THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

SCENARIOS FOR A SCIENCE SUPERPOWER

Exploring visions of a research-intensive UK

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Since joining UCL, Graeme spent several years as specialist advisor to the House of Lords Science and Technology Committee. He led reviews of research and innovation policy for the Scottish Funding Council, the Welsh Government and Universities Wales. During the approach to Brexit, Sir Adrian Smith and Graeme prepared a report for the UK science minister on frameworks for international collaboration.

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Introduction

For at least 20 years, successive Governments have put research and innovation at the heart of their programmes for growth. Public spending and private sector investment on research and innovation have risen significantly over that time but overall R&D investment in the UK as a proportion of economic activity has remained somewhat static. Meanwhile, many competitor nations have continued to expand R&D investment and knowledge-intensive businesses have become an even more prominent part of the global economy.

The political and economic context of UK R&D investment has varied during that time. Significant events including the banking crisis of 2008-9, the 2016 Brexit referendum, the Covid pandemic of 2020-21 and the war in Ukraine have rightly occupied centre stage for politicians. Meanwhile, a sequence of manifesto commitments, Government strategies and Parliamentary reports have proposed higher levels of overall investment in R&D, latterly aiming for 2.4% of GDP – the OECD average of several years ago. These proposals have been supported by countless contributions from professional institutions, industry associations, charities and others across the research and innovation community. The consensus has been clear, consistent and backed by evidence: the UK needs higher levels of R&D investment.

More recently, Government set out an ambition to make the UK a 'science superpower'. This version of the long-standing ambition for research and innovation expresses a desired outcome in addition to a level of investment. This somewhat ambiguous phrase has engaged politicians and caused some debate among researchers.

The context of R&D investment may well continue to change. Long term policy planning often takes place in an unpredictable and sometimes turbulent environment.

This report was prepared during a period of political volatility and recent debate over the interpretation of R&D statistics. However the rationale for the work has remained steady: exploring exciting options for the future of research and innovation that bring together the ambitions of government with the ambitions of the research community.

This report addresses a huge domain and we cannot cover it in the depth it deserves. Instead we have been guided by the topics that attracted attention during the round-table meetings and one-to-one meetings that we held across the country. We heard fascinating insights from a diverse population of contributors, many of whom we had not met before. Inevitably, some threads of discussion emerged that warrant deeper exploration than we have been able to afford them here. We share these findings in the hope that they will stimulate further discussion and debate in future.

Rationale and purpose

Government's ambition for the UK to become a 'science superpower' has been widely welcomed. The term 'science superpower' has been used by successive Prime Ministers, Chancellors, Science Ministers and other senior government figures as a metaphor for their enthusiasm and ambitions for research and innovation.

Science superpower status has been linked with Government commitments of longer standing: to raise the overall level of R&D investment in the UK to 2.4% of GDP by 2027 and then further to 3%. That goal is defined quantitatively, even if the numbers themselves are now open to debate in light of revised estimates of business investment. However, that goal is a measure of funding going into research and innovation rather than an ambition for the outputs and impact of the work. Commentators and analysts, including the House of Lords Science and Technology Committee, have observed that the term 'science superpower' is seldom defined or explained beyond the %GDP. The science superpower ambition turns attention to the benefits and consequences of investment in research and innovation but it is a headline rather than a detailed specification. The term 'science superpower' is potent but open to varied interpretations.

The term 'science superpower' is potent but open to varied interpretations

Against that background, this work seeks to explore the choices facing policy-makers on the journey to a UK economy

and culture more actively driven by research and innovation, a 'science superpower'. It examines the possible characteristics of a research and innovation ecosystem in which such a transformation has been achieved.

The question posed in this report is not **whether** the UK can achieve 'science superpower' status by the end of the decade. Instead, this report assumes that science superpower status and its economic stimulus are achieved and explores alternative versions of that future:

- What different versions of a UK science superpower are possible?
- What are the strengths and weaknesses of each version?
- What choices made by policy-makers will determine the version that is realised?

Successive Governments have made progress towards a larger and even stronger research and innovation ecosystem in the UK. A political culture of continuity in research and innovation, building on the commitments of previous adminstrations, will serve the UK well in achieving this ambition. This is a time for Government to harness political will and investment commitments to deliver a more innovative, R&D-led economy and culture with the widest possible public benefit and support.

Our purpose in writing this report is not to make recommendations about how to become a 'science superpower', but to stimulate debate and to highlight the

choices that lie on the path to a more research and innovation-intensive UK.

Government commitments to research and innovation

Raising overall R&D investment in the UK

Major political parties in both government and opposition have made repeated commitments to R&D investment in the UK. The rationale for such investment is often focused on the well-documented economic and social benefits of research investment at both national and regional levels. The key role of scientific evidence in policy development, the importance of science to international relations and the specific requirements of health care, defence and protection of the natural environment have reinforced the case for public spending in R&D over many years.

Our purpose is to highlight the choices on the path to a more research and innovation-intensive UK

The UK's modest levels of public and private spending on R&D are frequently acknowledged by Government and Parliament. The low level of R&D investment in the UK compared to other major economies around the world has been a persistent source of concern in Government and has prompted several flagship policies focused on increasing public and private sector investment. Recent developments in the collection and reporting of business investment in R&D change our

understanding of specific level of business investment but do not change the underlying issue.

In 2004, the Labour Government's Chancellor of the Exchequer, Gordon Brown, published a ten-year investment framework for research and innovation in which he stated:

> *"The Government's long-term objective for the UK economy is to increase … the ratio of R&D across the economy to gross domestic product to 2.5% by around 2014"*

At that time, the level of overall UK R&D investment equated to 1.86% of GDP.

In its 2017 Industrial Strategy, Theresa May's Government committed to:

> *"… reach 2.4% of GDP invested in R&D by 2027 and to reach 3% of GDP in the longer term…"*

This built on a similar commitment in the Conservative Manifesto for the 2017 general election. The Labour Party and the Liberal Democrats made equivalent manifesto commitments at that time.

These long-term approaches to R&D investment were welcomed widely by the research and innovation community and have shown signs of boosting confidence and enthusiasm among businesses, universities and charities. A taskforce of

business and university leaders convened by NCUB reported in 2020 that:

> *"…investing in research and development (R&D) will be a necessity to remain competitive and build back better in a fast-changing world. The Government's commitment to increase R&D investment to 2.4% of GDP by 2027 and 3% in the longer-term was a clear statement of intent that this should become common place – a new normal – for many businesses in the future."*

Nevertheless, R&D investment has remained stubbornly at around 1.7 - 1.8% of GDP despite repeated increases in many areas of public spending and a supportive narrative by Governments over the period since Gordon Brown's framework for research and innovation was published nearly twenty years ago.

At the time of the Industrial Strategy, the 2.4% goal was equivalent to the average level of R&D investment in OECD countries. Rising levels of R&D investment across the globe have raised that average even higher, to 2.7% in 2020, leaving the UK's ambition looking modest.

However, the challenge of raising R&D investment in the UK to 2.4% from its current level is substantial. For example, it is likely to create substantial additional demand for skills and infrastructure. Higher levels of public spending are an essential part of the picture – but only part of it. At every stage in the evolution of this policy, a sizeable increase in business

investment has been part of the Government's vision and a key part of the case for public spending.

