cluster V and STEM specialists were more likely to identify their KE and commercialisation support capabilities as enabling than universities in other clusters. Furthermore, these universities were also more likely than others to see the capabilities of their partners to work with their institution and absorb and exploit knowledge to drive innovation as an enabler of their crisis response (see Technical Annex, Table B.10). They also saw changing patterns of demand as less of an issue than other universities.

TABLE 11 **Mean score of the extent to which factors inhibited or enabled university strategic agility over the Pandemic period, by KE cluster (scale: -5: significant barrier to +5: significant enabler)**

CATEGORY	BRAND/ENABLER	CLUSTER					VARIATION ACROSS CLUSTERS ‡
		KE_V	KE_X	KE_E	KE_JM	KE_STEM	
University dynamic capabilities & relationships	Strategic capability to identify and evaluate trends, emerging opportunities & threats	1.5	0.8	0.8	0.2	2.4	
	Strategic capability to prioritise, sufficiently resource and implement promising initiatives to pursue emerging opportunities / overcome major threats	0.8	1.1	1.9	0.5	2.6	
	Strategic capability to reconfigure university resources/assets and structures to support long-term growth	1.4	1.5	0.9	1.2	2.2	
	University's relationships & networks with partners	2.6	2.1	2.4	0.8	2.2	
	Ability to adapt, refocus, reconfigure relationships with partners	1.9	1.8	1.0	0.3	2.4	
Ordinary capabilities & motivations	Administrative, operational, and governance capabilities to underpin delivery of strategic goals	1.5	0.0	0.2	0.7	1.0	
	Cultural attitudes and motivations towards innovation and socio-economic impact-driven activities, and experimenting with new approaches	2.3	0.0	1.1	0.6	1.6	†
	Knowledge exchange and commercialisation support capabilities	2.7	1.6	1.8	0.8	2.6	
Partner capabilities and needs	Capabilities of external partners to work with your university & absorb/exploit knowledge to drive innovation	1.3	0.0	-0.3	-0.3	3.0	*
	Changing patterns of demand from external partners for interactions with your university	0.5	-0.3	-0.2	-0.8	2.4	**
System capabilities and conditions	Availability of sufficient funding/financing in the system to support the further development of ideas / technologies towards innovative applications	-0.2	-0.7	-1.0	-0.9	2.2	
	Entrepreneurial and innovation capacities of the innovation system (local, sectoral) to work with universities & absorb/exploit knowledge to drive innovation	1.2	-0.2	0.4	-0.8	3.4	**
	Government or legal rules and regulations (e.g. around IP and commercialisation, grant conditions, charity law, state aid)	-0.5	-0.2	-0.9	-0.4	0.8	

*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%; † 15%.*

Overall, these findings reveal key aspects of university strategic agility during the pandemic. First, universities' strategic agility in response to the COVID shock was seen as being driven more by internal than external factors. Both universities' dynamic capabilities and relationships, and their ordinary capabilities, around KE support in particular, enabled this agility in most universities.

Second, that a relatively high proportion of universities regarded both their dynamic capabilities, and ordinary capabilities and culture as barriers or as neither barrier nor enabler suggests that capability gaps within universities may exist that affect strategic agility. In particular, their strategic capability to identify and evaluate trends, emerging opportunities and threats – their 'sensing' capability (Leih and Teece, 2016) – was regarded as a relatively weak enabler of strategic agility overall compared with their dynamic capabilities to find solutions to challenges and opportunities once known about.

One potential explanation for this finding is that the challenges and opportunities facing universities in the short term were relatively clear and more easily identifiable (for example, dealing with disruptions from lockdowns, developing vaccines and diagnostics, informing national policy responses, supporting local communities etc.). The bigger strategic challenge for universities was how they dealt with these known challenges. As we move through the crisis into the recovery period, we are now seeing universities having to confront major challenges on many fronts (well beyond just COVID). The ability of universities to identify, understand and act on a wider range of perhaps more complex and less clearly identifiable challenges will be crucial to enable them to position their organisations as important and active drivers of an innovation-led recovery.

Third, the findings reveal that many universities in cluster JM were both less likely than others to see their key capabilities around KE and commercialisation support as an enabler of their institution's crisis response, and more likely to see the abilities of their partners to work with them to drive innovation as a barrier. This suggests that the effects of the pandemic may be acting to increasingly exclude these universities from contributing to innovation.

Summary of key findings

Factors affecting the strategic agility of universities in response to the COVID landscape shock – A variety of internal and external factors affect the ability of universities to adapt to the disruption caused by the pandemic. These can be grouped into four key categories: (i) their 'dynamic' capabilities to identify and respond to new opportunities and threats, and the strength and flexibility of their relationships with partners; (ii) their 'ordinary' capabilities which underpin efficient and effective delivery of projects and activities with partners – this includes their knowledge exchange support; (iii) the capabilities and changing needs of their partners; and (iv) the capacity and conditions of the innovation system within which they operate to drive innovation.

Universities saw a mix of these dynamic and ordinary capabilities as particularly enabling of their ability to respond to the sudden hugely disruptive shock of the COVID-19 pandemic. Particularly important dynamic capabilities included their ability prioritise and allocate resources and implement change to overcome major challenges and pursue new opportunities, and the strength of their relationships with partners and their ability to adapt them. Their 'ordinary' capabilities to support knowledge exchange and commercialisation activities was also seen as a key enabler of their response.

Externally, many universities found the uncertainties caused by changing needs of partners as hindering their response to the pandemic, as was the lack of funding to support the translation of ideas into innovative applications. Approximately equal numbers of universities saw the capabilities of their partners to work with them as either hindering or enabling their response.

Our findings also suggest that smaller, more teaching-focused universities were less likely than others to see their capabilities to support KE and commercialisation support as an enabler of their crisis response, and were also more likely to see the abilities of their partners to work with them to drive innovation as a barrier. Combined, these suggest that the effects of pandemic may be acting to make it particularly challenging for these universities to adapt through the crisis and contribute to innovation in the recovery

8 Looking to an innovation-led recovery

Universities have the potential to contribute in many ways to an innovation-led recovery, whether through helping to generate novel technologies that can help seed industries of the future; to support companies in their local economies to solve problems, adapt to the changing competitive landscape, and adopt state-of-the-art technologies and processes to increase productivity and become more competitive; to helping people to upskill and meet the skills needs of emerging industries; to investing in build infrastructure, support and an entrepreneurial culture in the local economy to drive innovation.

In this section we explore the emerging strategic priorities of universities – as identified by university leaders with responsibility for their innovation portfolio – for driving innovation and economic development in the recovery period. We distinguish between 'how' universities can contribute to innovation in the recovery by looking at the strategic importance placed on different innovation functions of the university, and where they seek to contribute, namely the target areas where leaders see significant and viable strategic opportunities for their universities to contribute to innovation in the recovery.

8.1 Strategic priorities for universities for the Immediate Recovery period

The analytical framework developed in section 2.1 captures the many ways through which universities can contribute to innovation (i.e. their 'functions' in the innovation system). We categorised their functions into three broad areas:

- R&D activities to develop new technologies and ideas to drive innovation
- Applying knowledge and resources to support innovators
- Services and support targeted at strengthening the innovation system to enable the development, diffusion, and deployment in practice of new technologies and ideas.

A key question for is how these different roles and functions are being strategically prioritised by universities as we move through the pandemic and into the recovery. Consequently, we asked respondents to indicate on a scale from 0 (no importance) to 10 (extremely important) the strategic importance being placed by university leaders on the variety of innovation-focused roles and functions of the university in the Immediate Recovery period.

8.1.1 R&D to generate new technologies and ideas to drive innovation

Universities undertake a portfolio of types of R&D activities with different balances between a quest for fundamental understanding and considerations of its use in the world. They also work to develop prototypes of products and services as they seek to translate and develop their research outputs into practical applications that deliver an economic and social impact (Figure 17). As we move through the pandemic into the Immediate Recovery Period, when asked about what types of R&D activities they would place importance on to support the innovation objectives of their external partners, most universities reported that their applied research activities would be particularly important for their partners (85%). This compared to 66% citing their use-inspired basic research as important to drive innovation with external partners, and just 42% citing basic research. Prototype development, design and demonstration was cited by 47%. Reflecting the growing recognition of the value of mission and challenge-led efforts to tackle innovation, almost 70% said that developing challenge-driven programmes and centres of excellence that integrate different types of research with efforts to translate and develop it into practice would be important for the Recovery.

This order of prioritisation of these R&D-related functions of universities in supporting the innovation objectives of their partners is largely unchanged from pre-pandemic priorities (Ulrichsen, 2021, p.22).

FIGURE 17 **Importance placed by universities on different types of R&D activities to support the innovation objectives of their external partners in the Immediate Recovery period**

Note: sum of data points may not equal total % of universities scoring 7+ due to rounding

The importance placed on these different R&D activities varied across types of universities (Table 12). Unsurprisingly, basic research was seen as very important for most of the large research-intensive cluster V and X universities for supporting the innovation objectives of external partners, but much less so for both the less research-intensive cluster E and JM universities, and the STEM universities. Similarly, use-inspired basic research was very important for clusters V, X and E universities but only moderately important for those of clusters JM and STEM. There was significant statistical variation associated with these findings (see Technical Annex, Tables B.11 and B.12).

TABLE 12 **Percentage of universities in each KE cluster returning a score of 7+ (very/extremely important) for each type of R&D activity aimed at supporting the innovation objectives of their partners in the Immediate Recovery period**

R&D ACTIVITIES	CLUSTER					VARIATION ACROSS CLUSTERS ‡
	KE_V	KE_X	KE_E	KE_JM	KE_STEM	
Advancing understanding of fundamental principles through basic research	92	75	11	18	40	***
Use-inspired basic research to underpin the development of new technologies, processes, business models, products or services, policies and other institutions	92	75	67	50	50	**
Applied research to support development of new or significantly improved technologies, processes, business models, products or services, policies and other institutions	85	83	89	83	80	
Prototype development, design & demonstration of technologies, processes, products or services	54	25	56	50	50	
Developing challenge-driven programmes and centres of excellence that integrate research of different types/disciplines and provide targeted support for their further development and transfer into practice (including targeted training)	85	83	78	45	60	

*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%; † 15%. See Technical Annex Tables B.11 and B.12.*

Interestingly, there was very little statistical variation between KE clusters for other R&D activities, suggesting that to help drive the Recovery many universities of all types are placing significant importance on applied research and challenge-driven research.

These findings highlight the importance attached by universities to delivering R&D activities further downstream along the innovation chain beyond early-stage research, including working to develop prototypes and demonstrate their functionality in practice. This runs counter to the common historic perception of the primary function of universities being delivery of basic research. Rather than being homogeneous institutions, universities are more complex actors in the innovation system delivering a range of R&D functions to help drive innovation.

