Universities UK International

FUTURE INTERNATIONAL PARTNERSHIPS

PUTTING THE UK AT THE HEART OF GLOBAL RESEARCH AND INNOVATION COLLABORATION

October 2020

CONTENTS

INTRODUCTION

UK universities are global institutions. Their reputation is an asset in the projection of the UK around the world. They attract students from across the globe and offer to many UK students international experiences that are essential to their future professional success. In 2018-19, about 480,000 students studying at UK higher education institutions were from overseas[1], the UK being second only to the US as an overseas study destination of choice. They forge collaborations with researchers in institutions and businesses based overseas that are vital to the development of ideas and contribute endlessly to scientific progress and new commercial opportunities. Over three-quarters of all publicly-funded research and development takes place in a university and 76% of the work submitted by universities to the Research Excellence Framework was assessed as internationally excellent or world leading. Universities are key institutions in economic growth and industrial strategies, whether national, regional or local. In 2014–15, they generated £95 billion in gross output for the economy, directly supported more than 940,000 jobs[2], created over 3,800 start-ups and about 130 spin-off companies[3].

The Research and Development Roadmap published in July 2020 affirms the government's vision to make the UK a global centre of research and innovation after its departure from the EU. It confirms the commitment to increase public research investment to £22bn by 2024/25, the ambition to reach 2.4% of GDP investment in R&D by 2027 and support the breadth of research and innovation across the country. As the government plans the economic recovery, there is a growing demand to support inclusive economic growth and lasting solutions in areas such as public health, climate emergency and energy. In this paper, the higher education sector puts forward specific proposals to deliver the vision set out by government and improve the quality of life for all. It aims to put the UK at the heart of global research and innovation collaboration.

Over the next decade, universities will pull their weight to ensure that the UK is able to meet global, national, regional and local needs. The involvement of UK universities at the forefront of the fight against COVID-19 demonstrates the benefits of working with partners from around the world for everybody in society, whether through progress on a vaccine and therapeutic interventions, or understanding the economic, cultural and social consequences of the pandemic (see case study one). The international approach to HIV/AIDS is another example of alignment of scientific resource, with UK universities delivering global solutions to global problems through their partnerships.

Universities therefore will be instrumental to make the government's vision a reality through their international networks of excellent partners (Chapter 2) , their critical contribution to building innovation capacity in their local economy (Chapter 3) and their institutional partnerships with universities across the world (chapter 4) provided that their role as global collaborators becomes a feature of the domestic system in the future (Chapter 1).

[1] Source: HESA
[2] See UUK (2017) The economic impact of universities in 2014–15
[3] Source: HESA

Case study one - How universities are helping fight COVID 19 through research and innovation[4]

Numerous examples from across the country show the vital contribution that research undertaken by UK universities is making to the global effort against the outbreak. For instance:

Mathematical modelling work from Imperial College London is informing the UK government and US government response to the pandemic and providing vital insights into the nature of the outbreak, its spread, and risk.

The University of Oxford, supported by AstraZeneca, is advancing quickly on its ongoing response to address the challenges of a vaccine. It is working with the University of Sao Paulo on clinical trials. Brazil is a priority for the study because of the ascendant curve of the COVID 19. Oxford and AstraZeneca are collaborating with a number of countries and multilateral organisations to address local needs and define next steps on the supply of the vaccine to make it accessible around the world in an equitable manner.

Experts at the University of Southampton are modelling the effectiveness and timing of Covid-19 interventions for different regions of the world. The research is helping the World Health Organization and the European Centre for Disease Prevention and Control with response efforts.

Researchers at the University of Plymouth are working in partnership with Shanghai Veterinary Research Institute and Kansas State University to develop ways to vaccinate animal populations to tackle any future outbreaks before they reach humans.

Nnenna Nkata, a Cranfield University student has created a dashboard giving information on the spread of Covid-19 in Nigeria which is now in public use.

The University of Nottingham, in partnership with Stanford University and the Bank of England, is using their Decision Makers Panel to understand the economic impact of COVID-19 and provide evidence-based insights into business expectations and uncertainty.