The Science Superpower Agenda

Against that background, the then Prime Minister Boris Johnson reinforced and expanded the Government's ambitions for research and innovation. In an announcement on 8 August 2019, he said:

> *"I want the UK to continue to be a global science superpower…"*

The phrase 'science superpower' was used in many subsequent announcements by the Chancellor of the Exchequer, the Business Secretary, successive Science Ministers, the Government Chief Scientific Advisor and the Prime Minister himself as a headline for ambitious, visionary science policy.

The then Chancellor Rishi Sunak used the term 'science superpower' several times in the 2021 Budget and Spending Review. In relation to public spending, he said:

> *"… Gross Expenditure on R&D in the UK in 2019 was 1.8% of GDP, lower than other advanced economies and below the OECD average of 2.5%, a trend primarily driven by low business investment in R&D.*

"To address this, the government is increasing public R&D investment to record levels, providing £20 billion across the UK by 2024-25, including funding for EU programmes, to cement the UK as a global science and technology superpower."

In the context of business investment in R&D, he then said:

"To ensure the R&D tax reliefs continue to support cutting edge R&D methods, the government will expand qualifying expenditure to include data and cloud computing costs, reinforcing the UK's status as a science superpower."

The then Chancellor Rishi Sunak used 'science superpower' in the 2021 Budget and Spending Review

Speaking at a Global Investment Summit on 19 October 2021, the then Foreign Secretary Liz Truss celebrated the contribution of research intensive businesses to the UK economy and said:

"The United Kingdom is a science and tech superpower – open to ideas, open to investment, working to create opportunities and improve lives. We are determined to be bolder, more competitive and more forward-leaning than anywhere else on earth."

She continued:

"At the heart of this is a fundamental belief – which I know everyone in this room all shares – in the power of free enterprise. When people and businesses are free to

use their imagination, initiative, ingenuity and ideas, they deliver the best results. We've got to harness this innate potential."

These descriptions of a science superpower clearly emphasise the role of business R&D rather than public funding.

The Government Chief Scientific Advisor, Sir Patrick Vallance has used the term in relation to science advice to government. For example, he hosted a June 2022 event at the Royal Society, building on the Government's 2021 Integrated Review, on the theme of: 'Making the UK a Global Science Superpower' in which he described specific interventions by government that would strengthen science and technology in the UK.

In his introduction to the UK Office of Science and Technology Strategy, Sir Patrick writes about the "UK's quest to be a global science superpower" where he says:

"I have been supporting the Prime Minister to stand up two new government science structures, building on the strong systems we have for providing independent science advice."

The House of Lords Science and Technology Committee has conducted an inquiry that explores, among other things, 'What would it mean to be a science superpower?' The Science Minister, George Freeman, described his interpretation of a science superpower in evidence that Committee in March

2022. Mr Freeman put the science superpower agenda in an international context, emphasising the central role of publicly funded research excellence:

> *"The way I have defined "science superpower" is to mean how we can make sure the full value of UK science is harnessed for full global impact … This means funding world-class science as the bedrock to everything."*

Despite the change of leadership, the phrase remains in frequent use today, including the Chancellor Jeremy Hunt citing it in the 2022 Autumn Statement:

> *"…today I protect our entire research budget and confirm that we will increase public funding for R&D to £20 billion by 2024-5 as part of our mission to make the United Kingdom a science superpower."*

Despite the change of leadership, the phrase 'science superpower' remains in frequent use today

This range of commentary by senior figures reflects the breadth of interests within Government that could be served by stronger research and innovation in the UK. Speeches and strategies have made clear the Government's ambition and commitment for the UK to become a science superpower. However, the wide span of the agenda highlights the challenge of defining practical steps that should be taken – often at management and administrative levels – to turn the ambition into actions and outcomes. Questions arise about the relationship between different interpretations of a science superpower.

Tensions and choices will arise as the agenda is delivered. This does not in any way undermine the appeal of the science superpower agenda. But it does suggest that debate and challenge at an early stage would help to identify areas requiring clarification and choices that will require negotiation within government. Describing the Government's ambitions in terms of expenditure provides reassurance that policy will be backed with money. But expenditure alone does not describe the opportunities and challenges implicit in the superpower ambition.

The current UK landscape of research and innovation and its implications for the superpower agenda

A comprehensive map of research and innovation in the UK is beyond the scope of this report. Detailed descriptions are available from the Office of National Statistics, the House of Commons Library and the Foundation for Science and Technology. However, a brief overview of the current landscape provides part of the context for the superpower ambitions and a base from which to explore the future. We therefore focus on features of the landscape that are particularly relevant to the future scenarios for a scientific superpower.

The UK research community has a strong international flavour. That is significant when the science superpower agenda is positioned by Government as part of the UK's future global

agenda. Around half of business R&D investment comes from firms in the UK that are headquartered overseas, giving business R&D a strong international dimension. Sizeable R&D investment also flows into the UK from overseas sources. Similarly, research publications from UK universities have a strong international flavour with over 60% of research papers resulting from international collaborations. Historically, the UK research community has added further international emphasis through participation in EU research programmes and overseas development projects, both of which have been curtailed more recently.

The science superpower agenda is positioned by Government as part of the UK's future global agenda

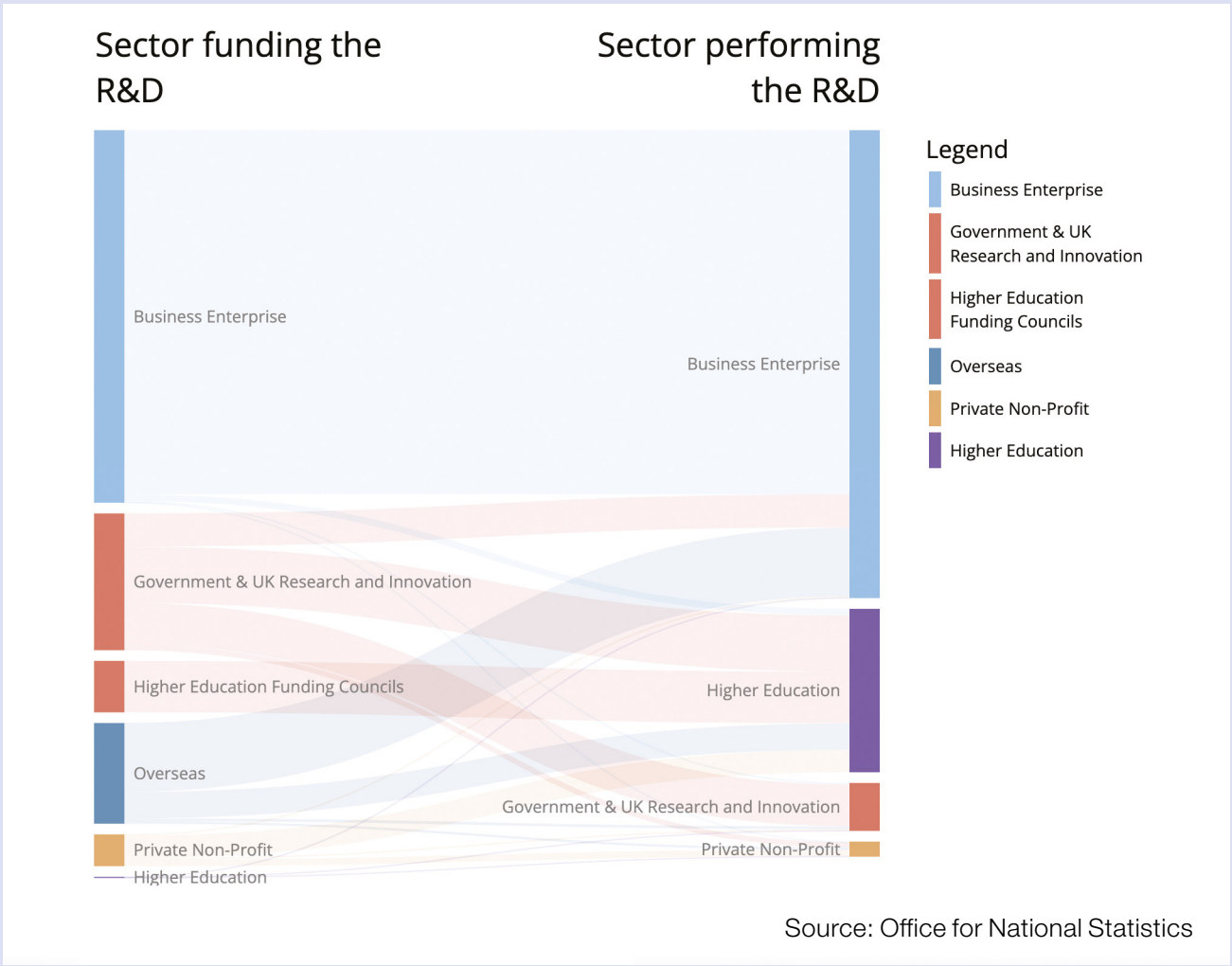
Figure 1 illustrates the overall shape of research and development funding in the UK. Sources of funding are shown on the left hand of the chart while the types of organization undertaking research are shown on the right-hand side. Flows of investment link one side to the other.