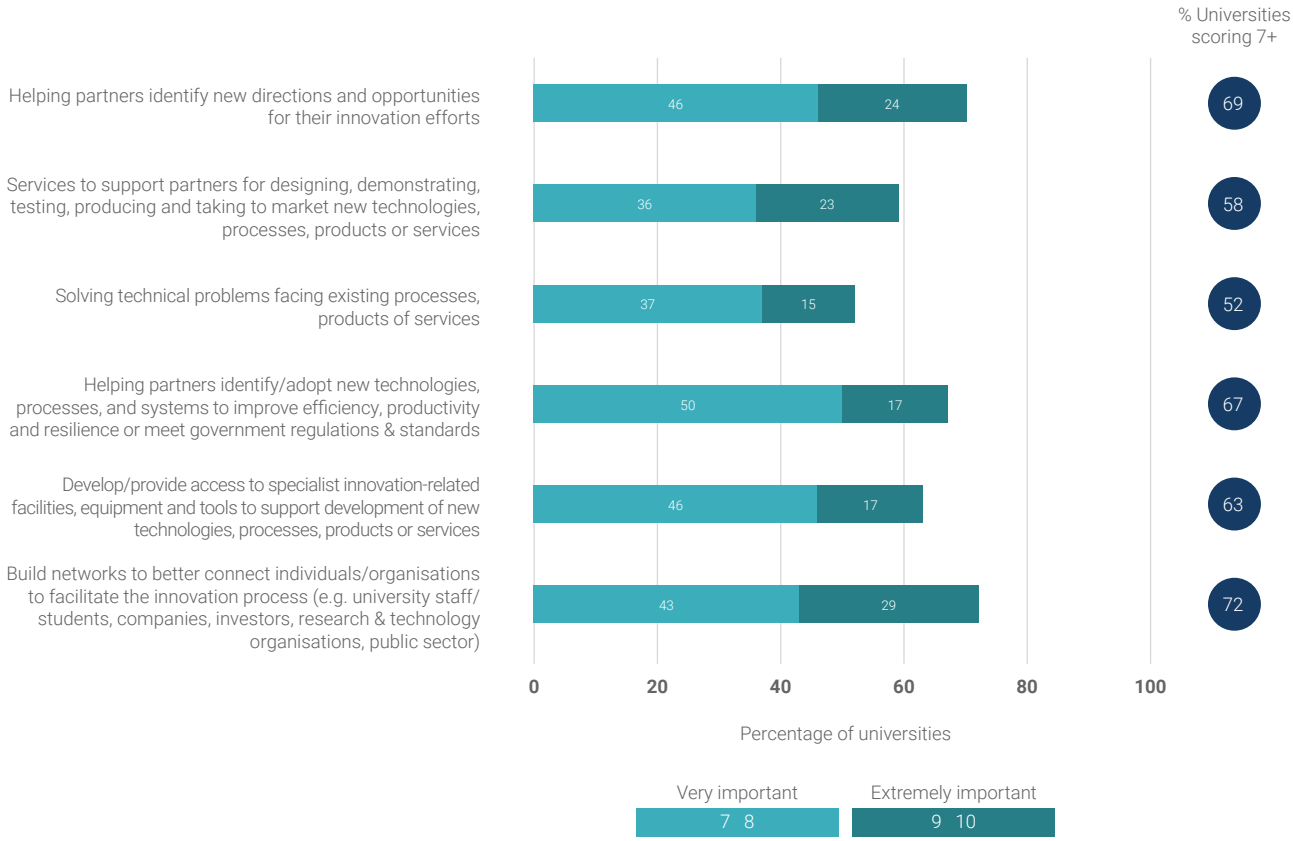
Furthermore, they reveal that many universities see challenge-driven research as important. This indicates that universities are looking to prioritise R&D activities moving forward that can help to shape the direction of innovation along specific development paths, and are adopting more 'transformative university' or 'development university' models to do so (see Section 2.1).

8.1.2 Innovation-focused services (beyond R&D) to support the innovation objectives of their external partners

Universities also provide important services and support – beyond R&D – to innovators to help their innovation activities develop. These typically draw on existing bodies of knowledge and other resources (e.g. facilities and equipment or tools). Figure 18 shows the importance university leaders are placing on these types of functions for their universities in the Immediate Recovery period.

The top three functions are: building networks to convene and better connect organisations to facilitate innovation; helping partners to identify new directions and opportunities for innovation; and helping partners to identify/adopt new technologies, processes and systems to improve efficiency, productivity, resilience or to meet regulations and standards. The latter is particularly important for tackling regional economic inequalities. Once again, the order of prioritisation of these types of services and support is largely unchanged from pre-pandemic priorities (Ulrichsen, 2021, p.23).

FIGURE 18 **Importance placed by universities on innovation-focused services and support (beyond R&D) to support the innovation objectives of their external partners in the Immediate Recovery period**



Note: sum of data points may not equal total % of universities scoring 7+ due to rounding

Table 13 looks at the variation in importance placed on these activities by universities in different KE clusters for supporting innovation in the Immediate Recovery period. Interestingly, there is very little statistical variation between types of universities, suggesting that universities of all types place significant importance in delivering a wide range of services and support to help their partners innovate.

The one exception is around developing and providing access to specialist innovation-related facilities, equipment, and tools to support development of new technologies, processes, products, or services. Using Dunn's test to pinpoint where the variation between subgroups exists shows that it is universities in KE cluster JM that are much less likely than others to prioritise this function. Universities of other clusters all exhibit a statistically similar propensity to prioritise this function (see Technical Annex, Tables B.13 and B.14).

TABLE 13 **Percentage of universities in each KE cluster returning a score of 7+ (very/extremely important) for each type of service or support (beyond R&D) aimed at supporting the innovation objectives of their partners in the Immediate Recovery period**

PARTNER SERVICES AND SUPPORT	CLUSTER					VARIATION ACROSS CLUSTERS ‡
	KE_V	KE_X	KE_E	KE_JM	KE_STEM	
Helping partners identify new directions and opportunities for their innovation efforts	77	83	56	73	50	
Services to support partners for designing, demonstrating, testing, producing and taking to market new technologies, processes, products or services	77	50	67	50	50	
Solving technical problems facing existing processes, products or services	58	58	56	42	50	
Helping partners identify/adopt new technologies, processes, and systems to improve efficiency, productivity and resilience or meet government regulations & standards	85	73	44	64	100	
Develop/provide access to specialist innovation-related facilities, equipment and tools to support development of new technologies, processes, products or services	85	67	75	33	75	*
Build networks to better connect individuals/organisations to facilitate the innovation process (e.g. university staff/ students, companies, investors, research & technology organisations, public sector agencies)	85	83	67	67	60	

*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%; † 15%. See Technical Annex Tables B.13 and 14.*

The results further highlight the inaccuracy of narratives in which large, broad-disciplined research-intensive universities are framed as being theory-focused 'ivory towers'. In reality, universities of all types place significant importance on working with partners to help tackle their innovation challenges and needs. It also reveals the potential importance of universities outside the more research-intensive V and X clusters in providing an important source of support to companies as they seek to become more innovative and productive.

8.1.3 Services and support to strengthen innovation systems to enable development and diffusion of innovations

Universities are also known to play important roles in helping to strengthen the capabilities and conditions of the innovation system that underpin the ability of firms and other organisations to innovate. Figure 19 shows the importance being placed on services and support to help develop the innovation systems within which the university operates.

FIGURE 19 **Importance placed by universities on services and support targeted at strengthening the innovation system to enable the development, diffusion and deployment in practice of new technologies and ideas in the Immediate Recovery period**

Note: sum of data points may not equal total % of universities scoring 7+ due to rounding

The first insight from this figure is the importance being placed by many universities on building both tangible and intangible infrastructure and conditions of the innovation system, namely around: developing physical/virtual infrastructure to drive innovation and entrepreneurship for the local economy (70%); investing effort to improve local quality of life (82%); and strengthening innovation and entrepreneurial culture (71%). These underpinning conditions are known to be important for the development of local high-tech clusters. It also suggests that, following the COVID shock, the civic role of universities of contributing to local socio-economic development has become a more important priority of many universities, a finding supported by our qualitative data in Section 6.

The figure also shows the active involvement of universities in helping to develop skills within the system to drive innovation and entrepreneurship. Many are placing importance on providing entrepreneurship education to staff and students (72%), and developing workforce skills 70%).

Many universities also emphasise their important role in developing and providing leadership, intelligence and expert advice to inform the strategic development of the system (e.g. a particular place, technology or sector) (68% of universities).

We found little statistical variation between types of universities in the importance they attach to most of these activities, suggesting that universities of all types place significant importance in delivering a variety of services and support to strengthen the capabilities and conditions of the innovation system (Table 14). There were three exceptions to this (full details in Technical Annex, Tables B.15 and B.16). The first is around efforts to improve local quality of life with universities in clusters V, X and JM more likely than those in other clusters to highlight this function. The second around efforts to strengthen the innovation and entrepreneurial culture within the innovation system, with the large research-intensive universities in cluster V and STEM specialists much more likely than others to emphasise this function. Finally, unsurprisingly the more research-intensive universities in clusters V and X are placing greater emphasis on providing targeted support, access to investment, and physical infrastructure for forming and developing spinouts/start-ups to commercialise new ideas and technologies than those in other clusters, likely reflecting that spinout activity is largely concentrated in these universities.

TABLE 14 **Percentage of universities in each KE cluster returning a score of 7+ (very/extremely important) for each type of function aimed at strengthening the wider innovation system to enable the development, diffusion and deployment in practice of new technologies and ideas in the Immediate Recovery period**

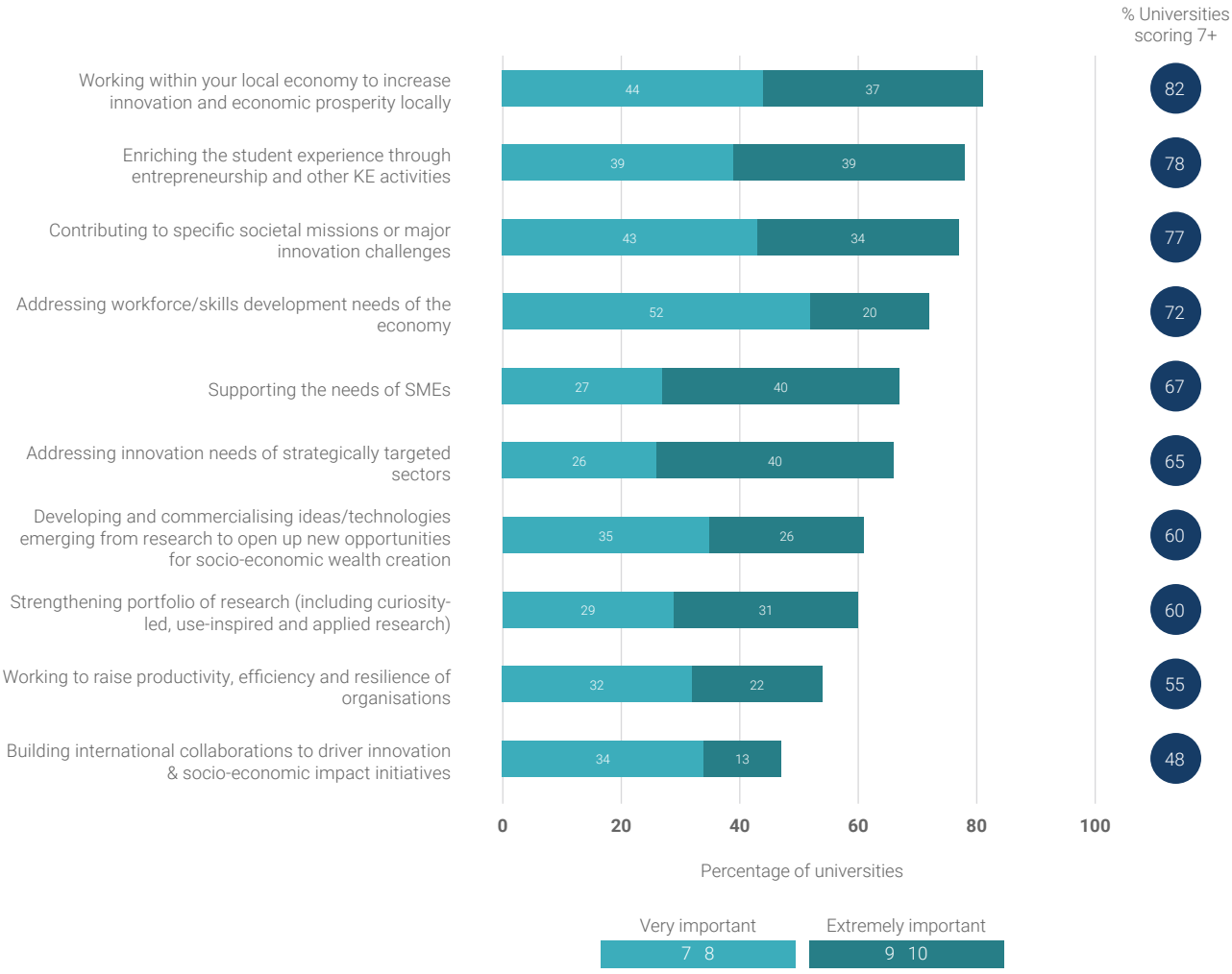
PARTNER SERVICES AND SUPPORT	CLUSTER					VARIATION ACROSS CLUSTERS ‡
	KE_V	KE_X	KE_E	KE_JM	KE_STEM	
Develop/provide leadership, intelligence and expert advice to inform strategic development of place, technology or sector (e.g. strategic direction, benchmarking, foresight, market insights)	77	67	56	64	100	
Inform development of relevant policies, regulations and standards, tax system, legal frameworks	69	58	44	27	60	
Raise public understanding of new technologies (e.g. ethical implications)	54	33	22	36	75	
Develop workforce skills (including through recruitment, and supporting workforce development)	50	67	89	67	75	
Providing targeted support, access to investment, and physical infrastructure for forming and developing spinouts/ start-ups to commercialise new ideas and technologies	92	75	44	33	50	***
Providing entrepreneurship education to staff/ students	77	75	67	64	100	
Facilitating the movement of people between academia and industry	46	42	56	45	75	
Efforts to strengthen the innovation and entrepreneurial culture	92	73	78	42	100	*
Work with local partners to attract inward investment to the region	85	73	56	55	75	
Develop physical/virtual infrastructure within the local economy to drive innovation and entrepreneurship (e.g. innovation centres, innovation districts, campus redevelopments, university enterprise zones)	92	83	67	50	75	
Efforts to improve the quality of life in your local area	83	92	78	83	60	*