[4] More examples of the role of universities in the crisis can be found in the #WeAreTogether campaign: https://www.universitiesuk.ac.uk/covid19/supporting-national-effort/Documents/we-are-together-case-studies-covid-19.pdf;

More examples on the role of social sciences departments in universities in responding to the crisis can be found on*:* https://campaignforsocialscience.org.uk/hub-of-hubs-social-sciences-responding-to-covid-19/

CHAPTER 1

Opening the domestic system to enhanced international partnerships

UK universities are already very good at international collaboration. Indeed, this openness to the world is a foundation of their high reputation and position in global rankings. However, they could work more, better and faster with partners and attract more of the best minds. New digital ways of working brought by the pandemic also make international collaboration more achievable than ever before. The challenge will be to ensure that the global role of universities is hardwired into the fabric of the research and innovation system so that they can make a bigger contribution to the economy and society in the UK and the wider global community.

'International collaboration is the foundation of UK science and innovation. It brings novel ideas, complementary skills and knowledge, and gives rise to breakthroughs that would not be possible otherwise. Greater collaboration leads to greater UK influence in the world' Professor Paul Boyle, Vice Chancellor, Swansea University

The higher education sector proposes to make the best of the government's commitment to increase investment in public research by evolving domestic funding mechanisms, structures and frameworks towards a more global outlook, thus taking the system as a whole to the next level up of openness and reach. This evolution is necessary to meet the government's international ambition and will have a systemic impact that goes well beyond benefits to individual institutions. It will deliver transformative change at scale over time by enabling universities to grow and diversify their international partnerships, and attract talent and investment to the UK.

The UK's association to Horizon Europe underpins valuable scientific partnerships that have been built up over many years whilst being a springboard to other productive partnerships across the world. More recently, the Newton Fund and the Global Challenges Research Fund have been the most notable international initiatives taken as part of the UK's Official Development Assistance commitment. They encouraged universities to contribute to building science capabilities in developing countries and forge richer networks. These international partnerships should continue. However, change is needed in the national system to advance these relationships to the next stage and intensify partnerships with countries that operate at the science and technology frontier.

In this paper, the higher education sector recommends making wide-ranging changes to key features of the current domestic research and innovation system that will enable researchers to work with the best counterparts, both in academia and industry and with as little friction as possible, through a comprehensive portfolio of funding vehicles that will:

- promote bottom up and top down international collaborations across disciplines, at all career stages, blue sky and applied research (Chapter 2);
- create stronger international knowledge exchange networks with innovative businesses based overseas and retain international entrepreneurs in their local economy (Chapter 3),
- and develop strategic partnerships with universities across the world to increase cooperation and boost the mobility of researchers and students (Chapter 4).

By establishing this structure of widely recognised vehicles to advance international partnerships, universities will be able to collaborate to an extent currently not possible.

This change will visibly build up the UK profile, including in international metrics and rankings, through: increased excellent research publications; increased foreign direct investment; new research fields and technology development where access to facilities, infrastructure, environments and data sets are limited nationally; cutting-edge businesses and start-ups in high tech sectors in the local economy. In turn, this enhanced reputation will attract more researchers, entrepreneurs and students. Failure to make this change risks a rebalancing of the global knowledge economy away from the UK. Over the last decade or so, Asian universities in particular have been boosting their international outlook, research and knowledge exchange capabilities as well as teaching. This is reflected in their strengthened positions and has implications for the global flow of talent and investment.

The recommendations in this paper reflect discussions from a wide range of conversations with universities of all sizes and specialisms, across regions in England and across the four nations of the UK. It is hoped that they will facilitate in-depth discussions and provoke more ideas to progress this agenda. There is a unique opportunity for government and UKRI to take these recommendations forward. The higher education sector, through UUKi, is willing to provide support and help make this change happen.

Summary of key recommendations

UK universities are global leaders in science and research, and will nurture a demonstrably unique global network of excellent research partners (Chapter 2)):

1. A new global prestige talent scheme should be established and aimed at attracting researchers from across the world to pursue blue sky research ideas in the UK. It should fund excellent researchers identified through independent, internationally recognised peer-review panels.

2. UKRI should strategically grow the scale and scope of system-to-system funding agreements with leading agencies from countries at the science and technology frontier. It would enhance UK researchers' ability to collaborate with excellent strategic partners in a greater array of regions and disciplines over the longer term.

3. The scheme providing funding for cross-borders research projects (so called 'co-investigator scheme') should be mainstreamed across all competitive UKRI research councils. It would enable more UK researchers to collaborate with excellent counterparts anywhere in the world, flexibly and at speed.