We note the limitations of metrics associated with measuring R&D. Measures give different pictures of R&D activity, for example comparing uptake of R&D tax credits with business surveys of R&D. However, we recognise the value of a single source of internationally-comparable data, as provided by ONS.

Business Investment

Business investment, at nearly £27bn in 2020, is by far the largest element of R&D funding in the UK while businesses are by far the largest type of organisation conducting research.

FIGURE 1: FLOWS OF RESEARCH AND DEVELOPMENT FUNDING IN THE UK IN 2019



Source: Office for National Statistics

Those characteristics are found in other leading research nations around the world and they are long-standing features of the UK. The growing emphasis on knowledge-based sectors of industry and the demise of many centralised corporate laboratories has changed the shape of business R&D. According to EU data, summarized by the House of Commons Library, the pharmaceuticals, automotive and aerospace sectors remain among the largest business sectors

for research while three of the top ten individual firms investing in R&D are in the banking sector.

Academic research in the UK performs particularly well against international comparisons with four of the world's top ten universities being located in the UK and this country produces a high proportion of global scientific publications (and an even higher proportion of highly cited papers) relative to the level of R&D investment in the UK. This exceptionally high performance across a broad span of academic disciplines resonates – arguably, at least - with claims to be a science superpower. One of the benefits of a strong academic research base is that it makes the UK a more attractive destination for international business investment in R&D.

Strong academic research makes the UK an attractive destination for international business R&D investment

Covid-19 shone a spotlight on the role of scientific advice in the development of public policy, with the Government's Chief Scientific Advisor and the Chief Medical Officer appearing next to the Prime Minister on prime-time news broadcasts for well over a year. Scientific evidence had a prominent place in the COP 26 climate change conference which the UK hosted in 2021. Science and engineering feature in news coverage on national security, public health and economic development. These add up to a growing profile for the role of science advice to government and may well explain why a larger number of Government Departments were allocated funds for research and innovation in the 2021 Budget and Spending Review.

Successive Governments and Parliaments have scrutinised the performance and administration of UK research and innovation extensively. That scrutiny includes numerous reviews and inquiries (most recently the Grant Review of UKRI, the Tickell Review of research bureaucracy and the forthcoming Nurse Review of the research landscape). New administrative structures have been introduced in the funding landscape (including ARIA and, of course, UKRI). Exciting new research and innovation projects are announced frequently. This well-established pace of scrutiny and reform suggests that progress towards higher levels of R&D investment may well be accompanied by changes in the structures and missions of organisations within the research and innovation landscape. That said, the balance of investment between research disciplines has not shifted radically over the last 20 years – life sciences and engineering & physical sciences have remained the largest funding domains while research budgets for arts, humanities and social sciences have remained smaller.

Method

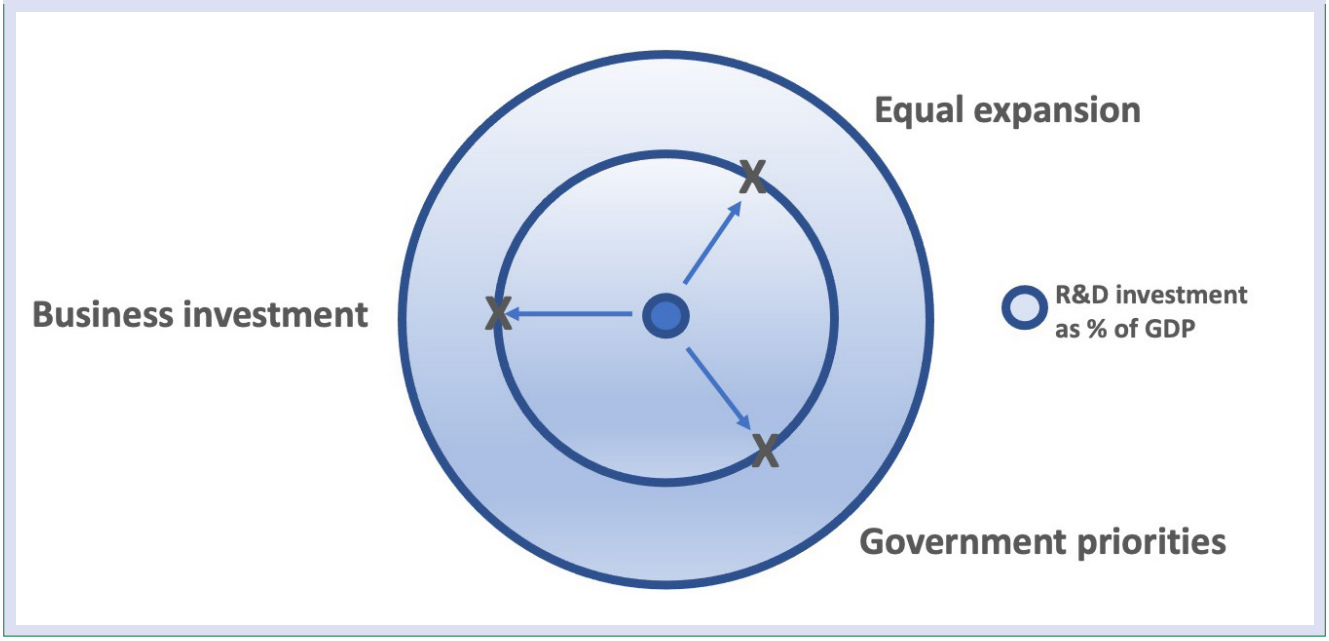
Future Scenarios

Against that background, Figure 2 illustrates the journey ahead to R&D contributing a greater share of national wealth. In recent years, this journey has been expressed in the target of raising R&D investment from 1.7% of GDP to 2.4% and beyond. We prepared this report in that context. We await further analysis of UK investment in R&D following the ONS' review of metrics for business R&D and the Government's response in term of R&D targets. Notwithstanding this analysis, the target set out in the Government's manifesto and recent Spending Review of reaching 2.4% of GDP invested in R&D represents a sizeable increase in R&D investment across the economy from today's levels. Our findings remain intact whether or not the numerical target changes.