*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%; † 15%. See Technical Annex Tables B.15 and B.16.*

8.2 Emerging strategic opportunities for university innovation-focused activities

Section 2.3.2 outlined a number of emerging innovation-related policy priorities in the UK. In this section, we examine the extent to which senior leaders of universities see significant and viable strategic opportunities in these areas as they look forward to the Immediate Recovery. Respondents were asked to rate the scale of opportunity on a scale from 0 (no opportunity) to 10 (very significant strategic opportunity). Figure 20 presents the percentage of universities identifying each area as significant (scores 7 and 8) and very significant (9 or 10).

FIGURE 20 **Viable strategic opportunities for the Recovery Period, driven by unmet needs, identified by universities as significant (score of 7-8) and very significant (score of 9-10)**



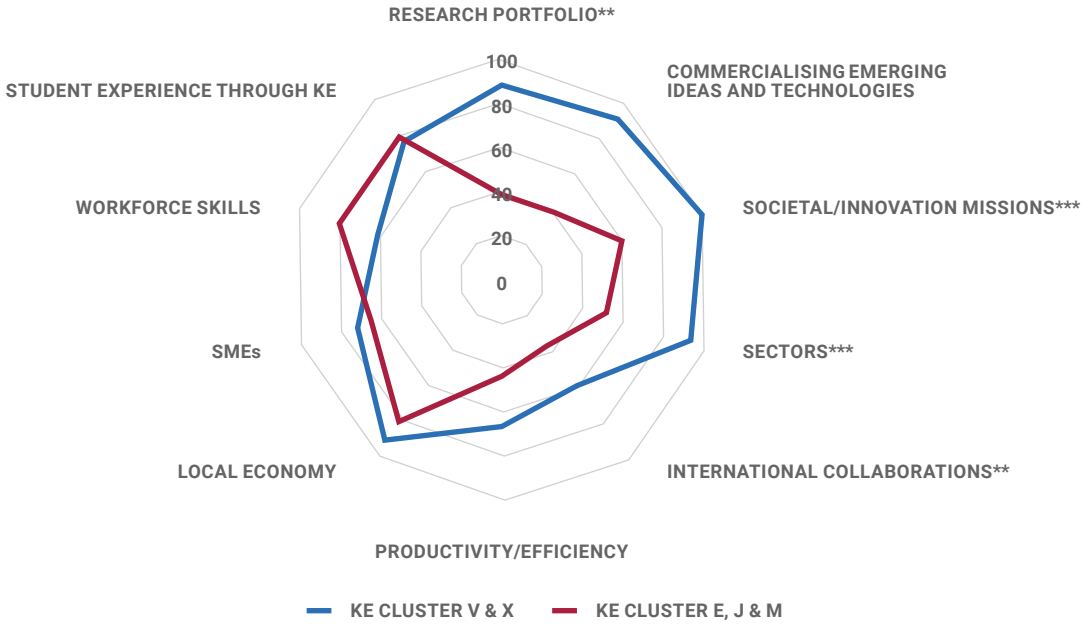
Note: sum of data points may not equal total % of universities scoring 7+ due to rounding

The top five areas offering significant/very significant viable opportunities for universities to contribute to the recovery are working within the local economy to increase innovation and economic prosperity; enriching student experience through entrepreneurship and other KE activities; contributing to specific societal missions or major innovation challenges; addressing workforce/skills development needs of the economy; and supporting the needs of SMEs. Between 67-82% of universities saw significant/very significant opportunities associated with these areas.

Given the ambitions of the UK Government for the UK to become a global science and innovation superpower post-Brexit (Freeman, 2022), it is perhaps concerning that comparatively fewer university leaders saw significantly viable strategic opportunities for building international collaborations to drive innovation in the recovery period; just 48% rated this area as at least significant (7+) and just 13% rated it as very significant (9+). Having now left the European Union, these international links will be even more important for delivering a 'global' Britain.

Strengthening innovation adoption and diffusion in the UK will also be critical for increasing productivity and efficiency of companies and addressing the UK Government's Levelling Up ambitions. With the long-term stagnation of productivity in the UK, it is also concerning that just 55% of universities identified this as a viable strategic opportunity for their institutions moving forward. Additional policy incentives may be needed in both of these areas to more effectively translate policy ambitions into strategic opportunities for universities.

FIGURE 21 **Viable strategic opportunities for the Immediate Recovery period identified by different types of universities as significant or very significant (percentage of universities identifying area as 7+ on the level of opportunity scale from 0: no opportunity to 10: significant strategic opportunity)**



*Notes: *** indicates the difference between clusters V & X and E, J & M are statistically significant at the 1% level; ** at the 5% level; * at the 10% level. Based on the Mann-Whitney non-parametric test of significance between two groups.*

We found statistical variation between the two aggregated KE clusters of V & X (larger, more research-intensive institutions) and E, J, & M (smaller, more applied research and teaching-driven institutions) associated with key areas of opportunity (Figure 21). Universities in clusters V & X saw much greater opportunities around contributing to specific societal missions or major innovation challenges than their counterparts in clusters E, J & M; similarly for developing and commercialising ideas and technologies emerging from research, strengthening research portfolios to drive innovation in the future, and addressing the innovation needs of key sectors (see Technical Annex Tables B.17 and B.18). They were also more likely to see opportunities in building international collaborations to drive innovation (60% for cluster V&X identifying this as at least a significant strategic opportunity versus 37% for cluster EJ&M).

The lack of statistical variation in key areas is also interesting. Figure 21 shows that most universities, regardless of type, see efforts to support their local economy in the recovery as important, as is leveraging KE to support and enrich the student experience.

Overall, the evidence when looking at different types of universities points to a degree of specialisation, with different types of universities being important in helping to drive the recovery in different ways and to deliver different government ambitions.

We also examined whether the strategic opportunities perceived by university leaders varied based in different types of region depending on the level of economic prosperity (low, mid, and high prosperity)[6] (Table 15). Crucially, our evidence shows that universities based in less prosperous parts of the UK were much more likely than others to see opportunities to contribute to the recovery by working with their local economy, working to raise productivity and efficiency of partners, working to address the innovation needs of SMEs and of specifically targeted sectors, and working to develop workforce skills. All of these areas will be critically important to helping the UK Government deliver on its Levelling Up ambitions to reduce spatial economic disparities across the UK.

TABLE 15 **Key viable strategic opportunities for the Recovery Period identified by universities in different types of regions based on the level of economic prosperity (percentage of universities identifying area as 7+ on the level of opportunity scale from 0: no opportunity to 10: significant strategic opportunity**

OPPORTUNITY	REGIONAL ECONOMIC PROSPERITY			VARIATION ACROSS CLUSTERS ‡
	LOW	MID	HIGH	
Strengthening portfolio of research (including curiosity-led, use-inspired and applied research)	62	78	47	
Contributing to specific societal missions or major innovation challenges	77	87	72	
Developing and commercialising ideas/technologies emerging from research to open up new opportunities for socio-economic wealth creation	69	75	42	*
Addressing innovation needs of strategically targeted sectors	78	78	42	**
Working to raise productivity, efficiency and resilience of organisations	70	61	31	**
Working within your local economy to increase innovation and economic prosperity locally	100	90	54	***
Enriching the student experience through entrepreneurship and other knowledge exchange activities	79	81	73	
Building international collaborations to drive innovation & socio-economic impact initiatives	47	65	40	
Supporting the needs of SMEs	78	77	47	*
Addressing workforce/skills development needs of the economy	84	67	59	*

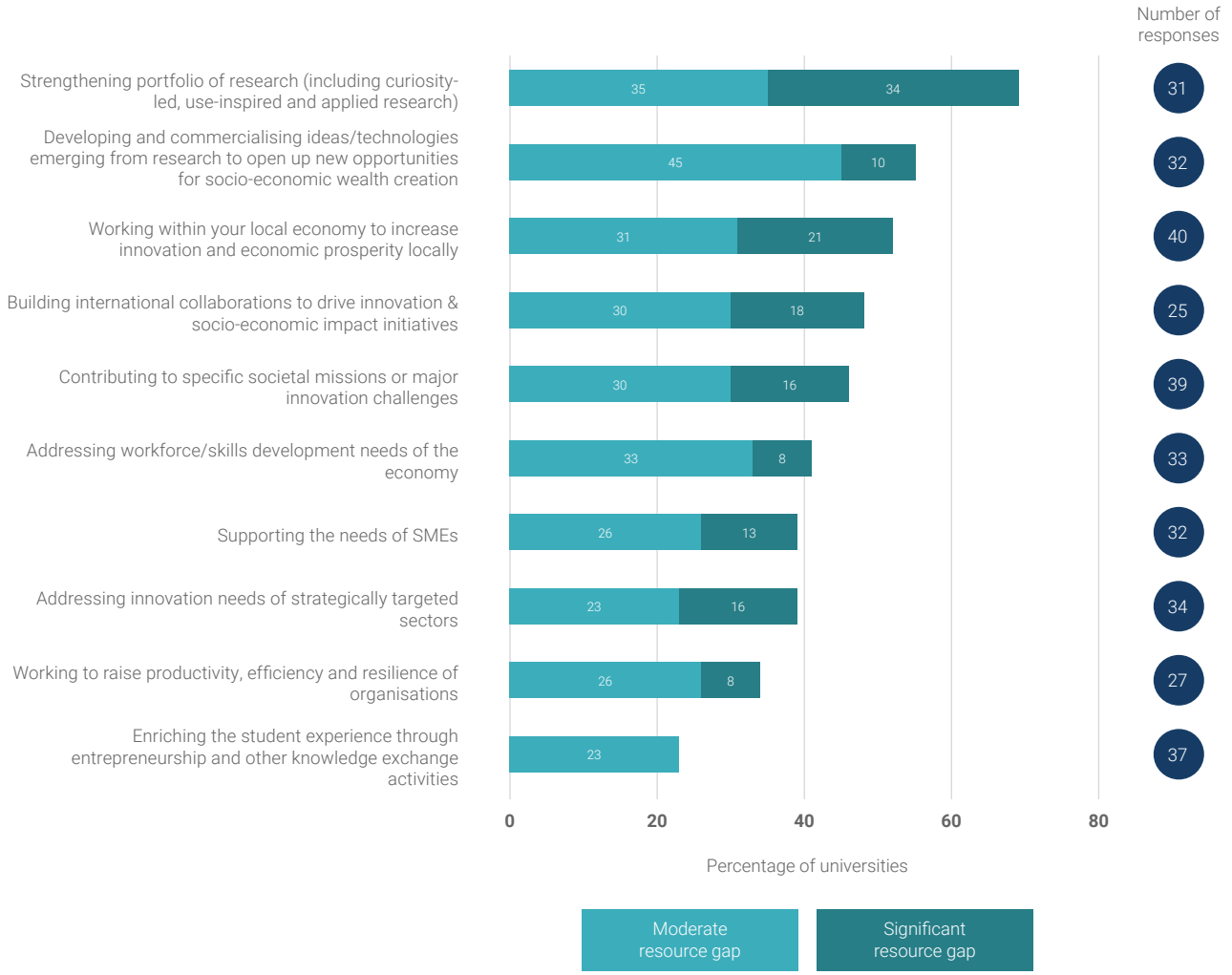
*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%*