UK universities are key players in building the future UK economy, and will attract a growing share of international business investment in their local community (Chapter3):

4. A new national policy priority for international knowledge exchange should be created and aimed at universities across the four nations of the UK. For English universities, a dedicated additional funding in the Higher Education Innovation Fund (HEIF) should focus on bringing business investment from overseas and, across the devolved nations similar prominence and equivalent funding should be made available.

5. Dedicated international calls should be part of the Research Partnership Investment Fund (RPIF) and the Strengths in Place Fund (SIP) to support regions that are high on the government 'levelling up' agenda. They should be designed to facilitate high quality bids involving co-investment from overseas businesses.

6. A dedicated flexible mechanism should be put in place to consider proposals for retaining high-value R&D activities in the local economy. The aim would be to avoid a 'domino effect' should big businesses move some of their activities outside the UK.

7. A competitive entrepreneurship programme should be established and aimed at retaining international students who are entrepreneurs to start and grow their businesses in the UK. This should be part of an effective approach promoting inward investment and local economic growth.

8. A 'One Front Door' model should be created to promote the UK as a destination of choice for Research and Development and signpost opportunities to potential investors and researchers. This would involve a joined-up promotion strategy bringing together UK representations overseas and building new capabilities.

UK universities draw on broad and stable institutional partnerships across the world, and will expand their global reach through increased cooperation and exchange of researchers and students (Chapter 4):

9. The Centres for Doctoral Training and the Doctoral Training Partnerships run by UKRI should provide more capacity to support international collaborative PhDs between UK universities and institutions overseas. This would lead to more excellent research, extend their global outlook and raise the UK reputation internationally.

10. A revised and more strategic version of the Rutherford Fund should be introduced to boost the international mobility of researchers. It should focus on early career researchers and be part of wider university strategies to scale up their institutional partnerships so that more international collaborations can be built on the initial mobility grant.

11. The effectiveness and efficiency of processing and delivering visa applications, including short term visas, should be fully integrated in any mechanism promoting the mobility of researchers.

12. System-to-system agreements between UKRI and leading agencies should be as comprehensive as possible if they are to be lasting. They should seek to ease potential restrictions in setting up international research degrees and in supporting the mobility of researchers and students as well as university alliances.

CHAPTER 2

UK universities are global leaders in science and research, and will nurture a demonstrably unique global network of excellent research partners

UK universities' top position in global research excellence is currently beyond dispute, but less certain is what the future holds. Sometimes universities' international initiatives are framed as a competitive necessity—for their reputation, for the global success of the UK and the economy. But if these are competitions, they are ones which everyone can win through the partnerships they generate, in the opportunities they open, in the fields and the minds they expand.

International collaboration is positively correlated with higher citation impact research[5]. Some transformative and high impact scientific discoveries trace their origins to research born out of sheer curiosity and don't yield immediate payoffs. Other endeavours solve societal challenges cross borders, harness new knowledge for the public good and promote dialogue between nations. It is therefore essential that UK researchers can work as seamlessly as possible with the best minds, wherever they are located in the world.

'At a time when the manifold benefits of international collaboration in scientific research are being daily demonstrated in response to the Covid-19 pandemic, we should seize the opportunity to establish system to system funding with a range of developed research economies and work to remove barriers to collaboration at all levels of academic endeavour'. Professor Dame Janet Beer, Vice-Chancellor, University of Liverpool

[5] https://www.universitiesuk.ac.uk/International/news/Pages/eu-collaboration-uk-universities-benefits-implications.aspx

Collaboration with the EU: Collaboration between the UK and the EU in the framework programmes strengthens the ability to tackle shared challenges, such as cancer, dementia and climate change. It is vital that the commitment to UK participation in principle in the R&D Roadmap translates into an agreement on the terms of participation.

Horizon Europe association should be a core part of the future relationship between the EU and the UK for research, underpinning valuable scientific partnerships that have been built up over many years. Both the UK and the EU have reaped the health benefits of these collaborations such as clinical trials, particularly on diseases with limited patient populations, are reliant on EU-UK collaboration, while close research partnerships continue to accelerate life-changing medical research. Our collective ability to respond to the threat of climate change and outbreaks of new diseases like Covid-19 has also been greatly improved by close scientific and clinical partnerships across Europe. Collaboration through the research framework programmes is a springboard to productive partnerships across the world. We owe it to future generations in the UK, the EU and beyond to ensure that the new EU-UK relationship best serves them through research.