Many versions of the research and innovation landscape could emerge, each with R&D investment at the target level of GDP. Choices made early in the journey may well determine the challenges and shortcuts that appear at later stages.

Identifying, let alone exploring, every possible choice would be impractical. We therefore present a condensed and simplified picture in Figure 2. Three scenarios for increases in R&D

FIGURE 2: THERE ARE MANY PATHWAYS FROM CURRENT LEVELS OF R&D INVESTMENT IN THE UK TO SIGNIFICANTLY INCREASED PROPORTIONS OF GDP



investment across the economy are presented here: each one a caricature of a future in which overall R&D investment in the UK has reached a higher level.

Scenario 1: equal expansion

The overall shape of the research base is unchanged: the proportions of business, UKRI and Government Department R&D remain constant. The scale of each part increases by the same proportion to reach 2.4% or more overall, leading to a sizeable uplift – around 50% - in funding for academic research.

R&D investment in the UK grows from public and private sources to a total of 2.4% of GDP. UK R&D investment moves

to a significantly higher place in world rankings but remains far below leading nations.

Public funding for academic research is approximately twice that of 2021 levels. This further highlights the role of R&D in society and raises expectations in a wider public that they should feel the benefits of research and innovation.

Universities and public sector research establishments remain the primary recipients of public R&D investment. The percentage of growth is similar across institutions leading to a research base of essentially the same shape as now but with a larger size. Around two-thirds of R&D investment continues to come from the private sector with much of the rest coming from Government.

Three scenarios are presented, each a caricature of a high R&D investment future

Scenario 2: prioritising business investment in R&D

The research base is maintained and strengthened but the priority for public spending and public policy is attracting business investment from global corporations by reforms to taxation, immigration, and skills policy.

With large new demands on public finances following the Covid pandemic, Government prioritises public spending to stimulate higher levels of business investment in R&D rather

than public spending on research in universities and research institutes.

Government pursues three principal areas: expanding existing UK R&D from research intensive firms; stimulation of R&D activity in UK businesses with currently low R&D; attraction of R&D-intensive businesses from overseas to locate in the UK;

To these ends, Government makes interventions that are strong enough to change patterns of business investment, for example by using public procurement, R&D tax credits and grants to businesses that make large new R&D investments.

The academic research base remains at its current size. As the strength of the academic research base is an attractor for R&D-intensive businesses, there is a time-lagged downward pressure on business investment because the scale of academic research fails to match the growth in business R&D. Progressively stronger fiscal stimuli may be necessary to sustain levels of business investment in the absence of a larger academic base.

Scenario 3: delivering government policy priorities

The 2.4% environment is more closely aligned to Government priorities such as net zero, an ageing population, regional development, national security and international trade. Government incentives – financial and otherwise – emphasise priority areas.

R&D investment closely follows the national priorities of the Government of the day such as net zero, an ageing population, regional development, national security and international trade.

In this scenario, Government deploys investment through a range of agencies, universities and bodies across Government, private and public sector as necessary to achieve progress in its policy priorities.

Public spending on R&D increases substantially while the balance of funders in the R&D landscape is likely to shift with the relevant lead Government Departments for each national priority having the largest increases and being empowered to set the direction of R&D within their domain.

The existing academic research base funding remains intact with additional new money might be used to create new institutions that are dedicated to research in priority areas for Government.

These scenarios are not predictions of the future, nor are they mutually exclusive

We made no attempt to prioritise the attractiveness or practicality of the scenarios. Each scenario has appealing characteristics, challenges in implementation, implications for public spending and implications for different parts of the existing research and innovation community.

These scenarios are not predictions of the future, nor are they mutually exclusive (indeed, the most likely outcome of current

policy will be some blend of scenarios). They are designed to prompt debate, clarifying ambitions for research and innovation in the UK, and identify ambiguities and uncertainties implicit in existing statements from government and the research sector. The scenarios also provoke constructive debate about the tensions and choices that should be made as research and innovation in the UK expands and evolves.

We held valuable, preliminary discussions with colleagues who specialise in the design and application of scenarios. Informed by their advice, we used the term 'scenario' in a colloquial sense and aimed for simplicity and clarity for each scenario. We remained open to the option of more detailed scenario development during discussions with a wider population of stakeholders. However, we found in practice that the three scenarios covered most – if not all – of the interpretations of the term 'science superpower' as understood by participants.

Assumptions

We made several explicit assumptions about the economic and political environment in which the scenarios were explored. These assumptions helped to focus discussions on the scenarios themselves rather than the wider backdrop.

First, we assumed that overall public spending on R&D reaches £22bn by 2026/7 and rises thereafter – as implied by successive announcements from Government. Progress towards this level of public funding was evident in recent

spending review settlements – albeit with some slippage in the original timetable. We assumed that the balance of investment, taking the total to 2.4% of GDP, comes from businesses and charities with businesses continuing to contribute the majority of overall R&D investment under most versions of the future. In other words. We did not debate whether that level of investment would be reached. We held the discussions on the basis that the higher level of investment was already in place and explored alternative scenarios in which that higher level of investment might appear.

Second, we assumed that there is no major external disruption to the UK economy. We expected economic indicators to vary over time and we expected some fluctuation in the confidence of financial markets, businesses, research institutions and individual researchers. Contextual issues such as the economic implications of the Covid-19 pandemic and adaptation to life outside the EU – and possibly outside Horizon Europe – were already recognised widely at the time of our workshops and other discussions.

We did not, however, anticipate at the outset of this work the rise in inflation that began earlier in 2022 and – according to the Bank of England forecast - looks likely to persist into 2023 before subsiding. Nor did we anticipate the rise in energy costs that will inevitably perturb some research-intensive businesses and some parts of the publicly-funded research community. However, these factors were widely publicised by the time we were in the later stages of consultation and discussions. We did not anticipate Ministerial changes during the summer of 2022.

Third, we assumed that there is no major change in the constitution of the United Kingdom. The UK had left the EU some time before our discussions began. The difficulty in finalising association to Horizon Europe due to unresolved issues on Northern Ireland had been widely publicised. The Government's levelling up white paper had been published before our work began, making clear that there was no direct substitution by Government for R&D support that had previously been secured from the EU regional development funds. The Scottish Government's position on Scottish Independence was already known.

Gathering advice from the community

The intention of this work has been to gather a wide range of views and to stimulate discussion. We have done this through roundtable discussions, 1-2-1 interviews and webinars with stakeholders across the research and innovation sector. These have engaged individuals from business, academia, academic publishing, international diplomacy, Government and research funders. We specifically aimed to reach beyond the community of analysts and commentators who make frequent contributions to debates on research and innovation policy.

Consultees from the research community came from a wide range of disciplines. With help from the British Academy and the School of Advanced Studies, we had valuable discussions with colleagues from the humanities and social sciences. For example, these allowed us to hear views on the historical

context of the science superpower agenda and gave us first-hand insight into the way that the term 'science superpower' is received by important stakeholders in the research community who do not identify themselves as 'scientists'.