6 *The economic prosperity of regions was proxied here by the gross value added per filled job at the NUTS 3 geography level. Regions were separated into three categories: lower prosperity (regions with GVA per job of less than or equal to 95% of the UK mean); mid prosperity (regions with GVA per job of more than 95 and but less than or equal to 105% of the UK mean); and higher prosperity (regions with more than 105% of the UK mean).*

8.3 Resource gaps hindering pursuit of emerging strategic opportunities

For universities to be able to deliver on the range of viable strategic opportunities identified for the recovery, they will need access to a range of resources (financial and other). To identify any key gaps in resources we asked universities to determine the 'gap' between the resources available and the resources 'needed' to pursue each opportunity they identified as important for their institution. The results are presented in Figure 22.

FIGURE 22 **Resource gaps hindering pursuit of viable strategic opportunities in the Immediate Recovery period for universities identified as significant (7+) by respondents**



The evidence in Figure 22 suggests that where universities identified significant opportunities for driving innovation in the recovery period, resource gaps are greatest for: strengthening research portfolios; commercialising ideas and technologies; working within the local economy to strengthen local innovation; and building international collaborations to drive innovation & impact. We found little significant statistical variation across KE clusters (see Technical Annex, Table B.20).

We did find statistical variation between regions associated with three opportunities, strengthening research portfolios; contributing to specific societal missions or major innovation challenges; and enriching the student experience through entrepreneurship and other knowledge exchange activities. In each case, we found that universities in regions of high prosperity saw less significant resource gaps than those in regions of mid or low prosperity (see Technical Annex, Table B.21).

FIGURE 23 **Comparison of the scale of opportunity and resource gaps for each area, for different types of university**

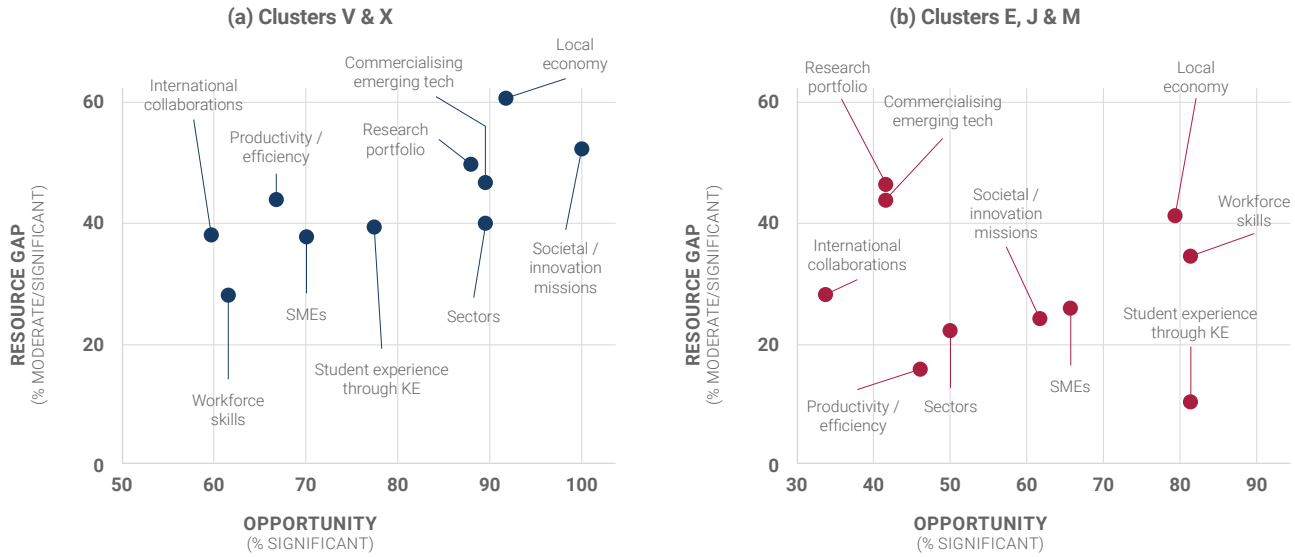


Figure 23 examines whether there is a link between the significance of strategic opportunities and the resource gaps to deliver them for each of the aggregate clusters V & X and E, J & M. The figure charts the percentage of universities identifying an area as significant (7+ on the scale) against the percentage of universities identifying a moderate or significant resource gap hampering their ability to deliver on the opportunity. For the larger research-intensive universities in clusters V & X, they perceive the biggest resource gaps in those areas where they see the largest opportunities for driving innovation in the recovery, namely through building their research portfolios, commercialising technologies, delivering on societal and innovation missions and challenges, and supporting their local economies. For universities in clusters E, J & M, key resource gaps emerge around key opportunities to contribute to their local economies and develop workforce skills.

Table 16 looks at how the scale of resource gaps hindering universities from pursuing key strategic opportunities varies with the types of regions they are based within (characterised by 'low', 'mid', and 'high' levels of economic prosperity of the regions). It shows quite clearly that universities based in less economically prosperous regions are more likely that others to experience significant resource gaps in pursuing opportunities that are critical to their ability to contribute to the Levelling Up agenda, for example, around working to contribute to innovation in their local economy and supporting the needs of SMEs.

TABLE 16 **Resource gaps hindering universities from pursuing viable strategic opportunities in key areas in the Immediate Recovery Period (percentage of universities identifying moderate or significant resource gaps)**

OPPORTUNITY AREA	REGIONAL ECONOMIC PROSPERITY (% universities identifying moderate / significant resource gap)			VARIATION ACROSS CLUSTERS ‡
	LOW	MID	HIGH	
Strengthening portfolio of research (including curiosity-led, use-inspired and applied research)	68	84	25	*
Contributing to specific societal missions or major innovation challenges	50	94	15	***
Developing and commercialising ideas/technologies emerging from research to open up new opportunities for socio-economic wealth creation	60	78	25	†
Addressing innovation needs of strategically targeted sectors	42	69	26	
Working to raise productivity, efficiency and resilience of organisations	44	56	11	
Working within your local economy to increase innovation and economic prosperity locally	51	88	29	***
Enriching the student experience through entrepreneurship and other knowledge exchange activities	28	37	13	
Building international collaborations to drive innovation & socio-economic impact initiatives	54	79	31	
Supporting the needs of SMEs	40	69	15	**
Addressing workforce/skills development needs of the economy	45	68	37	

*‡ Based on non-parametric Kruskal-Wallis test. Levels of significance *** 1%; ** 5%; * 10%, † 15%*

Summary of key findings

Strategic priorities for universities for the Immediate Recovery period – As we move into the Recovery Period, in terms of R&D activities, most universities (85%) see applied research as particularly important for helping to meet the innovation needs of their partners. In addition, around two-thirds see both use-inspired basic research as well as challenge-driven programmes as important.

Beyond R&D, universities of all types place significant importance on their efforts to work with partners to help them tackle their specific innovation challenges and needs, including helping them to identify new innovation directions and opportunities; and identify/adopt new technologies, processes and systems to improve efficiency, productivity, resilience or to meet regulations and standards. Building networks to better connect organisations to facilitate innovation was also seen as very important for the recovery.

Universities also play an important role in strengthening the capabilities and conditions of the innovation system that underpin the ability of organisations to innovate. Particularly important activities here were efforts to raise the innovation and entrepreneurial culture the innovation systems they operate within and the quality of life of their local areas. Also important for many were activities to develop workforce skills and provide entrepreneurship education. Furthermore, two thirds of universities emphasised their roles in providing leadership, intelligence and expert advice to inform strategic development of innovation systems as important for supporting the recovery.

Emerging strategic opportunities for university innovation-focused activities – Turning to where universities see strategic and viable opportunities for their institutions to contribute to the recovery from the pandemic, many universities of all types saw significant opportunities linked to working within the local economy to increase innovation and economic prosperity. Many also saw enriching the student experience through entrepreneurship and other KE activities as significantly important. For larger, more research-intensive universities, other important opportunities include contributing to specific societal missions and innovation challenges; commercialising emerging technologies to open up new wealth creating opportunities; and continuing to strengthen their portfolio of research that renews the pipeline of potential ideas to drive innovative applications.

Many fewer universities saw viable strategic opportunities moving forward for building international innovation-focused collaborations in the recovery period. This area is regarded as vital in delivering the UK Government's ambition for a 'global' Britain. Similarly, relatively fewer universities identified working to raise productivity, efficiency and resilience of organisations as providing significant viable strategic opportunities, a crucial foundation of the government's Levelling Up ambitions. Additional policy incentives may be needed in both of these areas.
An important finding in relation to the government's Levelling Up strategy is that universities based in less prosperous parts of the UK were much more likely than others to see opportunities in working with their local economy; working to raise productivity and efficiency of partners; working to address the innovation needs of SMEs and of specifically targeted sectors; and working to develop workforce skills.

Resource gaps hindering pursuit of emerging strategic opportunities – Significant resource gaps (including finance and other resources) are hindering universities' pursuit of otherwise viable opportunities for driving innovation in the recovery period. For larger, research-intensive universities, key areas with the greatest resource gaps include: working within the local economy to drive local innovation; contributing to key societal missions and innovation challenges strengthening research portfolios; commercialising ideas and technologies; and working to support the needs of specific sectors.

Crucially, universities in less economically prosperous regions were more likely to identify key resource gaps for pursuing opportunities in areas that will be important for mobilising the university base to deliver on the Levelling Up strategy, in particular working to contribute to innovation in their local economy and supporting the needs of SMEs.

9 Government support for navigating the crisis and recovery

The UK Government, as with governments around the world, took on additional roles and flexed existing tools to mobilise the innovation system in response to the COVD crisis, often deviating from typical pre-pandemic approaches to innovation policy. This included funding programme and other tools to support universities through the crisis. Policymakers are keen to learn lessons from this effort and apply them moving forward into the recovery. This section explores how effective crisis policy interventions were in enabling universities to navigate the crisis, and what further support could be provided to drive an innovation-led economic recovery.