Collaboration beyond the EU: There are multiple barriers to international research collaborations with excellent partners outside the EU, from arranging visas and work permits, to lack of dedicated funding mechanisms and complex bureaucracies. Finding excellent research collaborators is currently mostly an organic process undertaken by individual researchers in universities. The timing needs to be right and the opportunity may not present itself for years, if at all. At the same time, the digital age is making international collaboration easier and cheaper. Knowing how to make the most of online tools will require resources, but the extensive remote working experienced during the pandemic will shape interactions with collaborators across the globe in the future.

Talent comes with many different passports, and UK universities work to attract and nurture the most promising and creative minds. The R&D Roadmap announced the creation of an Office for Talent to make it easier for overseas researchers to work and settle in the UK. It is a great opportunity to launch a global prestige talent programme that will provide new routes for overseas researchers to join UK-based research teams. As key employers and providers of research environments, universities will be instrumental to the successful design and delivery of a programme aimed at attracting and, importantly, retaining talent.

At the same time, we must acknowledge that this is a multi-directional process. Academic mobility should not be viewed as a zero-sum game in which the country of arrival wins. Many UK-based researchers have benefitted from time spent studying or working overseas, and those who leave take with them strong collaborative links with UK counterparts. Enhancing students' and researchers' international outlook is important and recommendations are also made with a view to increase mobility (Chapter 4).

Opportunities for new and enhanced cooperation with excellent research teams based overseas should also be supported and improved to make the process as frictionless as possible. This can be done by shaping ambitious and strategic system-to system agreements with willing countries around shared research agendas, as well as opening up competitive grants to research proposals undertaken with high calibre investigators located overseas. It is the combination of, and complementarity between, these top-down and bottom-up approaches that will make the domestic research system highly responsive and outward-facing.

UKRI remains best placed as the principal funder to deliver the change outlined below. However, this is a step-change that will require building up new international capabilities within UKRI. It will be critically important to establish a robust governance model to ensure that UKRI can work more effectively with the higher education sector and other national players to develop the best collective approach as well as invest in added capacity to engage with overseas funders and deliver successfully.

'Strong relationships with researchers globally are vital to build the best evidence base. Research in the Humanities and Social Sciences inform decision makers and governments across the world on the impact of COVID containment measures on mental and physical health, job losses, schooling, inequalities, reinforced gender roles and past experiences on coping with diseases. Virtual Corona diaries are being collected internationally. Similarly, the Social Sciences of climate change is essential for navigating the scale, complexity and impact of the climate crisis' Dr Nadine Rossol, Deputy Dean of Partnerships, University of Essex

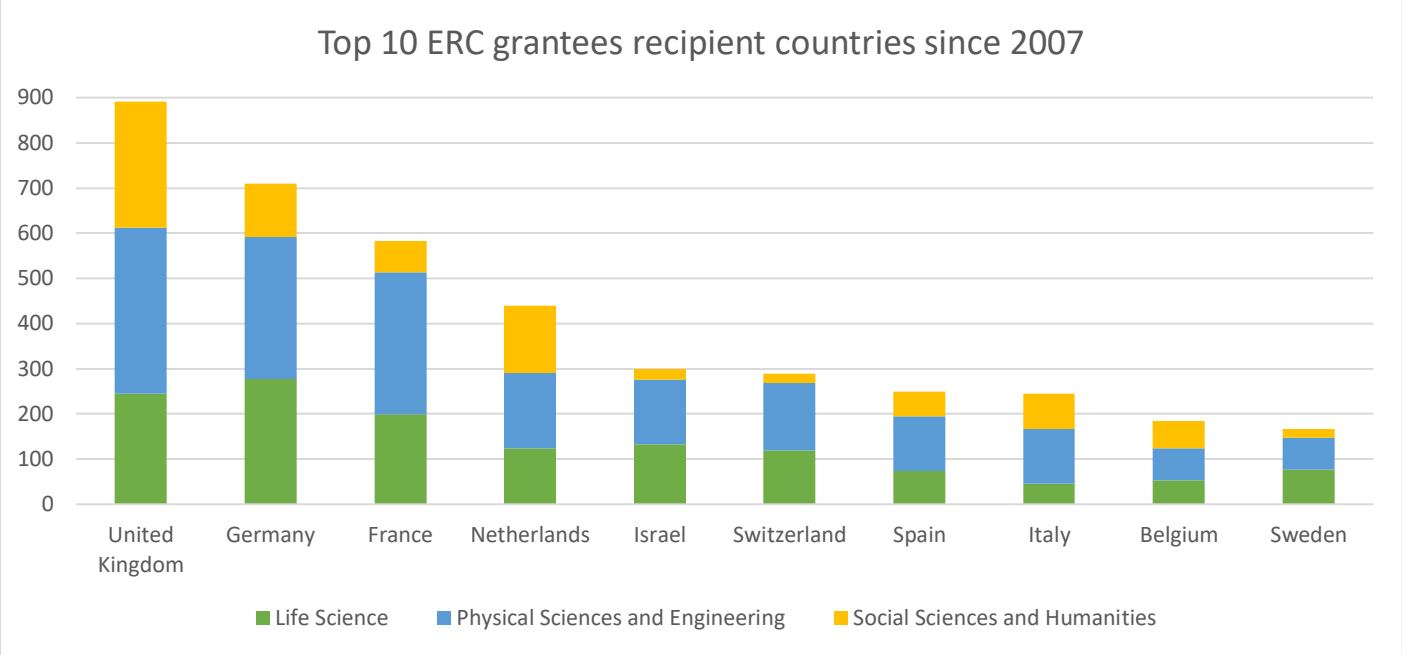
2.1 Launching a global prestige talent programme