We gathered views from many parts of the UK but did not attempt systematic coverage of every geographic region. With help from the Wales Innovation Network, we held a roundtable meeting in Cardiff and with help from the Scottish Funding Council we held an online event for a group of stakeholders in Scotland. These meetings – along with an interview with a senior figure in Northern Ireland – allowed us to hear distinctive views from colleagues in devolved nations of the UK. A larger webinar, open to all and hosted by the Foundation for Science and Technology, further expanded the diversity of our consultees.

We gathered views from many parts of the UK and we monitored media references

We monitored media references to the science superpower agenda. We cannot claim to have spotted every mention of the term but we combined media coverage with views from our consultations to identify broad patterns in subjective reactions to the term 'science superpower' and in more detailed interpretations of that term.

Consultation findings

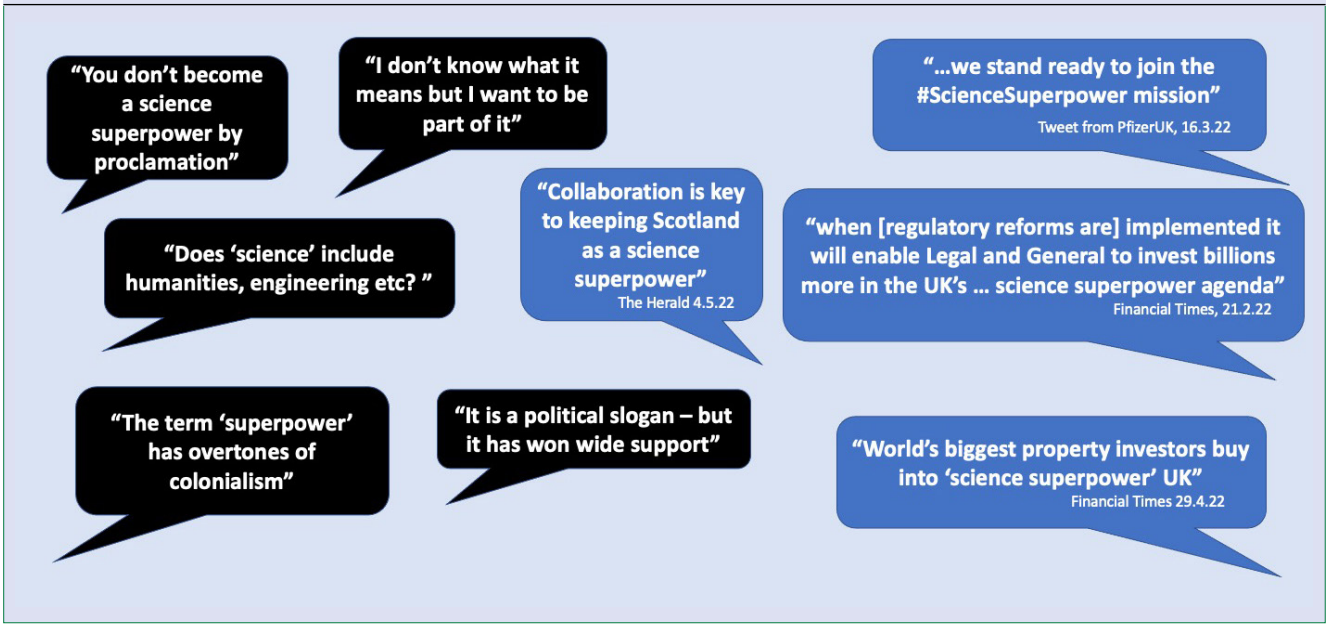
Responses to the term 'Science Superpower'

Across all consultees, there was broad support for the concept of a transformative agenda for R&D, including a substantial rise in investment and in contribution of R&D to the economy and culture of the UK. The concept of a science superpower was widely supported, but its presentation more contested.

While successive Governments have attempted to raise the level of R&D investment, this latest attempt is distinctive in its use of the term 'science superpower'. It would be easy to dismiss the term as a frivolous political slogan. That would understate the level of enthusiasm for the term within Government and understate the importance of such enthusiasm in the competition for political attention and scarce public funding.

That said, we heard a range of more sceptical reactions from colleagues within the research and innovation community. In particular, the term 'superpower' was interpreted by some to have colonial overtones and a degree of hubris, neither of which provided an ideal foundation for building international collaborations post-Brexit.

FIGURE 3: REACTIONS TO THE TERM "SCIENCE SUPERPOWER"



A sample of reactions to the term 'science superpower' is shown at figure 3. Quotations from media outlets are verbatim while other quotes have been paraphrased from comments made during consultations and discussions.

Broadly speaking, one group of reactions focused on the definition of the term 'science superpower'. For example:

- What is the scope of science – does it include all academic disciplines or is it confined to the natural sciences?
- Does the UK claim to be a science superpower or does it aspire to become one?
- What is the definition of a superpower and who measures the UK against that definition?

Another group of reactions responded to the term 'science superpower' as a slogan. For example:

- I don't know what it means but I want to be part of it
- It is an effective slogan that has attracted attention in the political world.
- It has overtones of colonialism and hubris. That is not a good basis for building international partnerships

A third group of reactions – largely in media outlets – demonstrates that the term 'science superpower' caught the attention of large businesses in the UK and overseas as well as former Prime Minister Tony Blair. This attention appears to highlight the role of science in other political agenda such as levelling up.

We gathered views on what would constitute a positive view of a UK 'science superpower' to our consultees. We heard a range of characteristics described, for example:

- Exerting global influence, including on research agenda and values
- Encompassing all research disciplines, including social sciences, humanities and the arts
- Economically self-sustaining and long-lasting

Responses to the proposed scenarios

Consultees offered distinct perspectives: those of practitioners, academics, funders, commissioners of research, international observers and others. Responses to the

scenarios varied accordingly and discussion was rich and detailed.

Throughout our discussions, it was widely recognised that, in reality, the UK research and innovation system would evolve in a way that combined elements of the three scenarios. However, we encouraged consideration of the scenarios in isolation, at least initially.

We have attempted to synthesise the many responses we heard and to characterise prominent themes. These are not exhaustive but, we hope, illustrative.

The table below (Figure 4) illustrates themes that emerged from the discussions.

The prospect of a predictable share of a rising budget reassured many

Responses to scenario 1: equal expansion

We initially thought of Scenario 1 as a null hypothesis. This scenario assumes no significant perturbation to the status quo beyond the increased level of funding. Many consultees did indeed feel that scenario 1 lacked credence. They felt it was highly unlikely that significant growth in the research and innovation system would be sponsored by Government in this way. In some fora, discussion of this scenario was peremptory.

However, in other quarters, there was much greater warmth for this scenario than we anticipated. The prospect of a predictable share of a rising budget reassured many,

FIGURE 4: REACTIONS TO THE PROPOSED SCENARIOS

Equal expansion	Business investment	Government priorities
Opportunities	**Opportunities**	**Opportunities**
Protects domains that may be threatened by further concentration	Strong case for expanding public spending on R&D	Government priorities reflect consensus (climate, health, defence etc)
Many stakeholders benefit a little	Expanded career pathways between academia and business	Signals long-term intent that attracts business investment
Challenges	**Challenges**	**Challenges**
Locks in weaknesses in system and prevents radical reform	Policy instruments to attract business investment	Stability of Government priorities over time
Securing political support	Lessens ability to balance investment across regions and sectors	Differences in priorities across devolved nations and regions of UK

particularly if they felt that growth might otherwise be concentrated away from their own geographic or thematic area of interest. For example, in the devolved nations, a growing, formula-based, allocation of public spending would guarantee predictable growth in investment.