9.1 Effectiveness of government support schemes

The survey explored the effectiveness of selected UK government schemes and funding programmes on the ability of universities to initiate, support and deliver innovation-focused activities and projects through the Ongoing Crisis period. We examined interventions aimed at supporting:

- The 'demand side' – those that supported partners to engage with universities and exploit the knowledge resources of the university to drive innovation. This included the general Coronavirus Job Retention scheme (supporting employers by covering part of the wages of staff placed on furlough) and the suite of schemes put in place to support innovative businesses (such as the New Future Fund, grants/loans for SMEs focusing on R&D, Innovate UK Sustainable Innovation Fund). The job retention scheme could also be used by universities.

- The 'supply side' – those that enabled universities to continue to generate and develop knowledge and other assets to support innovation. This included UKRI's rapid response calls for COVID-19 research, the UKRI/BEIS Sustaining University Research Expertise Fund (SURE), UKRI's changes to grants enabling recipients to re-purpose them to address COVID-19 challenges, and UKRI's grant extension allocations which aimed to provide organisations with resources to sustain UKRI funded research and fellowships (and support for technical and research infrastructures) through the pandemic.

- Interactions that facilitate the flow of knowledge between the supply and demand sides of the innovation system. This included the Research Council's Impact Acceleration Account (IAA) funding, core funding for KE (e.g. Research England's HEIF, Scottish Funding Council's (SFC) University Innovation Fund, HEFCW's Research Wales Innovation Fund, Northern Ireland's HEIF), and other KE funding programmes administered by the funding bodies of the devolved nations.

Respondents were asked to rate their judgement of the effectiveness of each government scheme or programme in helping their organisations to adapt and respond to the crisis on a scale of -5 (significantly negative) to +5 (significantly positive). The distribution of responses across the effectiveness scale and the mean score are shown in Figure 24.

FIGURE 24 **University perceptions of the effectiveness of government funding programmes and schemes on their ability to adapt and respond to the crisis during the Ongoing Crisis period**

Overall, the results reveal a number of key insights (Figure 24). First, funding programmes to support KE between partners and fund the progression and translation of research towards impact were particularly highly valued by universities as they sought to adapt to the crisis and pursue new opportunities. Universities also placed significant value on funding that enabled them to continue their research activities, in particular the block grant for research (quality-related or QR-funding) and additional rapid-response funding being made available to deliver COVID-19 related research. Many also believed that UKRI grant extension allocations and the ability to repurpose UKRI grants to address COVID-19 issues were effective in helping them through the pandemic.

The second insight is the importance of flexible funding during times of crisis for enabling universities to adapt and reconfigure to overcome major challenges and purse new opportunities to contribute to innovation. The three funding programmes with the highest mean score for effectiveness were core KE funding, the impact acceleration account funding, and QR funding for research. It suggests that universities required not just adaptable and responsive leadership and management but also the ability to rapidly reallocate resources to enable entrepreneurial staff to pursue new opportunities. A key characteristic of each of these three funding programmes is their flexibility, with decisions on how to spend the money made at the university or department level, based on local needs and conditions.

The third insight is that very few universities found the BEIS/UKRI Sustaining University Research Expertise Fund very effective in helping them to continue to initiate and deliver their innovation-focused activities and projects. While few say it had a negative effect, 64% of universities said it had no or very limited effect, compared with just 29% saying it had a positive effect.

9.2 Further policy support to enable universities to contribute fully to the economic recovery

Building on views of university leaders on the effectiveness of selected government interventions, the survey also sought views on what actions governments (including UK, devolved nations and regional government) could take over the short term (in the next year) to enable universities to contribute fully to driving innovation during the economic recovery. We developed a framework to analyse the responses[7], drawing on insights from the OECD STIP Taxonomy (EC-OECD, 2020, p.7) on policy areas and themes. We also highlight the historic rationales used to justify policy interventions to address issues in these areas. Findings are shown in Figure 25.

FIGURE 25 **Calls for greater government action**

7 We used a grounded-based approach (Charmaz, 2006, p.24) to capture these views.

9.2.1 Funding for research and KE

More funding for R&D, translation, and commercialisation to drive innovations

Respondents called for higher levels of flexible funding for research (such as QR funding), arguing that this would enable them to be more responsive to long-term research opportunities creating the breakthroughs that will drive the technologies and innovations to tackle the wide range of societal crises in the long-run. Public funding of research activities, such as QR funding, has historically been justified on the grounds of addressing various market failures, where characteristics of knowledge lead economies to systematically under-invest in R&D, resulting in sub-optimal social benefits (Chaminade and Edquist, 2006).

In addition, funding for research has to be accompanied by resources to translate and further develop research ideas and outputs into innovative applications that can unlock new sources of economic and societal wealth. Respondents emphasised the particular value of flexible funding for KE (e.g. HEIF in the UK, University Innovation Fund in Scotland as well as the Research Councils Impact Acceleration Accounts) as well as project and challenge-driven funds to pursue specific opportunities to translate and commercialise research for socio-economic gain. Innovate UK's Knowledge Transfer Partnerships were again singled out as a valued programme, with respondents noting that they are typically heavily oversubscribed.

These findings reinforce those shown in Figure 24 that both KE and QR funding programmes were considered most important in enabling universities to adapt and respond to the pandemic and continue to contribute to driving innovation through the crisis.

In addition to calls for additional funding, respondents also identified various timing-related issues associated with coordinating funding allocations that should be addressed. These included:

- Short notice of funding calls, which inhibited university-partner relationship building and the considered development of proposals
- Extended duration of HEIF allocation decisions, which created uncertainty and inhibited long-term university planning
- Conflicts between funders' expectations for impact to be realised ('quick wins') and university expectations for the length of time required to deliver significant impacts – known as 'time pacing' mismatch (Dougherty et al., 2013)
- Sequencing issues, such as insufficient scaling of funding or follow-on funding through different stages of the innovation chain
- Responsiveness issues concerning the lack of availability of flexible funding in some universities (particularly those that receive little core flexible KE funding) to enable universities to respond rapidly to partner need.

Respondents also reiterated the importance of having stable, recurrent and long-term funding to enable them to build and maintain productive engagement with partners. In particular there were calls for large collaborative programme grants to be for longer than 3 years (5+ year funding programmes were seen as needed); an ability to scale funding through the innovation chain; a slower pace of funding calls; more effective use of pre-call announcements; increased funding flexibility as demonstrated during the pandemic; and increased use of seedcorn funding for large, complex applications.

Justification for policy interventions to address these issues is often made on the grounds of addressing temporal policy coordination failure involving a lack of time-related coordination across different levels and policy areas (Weber and Rohracher, 2012). This type of failure is known to inhibit efforts to encourage innovation-focused activities and foster institutional change (Swan et al., 2010).

9.2.2 Research and innovation for society

More funding to shape innovation direction

As shown in Figure 20, many universities see significant viable strategic opportunities for innovation-focused activities to address major societal problems, exploit technological opportunities and contribute to local and regional development. Policy interventions to address a lack of targeted funding to prioritise innovation-focused activities and infrastructures contributing to acceptable development paths is justified on the grounds of mitigating directionality failures – where policy is expected to shape the direction of innovation towards transformative change (Weber and Rohracher, 2012).

Consistent with this, and in addition to increases in QR and KE funding, respondents called for additional funding in the following areas:

- Place-making funding to enable universities to respond to local COVID recovery-related needs and regional development priorities, notably the Shared Prosperity fund (SPF) and Connecting Capabilities Fund (CCF)
- Challenge-driven funding to enable universities to contribute to tackling global challenges and sustainable development goals, including capital funding for research infrastructures and funding for capability-building
- Funding for breakthrough research, particularly for emerging medicine and deep technology opportunities.

9.2.3 System governance & strategic direction

Improved monitoring, anticipation and involvement in self-governance

As the importance of sustainability and equity within innovation policy increases, issues associated with how innovation systems are governed and how the strategic direction of innovation is decided become crucial.

Respondents raised several issues related to the involvement of a range of actors in governance processes and the ability of these actors to draw upon a monitoring, anticipation, evaluation, and impact assessment system to aid decision-making, including:

- Lack of fora involving government, the private and third sectors, and universities to identify, discuss, agree, and address system challenges
- Insufficient decision-making responsibilities delegated to local stakeholders (e.g. to Metro Mayors, universities) for the design of programmes tailored to local development priorities and contexts
- Insufficient strategic policy intelligence arrangements (such as dissemination of knowledge on how the benefits of research and innovation are realised and may be anticipated)
- High cost of responding to calls to participate in evidence-based assessments of research, KE, and innovation activities for small institutions (such as KEF, KE Concordat and the HE-BCI survey).

Policy interventions to address such issues are justified on the grounds of addressing reflexivity failures – where the innovation system cannot sufficiently monitor, anticipate, and involve the variety of actors – often distributed across the innovation system – in processes of self-governance over the long time periods associated with transformative change (Weber and Rohracher, 2012).

Improved coordination and coherence across levels and areas of policy

In addition to issues related to the temporal coordination of funding discussed above, other policy coordination issues were also raised by respondents.

First, respondents raised questions related to opportunities associated with, and implementation of, certain instruments and policies, including:

- Whether the scale and scope of the European Regional Development Fund will be sustained by the Shared Prosperity Fund

- How any redistribution of funding from universities in better-off to worse-off regions within the Levelling Up strategy that may lead to decreased overall benefits will be addressed. This is known as the 'levelling down objection' (Parfit, 2002)
- Whether efforts to address geographical disparities within the 'levelling-up agenda' will, for political reasons, prioritise broadened participation for certain regions and areas (e.g. North of England) over others (e.g. Northern Ireland, South West, and very deprived areas within the more affluent regions in London and the South East)
- How the UK government's commitment will achieve the ambitions to increase spending on R&D to 2.4% of GDP, and how it will resource the delivery of the Innovation Strategy (BEIS, 2021).

Second, respondents described areas of conflicting priorities for universities arising from insufficient 'horizontal' coordination across government departments, including:

- Cuts to undergraduate fees, which would negatively impact innovation-focused activities
- Cuts to Overseas Development Assistance funding, which has had a detrimental impact on innovation-focused activities
- Funding research at less than full economic cost, which has impeded translational activities.

Third, respondents suggested several improvements to address issues related to a mismatch between the strategic intention of policies and their implementation, including:

- Focusing on driving collaborative, rather than competitive, approaches to the recovery through large-scale funding programmes aimed at driving transformative impact
- Addressing lengthy and bureaucratic processes of the Shared Prosperity Fund
- Augmenting the Shared Prosperity Fund with hypothecated and outcomes-based QR linked to specific desired outcomes such as regional prosperity and further HEIF funding
- Better enabling and funding collaborations between universities and regions at geographic scales determined by need rather than focusing on administrative geographies such as individual Local Enterprise Partnership areas
- Investing in capital infrastructure to support regional needs.

The justification for policy interventions to address these types of issues is generally based on addressing policy coordination failures – barriers which arise in the interaction of different levels and areas of policies relevant to transformative change (Weber and Rohracher, 2012).

9.2.4 Stimulating demand

Targeted support for specific partners and sectors

In addition to these 'supply side' issues, respondents also called for action to strengthen the 'demand side' for innovation-focused KE. We discussed earlier how the pandemic's effects have varied across both sectors of the economy and partner types (Sections 4.1 and 4.2). To address this issue, respondents called for additional financial support targeted at innovation-focused activities involving these sectors and partners, particularly for:

- Innovation-focused SMEs and firms badly hit by the pandemic to help them build resilience (one respondent noted that universities were well-placed to identify these firms)
- Third sector organisations, and sectors badly affected by the pandemic (e.g. social care, arts, heritage).