Universities have a long and successful track record in identifying, attracting and retaining high calibre researchers to the UK to pursue ground-breaking new ideas. This has a wide array of direct and indirect benefits for the science, institutions, the wider economy and society, such as:

- Scientific and research breakthroughs
- Pioneering completely new, interdisciplinary areas of research
- Subsequent grant capture
- Building hubs of excellence in evolving scientific fields
- Attracting and retaining other excellent scientists and researchers to the UK
- Establishing new international networks
- Translating excellence in science and research into competitive advantage for industry
- Cementing the UK's reputation as an international leader in research and innovation
- Creating knowledge which helps to address societal, environmental and public health challenges

The UK university sector's attractiveness as a destination is demonstrated by its strong record in the European Research Council and Marie Skłodowska-Curie Actions calls, which are widely seen as some of the most sought-after awards currently available. Since 2014, the UK has received more ERC funding than any other country, funding nearly 900 researchers to pursue ground-breaking research projects in the UK (figure one). Even more have benefitted from the option to bring their ERC grants to the UK from other EU systems.

Figure one



Source: www.erc.europa.eu

At present, the combination of EU funding and awards from UKRI, the National Academies and other UK foundations provides an attractive ecosystem to any researcher thinking about coming to UK to pursue blue-sky research ideas. For instance, UKRI's Future Leaders Fellowships programme, investing £900 million over four years, is valued by the sector. However, more should be done to retain and attract talent, especially in view of the UK's departure from the EU and uncertainty over future access to Horizon Europe. Other European and global systems have already enhanced their offer of high-value, fundamental research funding, so the UK risks falling behind in this international competition if further investment is not forthcoming (see case study two).

'An innovative programme that will allow universities to offer sufficient, long-term funding to attract outstanding international researchers to the UK is an urgent priority. The Royal Society Wolfson Fellowships cover only the natural sciences but clearly show how universities can enhance their offer to researchers if they are in position to do so. It will be good if the scheme follows best practice such as introducing an international peer review panel.' Professor Tara Dean, Pro Vice-Chancellor Research and Enterprise, University of Brighton

Case study two – Global talent recruitment in Singapore, Sweden and Poland

Singapore

Since 2006 National Research Foundation (NRF) in Singapore has been a department within the prime minister's office. One of its missions is to build up R&D capabilities and capacities through attracting foreign researchers, scientists and entrepreneurs in Singapore.

The Singapore NRF Fellowship provides opportunities for early career researchers to carry out independent research in Singapore over a five-year period. It is open to all areas of science and technology. Outstanding young scientists and researchers of all nationalities are welcome to apply. Each fellow is provided with a research grant of three million Singaporean dollars to support projects that exhibit high likelihood of a research breakthrough. The research grant can be used to cover personnel, equipment and consumables costs. NRF invites applications once a year, as well as taps on local research organisations and contacts to identify potential candidates.