Detractors of this scenario observed that the very nature of a proportionate increase in investment across all parts of research and innovation system prevents radical transformation. Indeed, it may entrench existing weaknesses. Many consultees argued that scenario 1 would give the weakest return on investment, and even questioned if it would be possible to achieve the 2.4% economic goal in this way.

That said a smaller number of consultees interpreted equal expansion as an envelope within which there could still be substantive change. They proposed that the overall balance of investment from the public and private sector to R&D could remain unchanged and provide a degree of stability while reforms took place within each part of the R&D system.

Responses to scenario 2: business investment

This scenario was widely interpreted as a plausible version of the future. It was noted that it was likely to be well-aligned with anticipated political objectives over upcoming years. It occupied the largest share of time in discussion overall.

The case for public investment in R&D in this scenario was considered to be strong because it is focused on attracting business R&D investment, aligned with creation of skilled and high-value jobs and stimulus of economic activity.

This scenario would require, and ultimately deliver, greater dynamism in the flow of talented people

Consultees noted that this scenario would require, and ultimately deliver, greater dynamism in the flow of talented people: between academia and business, and between countries across the world and regions of the UK. A sizeable increase in business R&D would drive up demand for talented people in business, potentially driving up salaries and appetite for STEM education and training.

A note of caution was sounded, recognising that designing policy instruments to attract business investment at scale is challenging. Growth in business investment in R&D over recent decades has been steady, but achieving a step-change in investment has proven elusive.

Realisation of this scenario implies greater concentration of activity and influence in R&D in the market. For some, the ceding of control over deployment of public investment in R&D to the market raised fears for the sustainability and integrity of the R&D system. It may, they posed, reduce Government's ability to balance and direct R&D investment for broader national goals, such as regional prosperity.

The notion of directed financial incentives for business appeared an attractive middle ground to some, enabling Government to direct business investment in line with national priorities. Others argued that there is no UK precedent for such an intervention at the scale needed to increase business investment by the amount needed to realise this scenario.

For many, this was a welcome scenario and felt to be overdue. Appetite was expressed for an invigoration of UK business innovation, significantly supported by Government.

Responses to scenario 3: government priorities

This scenario reflects, among other things, the growing R&D investment in Government Departments set out in the 2021 Spending Review and the emphasis on Whitehall-wide

coordination of research and innovation described in the Integrated Review of 2021. This scenario received less detailed exploration in some fora, but prompted fuller consideration from some, often with those consultees closer to Government.

A substantive shift towards R&D within and for Government could lead to a shift in the dominant cultural and intellectual framework for R&D. For example, the primary drivers for R&D in defence, security and resilience have distinct characteristics, and we observed a cultural distinctiveness between conversations in these quarters and others.

Similarly, R&D programmes commissioned by other Government departments in pursuit of their policy missions are likely to reflect the culture and decision-making priorities of those departments. In scenario 3, a new cast of characters in Government could become the majority budget holders in R&D.

Connection to public and political priorities could see stronger public support for R&D investment over time

Some argue that Scenario 3 has an explicit democratic characteristic. The national priorities of the Government of the day reflect the mood and will of the electorate, and the public have the power to change that set of national priorities through the polls. Therefore, if R&D is directed to national missions such as climate change, cost of living, or sovereign capability, then surely it is in service of the public. A greater connection to public and political priorities could see stronger and more stable public support for R&D investment over time.

Businesses, too, could be attracted by long-term commitments by Government to priorities for R&D. Long term commitment is often cited by business as a critical factor in giving them confidence to invest in areas where sizeable public procurement is an incentive for private sector R&D.

However, significant challenges arose with scenario 3. Discussions in the Devolved Nations raised an immediate constitutional concern: which 'Government priorities' are determined in Westminster and which are for devolved Governments?

Each of the Devolved Nations has distinct priorities, ambitions and boundaries. For example, the Scottish Government is opposed to cultivation of genetically modified crops whereas DEFRA supports gene editing in crops in England. The Scottish Government opposes new nuclear power stations in Scotland, whereas BEIS is committed to building new nuclear power stations in England.

Similarly, Devolved Nations each have distinct economic profiles. We heard compelling views on the distinctive characteristics of business R&D investment in parts of the UK with more SME-led R&D economies.

In these conversations, a desirable scenario was one in which enough flexibility was given to allow regions and nations of the UK to pursue the science superpower agenda in a bespoke way for their economy and community. This, they felt, would be

enabled by greater devolution of budgets and decision-making.

Finally, whilst the proposition of Government commitment to long-term national priorities for R&D was welcomed, it was noted that these can change with each change of administration or even sooner. Research priorities have often preceded and outlasted public and political interest.

Tensions and choices

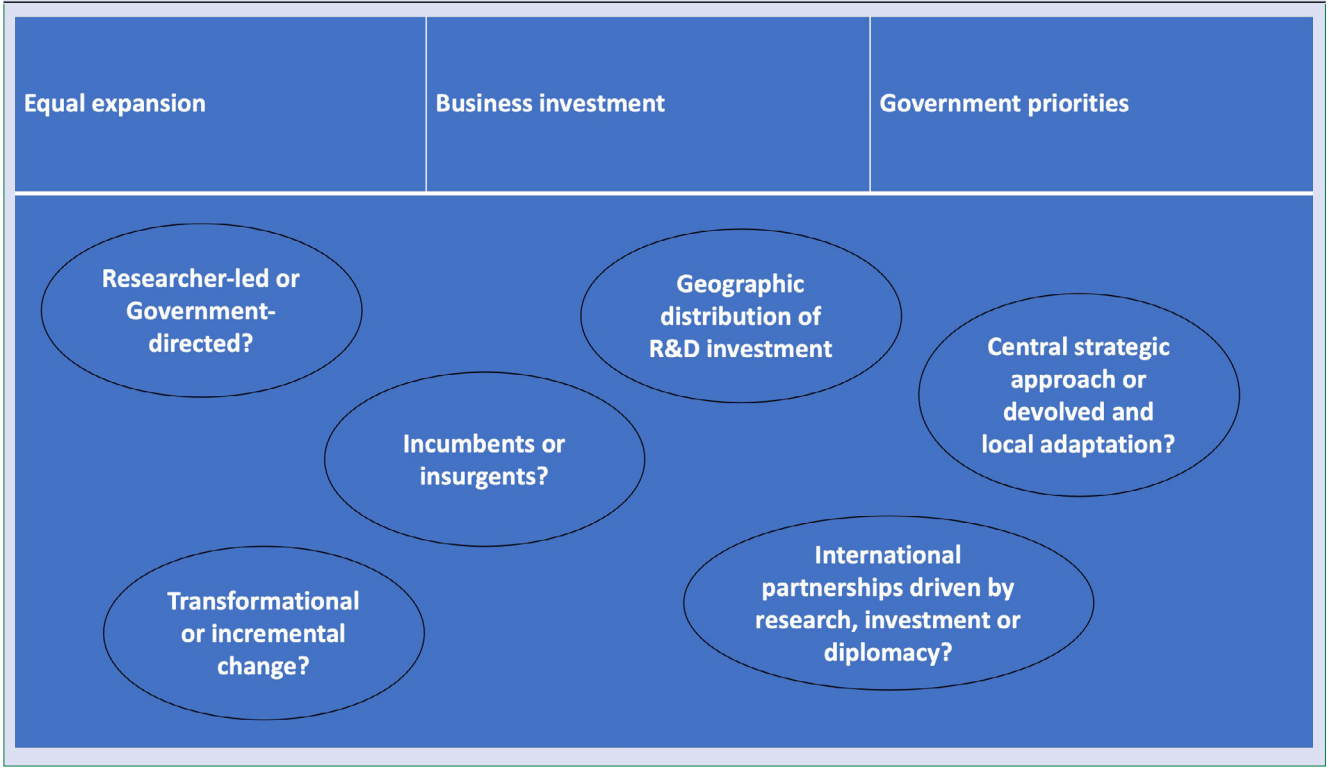
This section explores the policy choices arising from consideration of the scenarios and the tensions between them.