Policy interventions targeted at specific sectors and partners have been justified on the grounds that the pandemic has exacerbated externalities – where production or consumption of a good or service impacts an unrelated third party (Arnold et al., 2014) – that lead to reduced R&D spending. This reduction in spending has affected levels of university innovation-focused activities asymmetrically across sectors and partner types, and governments have a role in actively addressing this issue (Stiglitz, 2021; Stiglitz and Guzman, 2021).

Building partner capabilities for innovation
Demand is also affected by the levels of appropriate competencies and resources of partners, which enables them to participate and benefit from innovation-focused partnerships with universities. In order to boost demand, respondents also called for:

- Additional funding to build capabilities of SMEs in order to broaden participation in innovation. One respondent noted that their university had successfully introduced 'lite' knowledge transfer partnerships (KTP), suitable for businesses with insufficient capabilities to exploit full KTPs, and called for a national-level programme based on this model.

- Mechanisms to promote the value of research and innovation diffusion in regions of low innovation maturity. Recent innovation strategies in the US (US Congress, 2021) and Germany (BMBF, 2018) are addressing this issue through a mix of instruments including open innovation networks; provision of R&D services; and establishment of demonstration and testing facilities.

Policy interventions to build partner capabilities are typically justified on the grounds of addressing capability and learning failures in the innovation system – i.e. whether organisations hold sufficient competencies and resources to enable them to access new knowledge, learn, and adopt new technologies over time (Chaminade and Edquist, 2006).

9.2.5 Talent/workforce development

Building internal and system capabilities for innovation

In addition to the need to build partner innovation capabilities described above, respondents also called for additional support to build capabilities both within the university and more broadly within innovation systems. These included:

- Recruitment and development of university staff, particularly KE professionals, which a number of respondents described as impeding the ability of universities to seize innovation opportunities

- Attraction of international research and KE talent to UK universities

- Building student entrepreneurial skills

- Facilitating mobility of staff between academia and industry

- Building workforce skills (technical skills, continuing professional development, resilient leadership skills and skills tailored to regional requirements).

Again, interventions to address these issues would be justified on the grounds of addressing capability and learning failures in the innovation system.

9.2.6 Networks and collaborative platforms

Finally, respondents made a number of suggestions to create or strengthen network links and platforms for collaborations in order to better enable innovation, including:

- Programmes to build pre-competitive R&D consortia

- Programmes to develop capacities to build regional innovation systems, with the MIT REAP programme cited as an example (MIT, 2017)

- Programmes to build international collaborative platforms

- Enhanced jointly-funded collaborations between universities and Catapults.

Internationally, there are some interesting examples of programmes in these areas. These include pre-competitive R&D consortia such as Germany's Industrial Collective Research (IGF) programme (BMBF, 2018); regional innovation system capacity building programmes such as Germany's WIR! programme (BMBF, 2018) and the US Regional Technology Hubs (US Congress, 2021); and a variety of international collaborative platforms which emerged to coordinate the COVID R&D response (OECD, 2021, pp.122–143).

Policy interventions such as these have been historically justified on the grounds of addressing weak network failures – i.e. where weak or missing network links limit best practice diffusion and hamper mutual learning and awareness of sources of complementary knowledge (Weber and Rohracher, 2012).

Summary of key findings

Effectiveness of government support schemes – The UK Government and the devolved administrations have made efforts to help universities through the crisis, whether through creating new funding programmes, or expanding or revising existing programmes. Funding programmes that enabled flexibility and decentralised decision-making at the university or department level were regarded as most effective in enabling universities and academics to rapidly respond, adapt, and reconfigure to overcome major challenges, drive the translation of ideas into applications, and purse new opportunities to contribute to innovation. These programmes included core KE funding, impact acceleration account funding, and QR funding for research. They also include UKRI's rapid response grants to tackle COVID-related problems, and the ability to repurpose existing grants to focus on COVID. Few universities found the BEIS/UKRI Sustaining University Research Expertise Fund to have a positive effect in helping them to continue to initiate and deliver innovation-focused activities, with many saying it had no or very limited effect.

Further policy support to enable universities to contribute fully to the economic recovery – Building on the value placed on flexible funding in responding to the crisis, universities called for higher levels of flexible funding for research (such as QR funding) and core KE funding to enable them to be more responsive to long-term opportunities to both create breakthroughs that will drive technologies and innovations, and leverage their existing knowledge bases and resources to help their partners innovate. In addition, universities also called for additional resources to enable them to actively engage in addressing innovation-related endeavours to tackle major societal problems, exploit technological opportunities and contribute to local and regional development. Universities reiterated the importance of having stable, recurrent, and long-term funding programmes.

A variety of timing related issues associated with the coordination of funding allocations were identified, including short notice of funding calls; extended duration of HEIF allocation decisions; mismatched funder/university expectations for the time needed for impact realisation; and funding sequencing issues. Further, the need to improve coordination and coherence between funding programmes and incentives across different levels (e.g. regional vs national) and areas of policy; and across different government departments was highlighted. Greater coherence was also called for between the strategic intention of policies and their implementation.

Universities also called for action to strengthen the 'demand side' for innovation-focused KE, in particular to help innovation-focused SMEs, third sector organisations and those sectors badly affected by the pandemic. Additional funding to build capabilities of SMEs to broaden participation in innovation, and mechanisms to promote the value of research and innovation diffusion in regions of low innovation maturity were also called for.

Respondents also called for additional support to build capabilities to collaborate and innovate within the innovation system, including within the university (e.g. to recruit and retain staff to deliver KE and translational/innovation activities, and to attract international talent to universities) and to build entrepreneurial and workforce skills within the wider economy.

Lastly, universities called for greater efforts to help them build and strengthen networks to facilitate innovation and platforms to drive collaborations, such as pre-competitive R&D consortia, regional technology clusters, and international research and innovation platforms.

References

Agarwal, R. and Gaule, P. (2021) What drives innovation? Lessons from COVID-19 R&D. Washington D.C., International Monetary Fund WP/21/48.

Ambos, T.C., Mäkelä, K., Birkinshaw, J. and Este, P.D. (2008) 'When does university research get commercialized? Creating ambidexterity in research institutions', Journal of Management Studies, 45(8), pp. 1424–1447.

Antonioli, D., Bianchi, A., Mazzanti, M., Montresor, S. and Pini, P. (2013) 'Innovation strategies and economic crisis: Evidence from firm-level Italian data', Economia Politica, 30(1), pp. 33–68.

Archibugi, D., Filippetti, A. and Frenz, M. (2013a) 'The impact of the economic crisis on innovation: Evidence from Europe', Technological Forecasting and Social Change, 80(7), pp. 1247–1260.

Archibugi, D., Filippetti, A. and Frenz, M. (2013b) 'Economic crisis and innovation: Is destruction prevailing over accumulation?', Research Policy, 42(2), pp. 303–314.

Arnold, E., Farla, K., Kolarz, P. and Potau, X. (2014) The case for public support of innovation: At the sector, technology and challenge area levels. London: Technopolis, Report for the Department for Business, Innovation and Skills.

Bailey, D., Clark, J., Colombelli, A., Corradini, C., De Propris, L., Derudder, B., Fratesi, U., Fritsch, M., Harrison, J., Hatfield, M., Kemeny, T., Kogler, D.F., Lagendijk, A., Lawton, P., Ortega-Argilés, R., Otero, C.I. and Usai, S. (2020) 'Regions in a time of pandemic', Regional Studies, 54(9), pp. 1163–1174.

Barrero, J.M., Bloom, N. and Davis, S.J. (2020) COVID-19 Is also a reallocation shock. Cambridge, MA: Working paper 27137, National Bureau of Economic Research.

BEIS (2021) UK innovation strategy: Leading the future by creating it. London: Department of Business Energy and Industrial Strategy.

Bercovitz, J.E.L.L. and Feldman, M.P. (2007) 'Fishing upstream: Firm innovation strategy and university research alliances', Research Policy, 36(7), pp. 930–948.

Betz, F. (1997) 'Academic/government/industry strategic research partnerships', Journal of Technology Transfer, 22(3), pp. 9–15.

Bloom, N., Bunn, P., Mizen, P., Smietanka, P. and Thwaites, G. (2020) The impact of COVID-19 on productivity. London: Staff Working Paper No. 900, Bank of England.

BMBF (2018) Research and innovation that benefit the people: The High-tech strategy 2025. Berlin: Bundesministerium für Bildung und Forschung.

Boschma, R. (2005) 'Proximity and innovation: A critical assessment', Regional Studies, 39(1), pp. 61–74.

Breznitz, S.M. and Feldman, M.P. (2012) 'The engaged university', Journal of Technology Transfer, 37(2), pp. 139–157.

Bryan, K.A., Lemus, J. and Marshall, G. (2020) Crises and the direction of innovation. Available at SSRN: https://ssrn.com/abstract=3587973 or http://dx.doi.org/10.2139/ssrn.3587973.

Caraça, J., Lundvall, B.Å. and Mendonça, S. (2009) 'The changing role of science in the innovation process: From Queen to Cinderella?', Technological Forecasting and Social Change, 76(6), pp. 861–867.

Castillejo, J.A.M., Barrachina, M.E.R. and Sanchis-Ilopis, J.A. (2019) SMEs' strategies to face the onset of the great recession. Valencia, Spain: Working Paper no. 1910, Department of Applied Economics II, Universidad de Valencia.

Chaminade, C. and Edquist, C. (2006) Rationales for public policy intervention from a systems of innovation approach: The case of VINNOVA. Lund, Sweeden: Paper 2006/04, Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE).

Charmaz, K. (2006) Constructing grounded theory: A practical guide through qualitative analysis. London, New York and Delhi: Sage.

Chesbrough, H. (2020) 'To recover faster from COVID-19, open up: Managerial implications from an open innovation perspective', Industrial Marketing Management, 88, pp. 410–413.

Clark, B.R. (1998) Creating entrepreneurial universities: Organisational pathways of transformation. New York: Pergamon Press.

Clark, B.R. (2004) 'Delineating the character of the entrepreneurial university', Higher Education Policy, 17(4), pp. 355–370.

Cohen, W.M. and Levinthal, D.A. (1989) 'Innovation and learning: The two faces of R&D', The Economic Journal, 99(397), pp. 569–596.

Cohen, W.M., Nelson, R.R. and Walsh, J.P. (2002) 'Links and impacts: The influence of public research on industrial R&D', Management Science, 48(1, Special Issue), pp. 1–23.

Collins, F.S. and Stoffels, P. (2020) 'Accelerating COVID-19 therapeutic interventions and vaccines (ACTIV): An unprecedented partnership for unprecedented times', JAMA - Journal of the American Medical Association, 323(24), pp. 2455–2457.

Contreras, J.L. (2021) 'The Open COVID Pledge: Design, implementation and preliminary assessment of an intellectual property commons', Utah Law Review, 2021(4), art. 4.

Crisp, R. and Waite, D. (2020) Inclusive growth under a COVID-19 recovery. Sheffield, UK: Centre for Regional Economic and Social Research, Sheffield Hallam University.

CSET (2021) Outline of the People's Republic of China 14th five-year plan for national economic and social development and long-range objectives for 2035. Washington D.C.: Centre for Security and Emerging Technology.

Cuesta-Claros, A., Malekpour, S., Raven, R. and Kestin, T. (2021) 'Understanding the roles of universities for sustainable development transformations: A framing analysis of university models', Sustainable Development, doi: 10.1002/sd.2247.