There is a two-step selection process, comprising a shortlisting process and a final selection. Shortlisted candidates are invited to Singapore for a final interview by the NRF Fellowship Evaluation Panel, which is an international panel. Appointees are offered tenure-track faculty positions at Singapore-based universities and research institutions. They can also be offered positions at the five Research Centres of Excellence.

***

Sweden

Since 2013, the Swedish Research Council has been running a programme funded by the Swedish government with the aim to give top international researchers, at the level that he or she is qualified, a tenured post as a full professor and long-term support to develop their research fields to build a strong research environment at a Swedish research institution. Nominations to this programme were submitted by vice-chancellors of Swedish universities in two calls, one in 2013 and one in 2014.

The purpose of the grant for the recruitment of international leading researchers was to enable Swedish higher education institutions to offer long-term and sufficient funding for recruitment of eminent researchers from overseas. The grant serves as a tool to support recruitment of internationally leading researchers in areas within university strategic initiatives. With the help of the grant, an internationally outstanding researcher is able to move her or his research from overseas to a Swedish higher education institution. The awarded grants are being evaluated by an international panel to assess if the research environments have been established as coherent and feasible entities and that the terms and conditions of the grant are met. The evaluation also assesses to what extent the research environments and the research have been integrated at the universities and developed according to the aims of the application.

This forms part of an initiative aimed at creating research environments around some of the most prominent researchers at different career levels as well as stimulating more long-term goals for research, comprising three grants: international recruitment of eminent researchers (grants for international recruitment of leading researchers), recruitment of prominent younger researchers (consolidator grant programme) and support for the most prominent researchers (distinguished professor programme).

***

Poland

In June 2020, The Polish National Agency for Academic Exchange announced a new programme (NAWA Chair) offering universities and other scientific institutions a long-term financial package that covers the stay of world-renowned foreign scientists as well as funding for fundamental research, which will be financed by the National Science Centre. The prestigious grants awarded under the NAWA Chair programme is part of the strategy of internationalising Polish higher education and science by means of a long-term financial package.

The first edition of the programme is directed at higher education institutions and other scientific entities which carry out research in the areas of humanities as well as social and theological sciences. The next editions of the programme in the following years will be dedicated to other scientific disciplines.

NAWA's new programme makes it possible to invite to Poland world-class foreign scientists who work in the relevant disciplines. They will be hired as guest professors for a period between three and four years. In this time, as outstanding scientists they can become the hearts of strong scientific teams, do breakthrough research and help the entities apply for international grants. A grant funded by NAWA will cover the costs of the guest professor's and their research team's remuneration as well as the professor's mobility expenses. In addition, higher education establishments and other scientific institutions can apply for funds for fundamental research from the National Science Centre.

In view of this increasing global competition, the UK should instigate a brand new, globally prestigious award scheme to retain and attract talent. Experience from universities strongly suggests that the most talented researchers should be given access to large, long-term, competitive grants which are open to unproven or risky ideas, often crossing disciplinary boundaries. Awards should be viewed as transparent and prestigious through evaluation by international peer review panels and must give researchers the freedom to pursue new and emerging lines of enquiry. A variety of carefully designed funding opportunities are necessary to cover a full range of career stages allowing a diversity of career paths. Awards at different career stages should have different, yet complementary objectives, such as creating new hubs of excellence by attracting eminent researchers. Attention should be paid to striking the right balance with funding opportunities for homegrown talent and some recalibrating of existing schemes, such as UKRI's Future Leaders Fellowships programme, to ensure fairness and coherence.

'We have to do much more to promote a diverse research community. This means that national programmes to attract and retain talent must take into consideration wider personal circumstances, including family members. It also means encouraging diverse career paths and the potential for people moving between academia, industry and the public sector throughout their careers.' Professor Mark Spearing, Vice President, Research and Enterprise, University of Southampton

Key tenets of the scheme should include:

- Based entirely on excellence identified through international peer-review, whose independence is guaranteed by a scientific council populated by eminent researchers chosen from across the world
- Open to the world and to all disciplines, including new fields of knowledge and inter- or multi-disciplinary ideas
- Funded at a scale that makes it at least comparable with other global fundamental research fellowship schemes
- At least three entry points, with opportunities for talented PhD candidates, early-career researchers and eminent academics, and terms and conditions and award value and duration appropriate to each level (e.g. a lower requirement for working time spent in the UK for eminent researchers)
- Inclusive criteria to ensure that any such scheme is developed in a way that recognises excellence alongside leadership and contributes to a diverse research community
- Diverse and gender-balanced peer-review panels made up of internationally renowned researchers from the UK and across the globe
- Significant investment in global branding and marketing to set them apart from existing UK awards and appeal to an international audience, while remaining compatible with the wider UK funding landscape
- Dedicated financial support for international grantees to bring their family to the UK (e.g. visa and relocation expenses)
- A co-investigator grant option (see section 2.3)

In common with programmes of this type elsewhere, the involvement of universities will be central to its success. Awards should be well-tailored to attract the right researchers and, importantly, research environments (institutional research infrastructures, laboratories, computational infrastructure, libraries, real estate) should be internationally competitive to meet these researchers' expectations and retain them if the UK is to make the best of this investment. Universities will contribute their extensive experience to the successful design and delivery of this programme, including commitments around the long-term contract status of grantees.

2.2. Negotiating system-to-system agreements

UK researchers' international partnerships are currently funded through mechanisms, spanning from large, top-down programmes like Horizon 2020 to small mobility grants provided by UK funders or institutions themselves. When it comes to collaborative projects, there are clearly identifiable benefits to delivering funding through common pots in which multiple funders invest domestic funding which can be accessed by consortia of researchers on all sides. The most important of these benefits is avoiding the age-old 'double jeopardy' trap, whereby individual researchers each apply to their own national funding agencies for project funding, only for a project to collapse subsequently because one side or the other failed to obtain funding. This is a significant disincentive to international projects, so removing this risk for as many excellent collaborative partnerships as possible would be a boon for international collaboration.

In the absence of a single, supranational funding authority like the European Commission, 'lead agency' agreements are the optimum top down structure, in which one funder delegates authority to make funding decisions on collaborative bids to a counterpart agency. However, these agreements are complex to negotiate and depend on a high level of trust and openness between funders. UKRI already operates an array of excellence-based joint funding arrangements across the seven councils which are beneficial to the UK research community. However, the scale and scope of these arrangements should be more ambitious

and a number of geographical regions are not well represented, especially when it comes to large-scale, long-term projects.

The UKRI Fund for International Collaboration (FIC), which was set up in 2018, has increased the number of valuable collaboration opportunities by enabling individual UKRI councils to bid for funding for thematic calls which is matched with funding from international funding agencies. However, the overall array of calls is fragmented because the majority are developed through council-to-council dialogue, rather than system-to-system level discussion looking across the disciplinary spectrum (with Canada as a notable exception). This is, to some extent, a result of the small budget. Limited resources mean that funding has to be targeted in councils' priority areas and relationships, rather than taking a more holistic and strategic approach. With a larger budget, there would be potential to build on the FIC by developing stronger, more multi-faceted funding relationships with a number of key partner countries.

Another advantage of system-to-system agreements is that governments and funders can join forces with counterparts to fund collaborative projects in areas of shared mutual interest. An obvious contemporary example is the response to the Covid-19 pandemic. National governments from all over the world have combined forces to fund vaccinology research through partnerships such as Gavi, the vaccine alliance, and the Coalition for Epidemic Preparedness Innovations. Increasingly, research aimed at providing solutions to the climate emergency is a high priority in a number of countries and this creates a momentum to agree new research agendas. Some agreements structured around programmes with strong research themes and robust governance have proven to be wide and long lasting, as demonstrated by Japan's leadership in the past (see case study three). There is also a case for developing collaborative calls with trusted partners in topics such as security-sensitive research.

'Fostering collaboration across borders has never been more important, without it we will not be able to halt the progress of global pandemics or climate change. System to system agreements for research and innovation can play a pivotal role in our future strategy by enabling resources to be shared and minimising barriers to co-operation.' Professor Anthony Hollander, Pro-Vice Chancellor, Research and Impact, University of Liverpool

The UK's Presidency of the G7 and Chair of the COP26 in 2021 will create new impetus for the government to make proposals aiming at finding solutions to global issues. Grasping these opportunities to strengthen scientific ties between countries is critically important to deliver global solutions to global problems. The combination of topics chosen by the research community and very senior political buy-in can deliver unprecedented multilateral alignment and achieve progress for the global good. The higher education sector stands ready to engage with BEIS, UKRI and other players to bring insights into potential emerging areas of interest for scientific cooperation, help build support for proposals and make the best of these forthcoming UK leadership positions.