Some choices emerged from consideration of one scenario alone and have already been indicated, for example balancing the influence of central and devolved governments. Others arise from creative tensions between scenarios.

Distribution of higher levels of business investment may be unpredictable and to some extent uncontrollable

The table below (Figure 5) indicates some themes that emerged from discussions. We explore three themes in more detail below to illustrate the tensions and choices that arise from the scenarios, leaving discussion of other themes to be pursued after publication of this report.

FIGURE 5: TENSIONS AND CHOICES BETWEEN SCENARIOS



Geographic distribution of R&D investment

In scenario 2, 'business investment', the geographic distribution of higher levels of business investment may be unpredictable and to some extent uncontrollable. At one extreme, business investors from around the world could be drawn to high profile locations with the UK, with existing clusters of research and innovation serving as magnets for further investment. That could reinforce existing clusters at the expense of less research-intensive regions, amplifying regional disparities.

In scenario 3, 'Government priorities', the Government may wish to deploy R&D investment in such a way as to achieve

other national priorities, such as regional development and economic growth. The Levelling Up White Paper of 2022 cites R&D investment as one of four flagship priorities, committing to increase R&D investment across the North, Midlands, South West, Scotland, Wales, and Northern Ireland by 40% by 2030, with the intent "to leverage at least twice as much private sector investment over the long term to stimulate innovation and productivity growth".

Designing policy instruments to attract sustainable business investment at the scale required is challenging. Growth in business investment in R&D over recent decades has been steady while achieving a step-change in investment has proven elusive. That challenge may be even greater – or more expensive - if such policy instruments aimed to not only attract business investment but also influence its location or prioritise between business sectors or technologies.

Geographic location of R&D investment by the public and private sector could be substantially influenced by whether the Government adopts:

- a free-market approach to business investment; or
- directs public spending to pursue economic growth in specified parts of the country.

In either case, stable and predictable policy is more likely to be effective than shorter term initiatives.

Incumbent or insurgents

Scenario 1 will inevitably benefit incumbent stakeholders who are invested in current funding arrangements. Arguably, progressively higher levels of R&D investment will take the shape of scenario 1 unless interventions of sufficient force are used to re-direct public and private investment towards different outcomes.

A vibrant research and innovation ecosystem depends on insurgency – challenging existing ideas

A vibrant research and innovation ecosystem depends on insurgency, challenging existing evidence, ideas and institutional structures with proposals – only some of which will be accepted – for even better performance and new research discoveries. Emphasis on vital insurgency should be balanced against the need for a stable and predictable environment in which researchers can get on with the job of doing research.

The scale, economic importance and political appeal of business R&D investment should secure its place at the heart of scenario 1. Under scenario 2, business R&D will grow even larger. It is unclear how a progressively larger body of business R&D should optimally influence public spending. Research in universities is valued for its independence and creativity, and that may be undermined by influence from business or Government. However, the scale of investment in the research base is justified partly by its impact on the economy and that should be

enhanced with strong links between publicly funded researchers and the users of research in business and elsewhere.

The reputation of university research in the UK acts as a magnet to global business investors and international students, further strengthening the UK research and innovation landscape and reinforcing the role of large research universities as cornerstones of UK research and innovation. Under scenario 1 the scale and international reputation of university research would almost certainly grow with the largest incumbents quite possibly being the largest beneficiaries.

Public Sector Research Establishments, including Government laboratories, Research Council campuses and institutes and the Catapult Network combine with the more recent Advanced Research and Innovation Agency to make up a sizeable body of R&D in the UK. A taxonomy by the Royal Society gives an indication of their combined scale and diversity. Under scenario 3, Government Departments may well choose to expand their own research institutions. How should a larger population of Government researchers influence Government policy? Should they provide evidence that is open to peer review, public scrutiny and comparison with other sources of advice? Or should such institutions focus on confidential advice on confidential issues? Would such questions be resolved by individual Government Departments or through the Government Office of Science?

Transformational or incremental change

Government emphasis on economic growth and productivity have been closely linked to their investment in research and innovation. In the 2021 Spending Review, the Treasury said:

> *"Innovation and technological progress are central to driving long-term growth and improved living standards; evidence shows that countries with higher Research and Development (R&D) activity tend to have higher productivity"*

Incremental increases in funding could be part of the picture but could not alone achieve the Government's ambition

Corresponding commitments to raise UK R&D investment often come with timetables that resonate with political audiences. The 2021 Spending Review further reinforced the Government's widely welcomed commitment to raising R&D investment. As the 2021 Spending Review put it:

> *… ambition to increase [Government] R&D spending to £22bn by 2026-27 and drive economy-wide R&D investment to 2.4% of GDP in 2027".*

This increase will take the UK to around 40% above current levels of investment during the next 5 years. Under a literal interpretation of scenario 1, this would imply a 40% expansion of the population of researchers and a similar expansion of the laboratory estate. Institutions whose research income does

not cover the full economic cost of their research would face large financial deficits. The challenge of recruiting and accommodating such a rapid expansion of researchers would test any leadership team. Incremental increases in funding could be part of the picture but could not alone take the UK research and innovation system close to the Government's ambition during the next 5 years under any of our scenarios.

Salary levels and PhD stipends will need to be competitive both internationally and with other employment options in the UK. Increasing levels of remuneration for researchers may prove essential if, under any of the scenarios, a significantly larger number of people must be attracted to research careers to meet the science superpower ambition.

On the other hand we currently have a public sector funding model that leaves many research institutions with financial deficits for research. Funding research at a level closer to its full cost would – in a stroke – improve the financial resilience of research institutions and give them the financial agility to explore exciting new ideas in research and innovation without always pursuing grant applications. This option would be clearly consistent with scenarios 1 and 3 and may also contribute to scenario 2.

UK research infrastructure is strong but needs sustained investment to match international competitors, particularly under scenario 1. Scenarios 2 and 3 open possibilities for major new research institutions that could attract foreign direct investment in R&D, focus on long-standing government priorities. Sizeable investment in infrastructure, institutes

focused on new priorities and – essentially – funding the long-term cost of operating these new investments would be tangible expressions of the UK's move to superpower status.

A transformational change in the UK's research and innovation activity would require the development and coordination of multiple strategies pursued by Government, the public and private sector. A stimulus for change at scale would be required, supported by market conditions, regulation, infrastructure, skills, and investment. The political signaling of the science superpower agenda could represent such a stimulus if it is supported by a coordinated and innovative efforts to attract and sustain business, academic and third sector R&D in the UK.