Denyer, D. (2017) Organizational resilience: A summary of academic evidence, business insights and new thinking. Bedford, UK: BSI and Cranfield School of Management.

Dougherty, D., Bertels, H., Chung, K., Dunne, D.D. and Kraemer, J. (2013) 'Whose time is it? Understanding clock-time pacing and event-time pacing in complex innovations', Management and Organization Review, 9(2), pp. 233–263.

van Driel, H. and Schot, J. (2005) 'Radical innovation as a multilevel process: introducing floating grain elevators in the Port of Rotterdam', Technology and Culture, 46(1), pp. 51–77.

Ebersberger, B. and Kuckertz, A. (2021) 'Hop to it! The impact of organization type on innovation response time to the COVID-19 crisis', Journal of Business Research, 124, pp. 126–135.

EC-OECD (2020) STIP compass taxonomies describing STI policy data, edition 2019. Paris: OECD Publishing.

EC (2020) The role of research and innovation in Europe's recovery. Brussels: European Commission.

Edler, J. and Georghiou, L. (2007) 'Public procurement and innovation - Resurrecting the demand side', Research Policy, 36(7), pp. 949–963.

Flammer, C. and Ioannou, I. (2021) 'Strategic management during the financial crisis: How firms adjust their strategic investments in response to credit market disruptions', Strategic Management Journal, 42(7), pp. 1275–1298.

Foa, R.S., Klassen, A., Slade, M., Rand, A. and Collins, R. (2020) The global satisfaction with democracy report 2020. Cambridge, UK: Centre for the Future of Democracy, University of Cambridge.

Foa, R.S., Romero-Vidal, X., Klassen, A.J., Fuenzalida Concha, J., Quednau, M. and Fenner, L.S. (2022) The great reset: Public opinion, populism, and the pandemic. Cambridge, UK: Centre for the Future of Democracy, University of Cambridge.

Freeman, G. (2022) A global research and innovation powerhouse: The role for our leading institutions. Speech to Cambridge Centre for Science & Policy. Available at: https://www.csap.cam.ac.uk/events/george-freeman-lecture-2022/ (Accessed: 10 May 2022).

Geels, F.W. and Schot, J. (2007) 'Typology of sociotechnical transition pathways', Research Policy, 36(3), pp. 399–417.

Georgieva, K. (2020) A new Bretton Woods moment. Available at: https://www.imf.org/en/News/Articles/2020/10/15/sp101520-a-new-bretton-woods-moment (Accessed: 13 December 2021).

Griffith-Jones, S. and Cozzi, G. (2016) 'Investment-led growth: A solution to the European crisis', in Jacobs, M. and Mazzucato, M. (eds.) Rethinking capitalism: Economics and policy for sustainable and inclusive growth. Chichester: Wiley-Blackwell.

Gross, D.P. and Sampat, B.N. (2021) 'The economics of crisis innovation policy: A historical perspective', AEA Papers and Proceedings, 111, pp. 346–350.

Gunasekara, C. (2006) 'Reframing the role of universities in the development of regional innovation systems', Journal of Technology Transfer, 31(1), pp. 101–113.

Guston, D.H. (2000) Between politics and science: Assuring the productivity and integrity of research. Cambridge, UK: Cambridge University Press.

Guston, D.H. and Keniston, K. (1994) The fragile contract: University science and the federal government. Cambridge, MA and London: MIT Press.

Guzmán-Valenzuela, C. (2016) 'Unfolding the meaning of public(s) in universities: Toward the transformative university', Higher Education, 71(5), pp. 667–679.

HM Government (2020) UK research and development roadmap. London: HMSO.

HM Government (2021) Global Britain in a compatitive age: The integrated review of security, defence, development and foreign policy. London: HMSO.

HM Treasury (2021) Build back better: Our plan for growth. London: HMSO.

Huggins, R. (2010) 'Forms of network resource: Knowledge access and the role of inter-firm networks', International Journal of Management Reviews, 12(3), pp. 335–352.

Hughes, A. and Kitson, M. (2014) Connecting with the Ivory Tower: Business perspectives on knowledge exchange in the UK. Cambridge, UK: Centre for Business Research, University of Cambridge and UK Innovation Research Centre.

Hughes, A. and Kitson, M. (2012) 'Pathways to impact and the strategic role of universities: New evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development', Cambridge Journal of Economics, 36(3), pp. 723–750.

Hughes, A., Kitson, M., Probert, J., Bullock, A. and Milner, I. (2011) Hidden connections: Knowledge exchange between the arts and humanities and the private, public and third sectors. Swindon, UK: Report to the Arts & Humanities Research Council by the Centre for Business Research, University of Cambridge.

Hughes, A., Lawson, C., Kitson, M., Salter, A., Bullock, A. and Hughes, R.B. (2016) The changing state of knowledge exchange: UK academic interactions with external organisations. London: National Centre for Universities and Business.

IMF (2021) World economic outlook: Managing divergent recoveries. Washington, DC: International Monetary Fund.

Jacobsson, S. and Vico, E.P. (2010) 'Towards a systemic framework for capturing and explaining the effects of academic R&D', Technology Analysis and Strategic Management, 22(7), pp. 765–787.

Johnstone, P. and McLeish, C. (2020) The 'COVID war'? Reflections on mechanisms and imprints of the COVID-19 pandemic. Brighton, UK: University of Sussex Deep Transitions working paper DT2020—05.

Jung, H., Hwang, J.T. and Kim, B.K. (2018) 'Does R&D investment increase SME survival during a recession?', Technological Forecasting and Social Change, 137, pp. 190–198.

Kelleher, L. and Ulrichsen, T.C. (2022) Innovation policy and the university system in times of crisis and recovery: What we know and what it means. Cambridge, UK: University Commercialisation and Innovation Policy Evidence Unit.

Kitson, M., Howells, J., Braham, R. and Westlake, S. (2009) The connected university: Driving recovery and growth in the UK economy. London: Nesta.

Kline, S.J. and Rosenberg, N. (1986) 'An overview of innovation', in Landau, R. and Rosenberg, N. (eds.) The positive sum strategy: Harnessing technology for economic growth. Washington, D.C.: National Academy of Sciences, pp. 275–305.

Laperche, B., Lefebvre, G. and Langlet, D. (2011) 'Innovation strategies of industrial groups in the global crisis: Rationalization and new paths', Technological Forecasting and Social Change, 78(8), pp. 1319–1331.

Lazonick, W. and Mazzucato, M. (2013) 'The risk-reward nexus in the innovation-inequality relationship: Who takes the risks? Who gets the rewards?', Industrial and Corporate Change, 22(4), pp. 1093–1128.

Lee, Y.S. (2000) 'The sustainability of university-industry research collaboration: An empirical assessment', Journal of Technology Transfer, 25(2), pp. 111–133.

Leih, S. and Teece, D. (2016) 'Campus leadership and the entrepreneurial university: A dynamic capabilities perspective', Academy of Management Perspectives, 30(2), pp. 182–210.

Lester, R.K. (2005) Universities, innovation, and the competitiveness of local economies: A summary report from the local innovation systems project—Phase I. Cambridge, MA: MIT.

Lewis, M.W., Andriopoulos, C. and Smith, W.K. (2014) 'Paradoxical leadership to enable strategic agility', California Management Review, 56(3), pp. 58–77.

Lynch, H.F., Caplan, A., Furlong, P. and Bateman-House, A. (2021) 'Helpful lessons and cautionary tales: How should COVID-19 drug development and access inform approaches to non-pandemic diseases?', American Journal of Bioethics, 21(12), pp. 4–19.

Martin, R. (2021) 'Rebuilding the economy from the COVID crisis: Time to rethink regional studies?', Regional Studies, Regional Science, 8(1), pp. 143–161.

Mazzucato, M., Kattel, R. and Ryan-Collins, J. (2020) 'Challenge-driven innovation policy: Towards a new policy toolkit', Journal of Industry, Competition and Trade, 20(2), pp. 421–437.

Meyer, A.D. (1982) 'Adapting to environmental jolts', Administrative Science Quarterly, 27(4), pp. 515–537.

MIT (2017) MIT REAP Regional Entrepreneurship Acceleration Program. Available at: https://reap.mit.edu (Accessed: 14 February 2022).

van Mossel, A., van Rijnsoever, F.J. and Hekkert, M.P. (2018) 'Navigators through the storm: A review of organization theories and the behavior of incumbent firms during transitions', Environmental Innovation and Societal Transitions, 26(July), pp. 44–63.

NCUB and UCI (2021) Innovation and resilience in a crisis: The impact of COVID-19 on UK business R&D. London: National Centre for Universities and Business.

OECD (2021) OECD science, technology and innovation outlook 2021: Times of crisis and opportunity. Paris: OECD Publishing.

OECD (2020) Building back better - A sustainable, resilient recovery after COVID-19. Paris: OECD Publishing.

Parfit, D. (2002) 'Equality or priority?', in Clayton, M. and Williams, A. (eds.) The ideal of equality. New York: Palgrave Macmillan, pp. 81–125.

Parker, R. and Lundgren, P. (2022) 'The role of universities in transformative innovation policy', Science and Public Policy, 49(2), pp. 159–167.

Patrucco, A.S., Trabucchi, D., Frattini, F. and Lynch, J. (2022) 'The impact of COVID-19 on innovation policies promoting open innovation', R&D Management, 52(2), pp. 273–293.

Paunov, C. and Planes-Satorra, S. (2021a) What future for science, technology and innovation after COVID-19? Paris: OECD Publishing.

Paunov, C. and Planes-Satorra, S. (2021b) Science, technology and innovation in the time of COVID-19. Paris: OECD Publishing.

Paunov, C., Planes-Satorra, S. and Moriguchi, T. (2017) What role for social sciences in Innovation? Reassessing how scientific disciplines contribute to different industries. Paris: Science, Technology and Innovation Policy Paper No. 45, OECD Publishing.

Perkmann, M., Salandra, R., Tartari, V., McKelvey, M. and Hughes, A. (2021) 'Academic engagement: A review of the literature 2011-2019', Research Policy, 50, p. 104114.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A. and Sobrero, M. (2013) 'Academic engagement and commercialisation: A review of the literature on university–industry relations', Research Policy, 42(2), pp. 423–442.

Perrow, C. (1984) Normal accidents: Living with high-risk technologies. New York: Basic Books.

Rohe, W. (2017) 'The contract between society and science: Changes and challenges', Social Research, 84(3), pp. 739–758.

Roper, S. and Turner, J. (2020) 'R&D and innovation after COVID-19: What can we expect? A review of prior research and data trends after the great financial crisis', International Small Business Journal: Researching Entrepreneurship, 38(6), pp. 504–514.

Sánchez-Barrioluengo, M. and Benneworth, P. (2019) 'Is the entrepreneurial university also regionally engaged? Analysing the influence of university's structural configuration on third mission performance', Technological Forecasting & Social Change, 141, pp. 206–218.

Schot, J. (2020) 'Interpreting COVID-19 through the lens of the second Deep Transition', Ökologisches Wirtschaften, 3(35), pp. 19–21.

Schot, J. and Steinmueller, W.E. (2018) 'Three frames for innovation policy: R&D, systems of innovation and transformative change', Research Policy, 47(9), pp. 1554–1567.

Schumpeter, J. (1942) Capitalism, socialism, and democracy. New York: Harper and Brothers.

Schwab, K. and Malleret, T. (2020) COVID 19. The great reset. Cologny, Switzerland: World Economic Forum.

Science and Technology Select Committee (2021) Government R&D funding in 2021. Available at: https://parliamentlive.tv/event/index/f6cb5d98-d689-4b98-8a8a-5de37777ab7e (Accessed: 10 June 2021).

Soininen, J., Puumalainen, K., Sjögrén, H. and Syrjä, P. (2012) 'The impact of global economic crisis on SMEs: Does entrepreneurial orientation matter?', Management Research Review, 35(10), pp. 927–944.

Spescha, A. and Woerter, M. (2019) 'Innovation and firm growth over the business cycle', Industry and Innovation, 26(3), pp. 321–347.

Stern, N., Unsworth, S., Valero, A., Zenghelis, D., Rydge, J. and Robins, N. (2020) Strategy, investment and policy for a strong and sustainable recovery: An action plan. London: CEP Paper 005, LSE Centre for Economic Performance.

Stern, N. and Valero, A. (2021) 'Innovation, growth and the transition to net-zero emissions', Research Policy, 50(9), p. 104293.

Stiglitz, J.E. (2021) 'The proper role of government in the market economy: The case of the post-COVID recovery', Journal of Government and Economics, 1, p. 100004.

Stiglitz, J.E. (2016) 'Inequality and economic growth', in Jacobs, M. and Mazzucato, M. (eds.) Rethinking capitalism. Chichester: Wiley-Blackwell.

Stiglitz, J.E. and Guzman, M.M. (2021) 'The pandemic economic crisis, precautionary behavior, and mobility constraints: An application of the dynamic disequilibrium model with randomness', Industrial and Corporate Change, 30(2), pp. 467–497.

Stilgoe, J., Owen, R. and Macnaghten, P. (2013) 'Developing a framework for responsible innovation', Research Policy, 42(9), pp. 1568–1580.

Stokes, D.E. (1997) Pasteur's quadrant: Basic science and technological innovation. Washington D.C.: Brookings Institution Press.

Swan, J., Bresnen, M., Robertson, M., Newell, S. and Dopson, S. (2010) 'When policy meets practice: Colliding logics and the challenges of "Mode 2" initiatives in the translation of academic knowledge', Organization Studies, 31(9–10), pp. 1311–1340.

Teece, D.J. (2018) 'Managing the university: Why "organized anarchy" is unacceptable in the age of massive open online courses', Strategic Organization, 16(1), pp. 92–102.

Teece, D.J. (2014) 'The foundations of enterprise performance: Dynamic and ordinary capabilities in an (economic) theory of firms', Academy of Management Perspectives, 28(4), pp. 328–352.

Thomas, C. and Nanda, S. (2021) Research at risk: Mitigating the impact of COVID-19 on health R&D investment. London: Institute for Public Policy Research.

Tietze, F., Vimalnath, P., Aristodemou, L. and Molloy, J. (2020) 'Crisis-critical intellectual property: Findings from the COVID-19 pandemic', IEEE Transactions on Engineering Management, June, doi: 10.1109/TEM.2020.2996982.

Trencher, G., Yarime, M., McCormick, K.B., Doll, C.N.H. and Kraines, S.B. (2014) 'Beyond the third mission: Exploring the emerging university function of co-creation for sustainability', Science and Public Policy, 41(2), pp. 151–179.

Ulrichsen, T.C. (2021) Innovating during a crisis: The effects of the COVID-19 pandemic on how universities contribute to innovation. London: National Centre for University and Business, and UCI Policy Evidence Unit, University of Cambridge.

Ulrichsen, T.C. (2019) Developing university-industry partnerships fit for the future. Oxford, UK: Report for Oxford-UIDP Summit 2019. University of Oxford.

Ulrichsen, T.C. (2018) Knowledge exchange framework metrics: A cluster analysis of higher education institutions. Cambridge, UK: Technical report for Research England. UCI Policy Evidence Unit, University of Cambridge.

Ulrichsen, T.C. (2022) Rising to the challenge: Mobilising university-industry-government partnerships to lead an innovation-driven recovery (forthcoming). Oxford Summit 2021 Insights Report. University of Oxford: Oxford, UK.

US Congress (2021) United States Innovation and Competition Act of 2021. S.1260, 117th Congress (2021-2022). https://www.congress.gov/bill/117th-congress/senate-bill/1260.

Uyarra, E. (2010) 'Conceptualizing the regional roles of universities, implications and contradictions', European Planning Studies, 18(8), pp. 1227–1246.

Wang, L., Zhang, M. and Verousis, T. (2021) 'The road to economic recovery: Pandemics and innovation', International Review of Financial Analysis, 75, p. 101729.

Wanzenböck, I., Wesseling, J.H., Frenken, K., Hekkert, M.P. and Weber, K.M. (2020) 'A framework for mission-oriented innovation policy: Alternative pathways through the problem-solution space', Science and Public Policy, 47(4), pp. 474–489.

Weber, K.M. and Rohracher, H. (2012) 'Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive "failures" framework', Research Policy, 41(6), pp. 1037–1047.

Winch, G.M., Cao, D., Maytorena-Sanchez, E., Pinto, J., Sergeeva, N. and Zhang, S. (2021) 'Operation Warp Speed: Projects responding to the COVID-19 pandemic', Project Leadership and Society, 2, p. 100019.

Wucker, M. (2017) The gray rhino: How to recognize and act on the obvious dangers we ignore. New York: St. Martin's Press.

Youtie, J. and Shapira, P. (2008) 'Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development', Research Policy, 37(8), pp. 1188–1204.

Zenghelis, D. (2016) 'Decarbonisation: Innovation and the economics of climate change', in Jacobs, M. and Mazzucato, M. (eds.) Rethinking capitalism. Chichester: Wiley-Blackwell.

Appendix A: KE clusters and their characteristics

The UK university system consists of a diversity of universities in terms of their scale, disciplinary focus, resources, and expertise, all of which shape where and how they are able to contribute within the innovation system. This diversity of universities is important, with different institutions working with different types of economic and social actors, and contributing in different ways to tackle socio-a wide variety of economic, technological, industrial and regional challenges. An attempt to identify and cluster English universities into similar types was undertaken in Ulrichsen (2018). The analysis treated specialist institutions (e.g. focusing on the arts or STEM disciplines) as distinct and having a unique character and KE opportunity potential compared to broad discipline HEIs. The cluster analysis was applied to broad discipline HEIs and resulted in five clusters of institution with broadly similar structural characteristics that are likely to affect how they engage with external partners to develop, exchange and deploy knowledge. These clusters now underpin the English Knowledge Exchange Framework (KEF) for English universities. To support this study, we extended the clusters to incorporate Scottish, Welsh, and Northern Irish universities.

FIGURE A.1 **Disaggregating the English HE sector into clusters of similar universities**

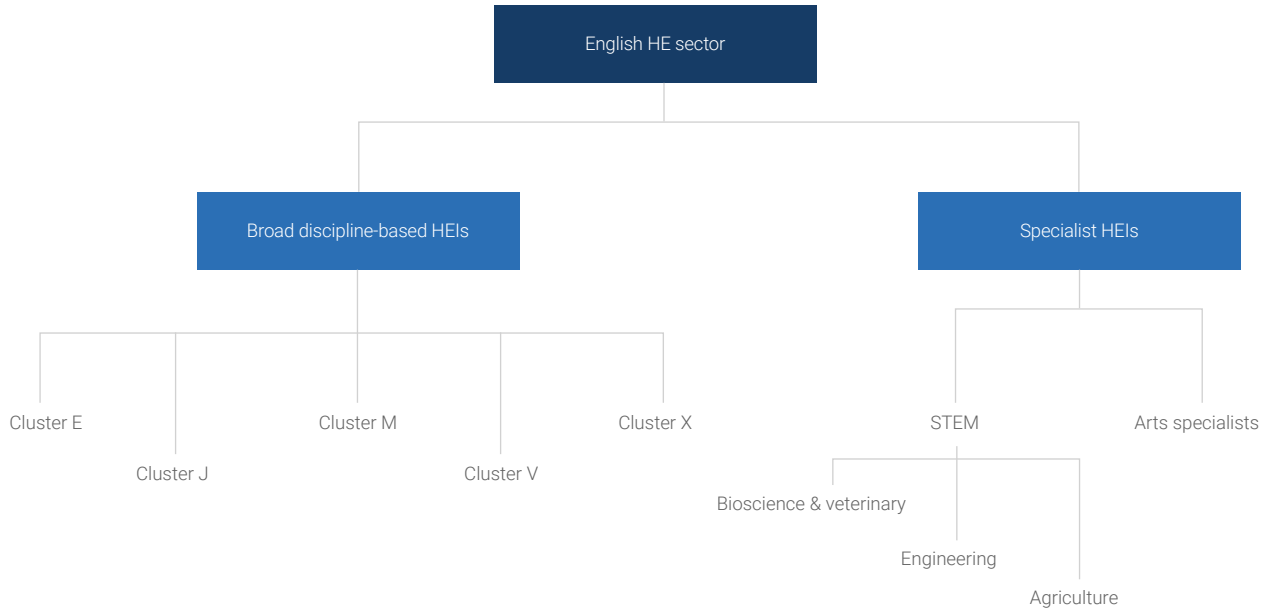


TABLE A.1 **KE cluster characteristicsImmediate Recovery Period (percentage of universities identifying moderate or significant resource gaps)**

CLUSTER	CHARACTERISTICS
Cluster E	• Large universities with broad discipline portfolio across both STEM and non-STEM generating excellent research across all disciplines • Significant amount of research funded by gov't bodies/hospitals; average of 9.5% from industry. • Large proportion of part-time undergraduate students. Small postgraduate population dominated by taught postgraduates.
Cluster J	• Mid-sized universities with more of a teaching focus (although research is still in evidence) • Academic activity across STEM and non-STEM disciplines including other health, computer sciences, architecture/ planning, social sciences and business, humanities, arts and design • Research activity funded largely by government bodies/hospitals; average of 13.7% from industry
Cluster M	• Smaller universities, often with a teaching focus • Academic activity across disciplines, particularly in other health domains and non-STEM • More research activity funded by gov't bodies/hospitals; average of 14.7% from industry.
Cluster V	• Very large, very high research intensive and broad-discipline universities undertaking significant amounts of excellent research • Research funded by range of sources including UKRI, other government bodies and charities. Average of 10.2% from industry. • Significant activity in clinical medicine and STEM • Student body includes significant numbers of taught and research postgraduates.
Cluster X	• Large, high research intensive and broad-discipline universities undertaking a significant amount of excellent research • Much of research funded by UKRI and other government bodies. Average of 8.5% from industry • Discipline portfolio balanced across STEM and non-STEM although less or no clinical medicine activity • Large proportion of taught postgraduates in student population
Arts specialists	• Specialist institutions covering arts, music and drama (as defined by a very high concentration of academic staff in these disciplines). A range of sizes of institutions, although many are relatively small and specialist.
Science, Technology, Engineering and Maths (STEM) specialists	• Specialist institutions covering science, technology, engineering and mathematics (as defined by a very high concentration of academic staff in these disciplines). Often high amounts of excellent research, particularly in bioscience & veterinary and engineering. • Note: This group has been further split into three groups to highlight the different nature of institutions within the 'STEM' umbrella.

Source: Research England (2020) Knowledge Exchange Framework: Clustering and Narrative Statements, available at https://www.ukri.org/wp-content/uploads/2021/10/RE-01102021-KEFClusteringNarrativeTemplateReport-Oct21deadline.pdf

UNIVERSITY OF CAMBRIDGE

UCI POLICY EVIDENCE UNIT

National Centre for Universities and Business

University Commercialisation and Innovation Policy Evidence Unit
Institute for Manufacturing, University of Cambridge, 17 Charles Babbage Road, CB3 0FS