Observations

The balance of influence

Any route to becoming a 'science superpower' is likely to combine elements of each scenario. Indeed, any one scenario in isolation would present a simplistic vision of the future.

For example:

- Heightened public concern and Government emphasis on climate change, public health and national security may well require new R&D institutions and initiatives that are best created through partnerships between businesses, government departments and universities.
- Large, high-performing clusters of university research, sometimes alongside Research Council or Government facilities, have for many years helped to attract business investment in R&D to the UK. Any attempt to raise business investment to science superpower levels will require a thriving publicly funded research base in universities and institutes.
- Increased volumes of R&D in businesses and government will require larger numbers of highly qualified professionals with skills to perform R&D in those domains. That, in turn, would require more researchers to move between business,

government and universities more freely than we observe at present, if only to supply businesses and government laboratories with a larger numbers of PhD graduates.

The optimum outcomes of a single scenario are unlikely to be retained in any combination of scenarios. Compromises, prioritisation and difficult choices will be inevitable as scenarios are merged.

This requires a balance of power and influence between Government, business and and research institutions

The challenge is striking the optimum balance and blend between scenarios that will achieve the transformational change of becoming a 'science superpower' while protecting and enhancing research strengths in universities, government research institutions and the business community.

At one level this balance is struck by resource allocation: the distribution of public funding, Government's choice to forgo tax income through R&D tax credits and any decision by Government to use public spending as a stimulus for business innovation.

At another level, this requires a balance in the distribution of power and influence between Government, business investors, academic researchers and research institutions. A wider public should also have a stronger voice in the Government's ambitions for R&D growth. The interest and

influence of the public may grow stronger as the scale and profile of research and innovation increase.

Shaping the R&D landscape

Consideration of these scenarios reveals different locales for decision making and resource allocation for UK R&D. The scenarios indicate different casts of characters, and perhaps different cultural and intellectual frameworks, that emerge as dominant actors in shaping UK R&D.

Different cultural and intellectual frameworks emerge as dominant actors in shaping UK R&D

Under the 'equal expansion' Scenario 1, the landscape of influence is not changed, but expands in much the same way as the investment. Government and its agencies set much of the high-level agenda for publicly-funded R&D and for regulatory, procurement and tax regimes that influence the attractiveness of the UK to business investors. At a more detailed level, individuals in the research community exert a collective influence, working with funding agencies to peer review proposals for research and to appraise the research performance of universities periodically through the Research Excellence Framework. Business investors, of course, are free to determine the scale, location and scientific priorities of their intramural R&D programmes which make up most of the overall research landscape.

Under the 'business investment' Scenario 2, business investors would acquire a significantly higher level of influence as business R&D became a progressively larger portion of the overall landscape. The cast of characters influencing UK R&D investment may become more international, as over half of UK business R&D investment is by companies headquartered abroad.

Decision-making on R&D in Government would focus on incentivising business investment. Government would retain, to some degree, influence through its control of incentives and rewards for business. For example, Government's decision to expand R&D tax credits to include "data and cloud costs" explicitly supports research where these costs are a significant element of R&D expenditure. Government investment in nuclear, aerospace and AI R&D provides explicit encouragement to business investors in these sectors.

Under the 'government priorities' Scenario 3, greater buying power and corresponding influence would be situated in government departments and their agencies as they deploy R&D investment in the pursuit of national goals. Significant rises in R&D budgets may be seen in many government departments that currently have low R&D activity to enhance their R&D capability. Such expansion would benefit from a parallel rise in in-house expertise in R&D commissioning and analysis.

The volume of commissioned R&D in private consultancies and universities may grow as a result. This could result in, for

example, universities looking to a wider range of Government departments for research income than today, and potentially a reshaping of the balance of R&D towards 'applied' and 'experimental development' research, as categorised by Frascati.

The Cabinet Office has pursued an objective of open access to research results across Government and, where feasible, the public domain over recent years. Maintaining the principles of open access to Government research would be an important issue in a scenario in which Government became a dominant commissioner and user of R&D.

One key to the science superpower agenda is an arc of ambition that spans generations of political leaders

Political continuity

A single electoral cycle cannot provide enough time to meet every dimension of a science superpower ambition. It takes longer to raise the level of R&D investment in the UK to an internationally competitive level and make the most of this greater investment to support prosperity, health and quality of life across the country. Meanwhile, every step of progress helps successive governments handle challenges in climate change, national security, energy security, the integrity of the food chain and further unpredictable issues that are faced by every Government.

New Ministers may feel under pressure to demonstrate personal achievements. Frequent changes in Ministerial

appointments add to that pressure, allowing even less time for an individual to leave their mark. Government gives itself a longer road to travel if it gives way to political pressure, creating new initiatives that are no more effective than the arrangements they replace.

One key to the science superpower agenda is for Ministers to craft priorities that deliver results in a political timeframe while maintaining an arc of ambition that spans generations of political leaders.

Conclusions

The purpose of this report is to stimulate debate and to highlight the choices that lie on the path to becoming a more research and innovation-intensive UK.

Through consultation with a rich array of people and organisations, we have highlighted opportunities and challenges associated with three scenarios by which the UK might achieve the economic and cultural goal of becoming a 'science superpower'.

We have seen that some of the desirable outcomes of each scenario are in tension with each other. Choices that promote certain outcomes may limit others. Therefore, consideration of the merits and pitfalls of those choices at this stage could be valuable to policy-makers seeking to optimise policy interventions and public investment in R&D.

As a new administration begins its term of office, choices about how to direct the UK's R&D agenda will rightly come under review. New Ministers will have a new agenda. Understanding the choices available and trade-offs between them is important to help Ministers and policy-makers deliver the national agenda they want to pursue to maximum public advantage.

The public and the R&D community have a voice in shaping the nature of a more research and innovation-intensive UK. Understanding the choices at hand will help navigate the path ahead.

List of consultees

Name	Role	Organisation
Rob Ashelford	Head	NESTA Wales
Caroline Barelle	Chief Executive Officer	Elasmogen
Kellie Beirne	Director	Cardiff Capital Region City Deal
Rhys Bowley	Manager	Low Carbon Energy and Environment Research Network Wales
Paul Boyle	Vice-Chancellor Chair of Wales Innovation Network Board	Swansea University
Lisa Brodey	Science Counselor	US Embassy London
Andrew Caldwell	Defence and Security Accelerator	Ministry of Defence
Michael Charlton	Vice President	Learned Society of Wales
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Laura Cuss	Director of Strategy	Aerospace Technology Institute
James Davies	Chief Executive Officer	Industry Wales
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Kieron Rees	Assistant Director	Universities Wales
Martin (Lord) Rees	Astronomer Royal and Emeritus Professor of Cosmology and Astrophysics	University of Cambridge
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Dan Shah	Director, Investment Strategy and System Insight	UKRI
Magdalena Skipper	Editor in Chief	Nature
Hetan Shah	Chief Executive	British Academy
Barry Smith	Director of the Institute of Philosophy	School of Advanced Study
Robert Sorrell	Formerly VP Research and Innovation at BP	Independent Technology and Policy Advisor
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Claire Thorne	Co-Chief Executive Officer	Tech She Can & Deep Science Ventures
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Amanda Wilkinson	Director	Universities Wales
David (Lord) Willetts	President of the Advisory Council and Intergenerational Centre	Resolution Foundation
James Wilsdon	Digital Science Professor of Research Policy Director, Research on Research Institute	University of Sheffield

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