Case study three - The Human Frontier Science Programme[6]

The Human Frontier Science Program (HFSP) is a programme based in Strasbourg, France, that funds basic research in life sciences. HFSP receives financial support from the governments or research councils of Australia, Canada, France, Germany, India, Italy, Japan, Republic of Korea, New Zealand, Norway, Switzerland, UK, USA, as well as from the European Union (on behalf of the non-G7 EU members). The funds are combined into a single budget and are allocated to awards on the basis of HFSP's own peer review system on the sole basis of scientific excellence.

In 1986, a feasibility study was carried out by leading Japanese scientists under the auspices of the Japanese prime minister's Council for Science of Technology to explore possible means to encourage international collaboration in basic research. Discussion was expanded to include scientists from the G7 summit nations and the European Union, resulting in the "London Wise Men's Conference" in April 1987, which endorsed the suggestion. Prime minister Yasuhiro Nakasone of Japan proposed the Human Frontier Science Program at the Venice Economic Summit in June 1987. The Economic Summit partners and the Chairman of the European Community welcomed the initiative and activities aimed at implementing it were started. The implementing body, the International Human Frontier Science Program Organization (HFSPO), was established in 1989.

Research grants are awarded for novel collaborations involving extensive collaboration among teams of scientists working in different countries and in different disciplines. Two types of grants are available: Young Investigator Grants and Programme Grants. Cross-disciplinary fellowships are intended for postdoctoral fellows with a PhD degree in the physical sciences, chemistry, mathematics, engineering and computer sciences who wish to receive training in biology.

International peer review is a cornerstone of the procedures used in making awards. There is one review committee for Fellowships and one for Research Grants each consisting of 24 to 26 scientists. They have a broad international representation of scientific experts and each reviews applications in all scientific fields supported by the HFSP. This ensures that awards are made according to international scientific standards and the presence of reviewers from many countries minimises geo-political bias. Extensive research is carried out into the expertise and reputation of potential members before appointment to ensure maintenance of the highest standards. The evaluation procedures are under constant review and the HFSP secretariat works closely with the members of the review committees and the Council of Scientists to ensure that all applications are assessed as thoroughly as possible.

The move towards multilateral funding mechanisms would be welcomed by the university research community. One of the reasons that the EU funding programmes are so highly valued is the opportunity to receive funding to work with a wide array of partners, including some of the UK's closest and strongest counterparts. Universities support the development of a strategic plan to move towards more multilateral collaborative partnerships, some of which already exist in Europe (see case study four). This will take time to build, but there is an opportunity for the UK to take a leading role in the development of new international strategic alliances. This logic can and should also be applied to our proposed global prestige talent scheme, which could incorporate other economies to make calls even more competitive and prestigious.

[6] More information on https://www.hfsp.org/

Case study four – D-A-CH multilateral agreement

In 2008, an agreement was signed between the German Research Foundation (DFG), the Austrian Science Fund (FWF) and the Swiss National Science Foundation (SNSF), regarding the mutual opening of the respective funding programmes to simplify the execution of cross-border research projects. Under this agreement, applications submitted by researchers from two or all three of these countries need only be evaluated by the Lead Agency. The project parts performed in each of the three countries has to be interdependent and complementary.

The programme is accessible to researchers in all disciplines at German, Austrian or Swiss research institutions who have completed research training (generally a doctorate) and who are eligible to submit proposals to their respective national funding agencies.

Projects must compete with purely national proposals. The research project must therefore offer high academic quality and originality at an international level. Bilateral and trilateral research projects in which a proportion of the research takes place in Germany, Austria and/or Switzerland are submitted to the lead agency in one of the three partner countries. Following approval, these D-A-CH projects are then funded separately by the relevant national funding organisations. The funding is project specific and lasts several years.

With a view to move towards this aim, the current range and scope of international funding agreements should be increased to cover a greater array of geographical regions and wider ranging disciplinary focus areas. There should be a particular focus on stimulating collaboration with advanced economies within and beyond the EU, which has been underfunded in the past. UKRI budgets should be uplifted to achieve this aim and ensure that domestic funding is not diverted. This investment will lead to more international co-authorship and will enhance researchers' ability to collaborate with excellent partners in areas of strategic national importance, leading to tangible positive outcomes.

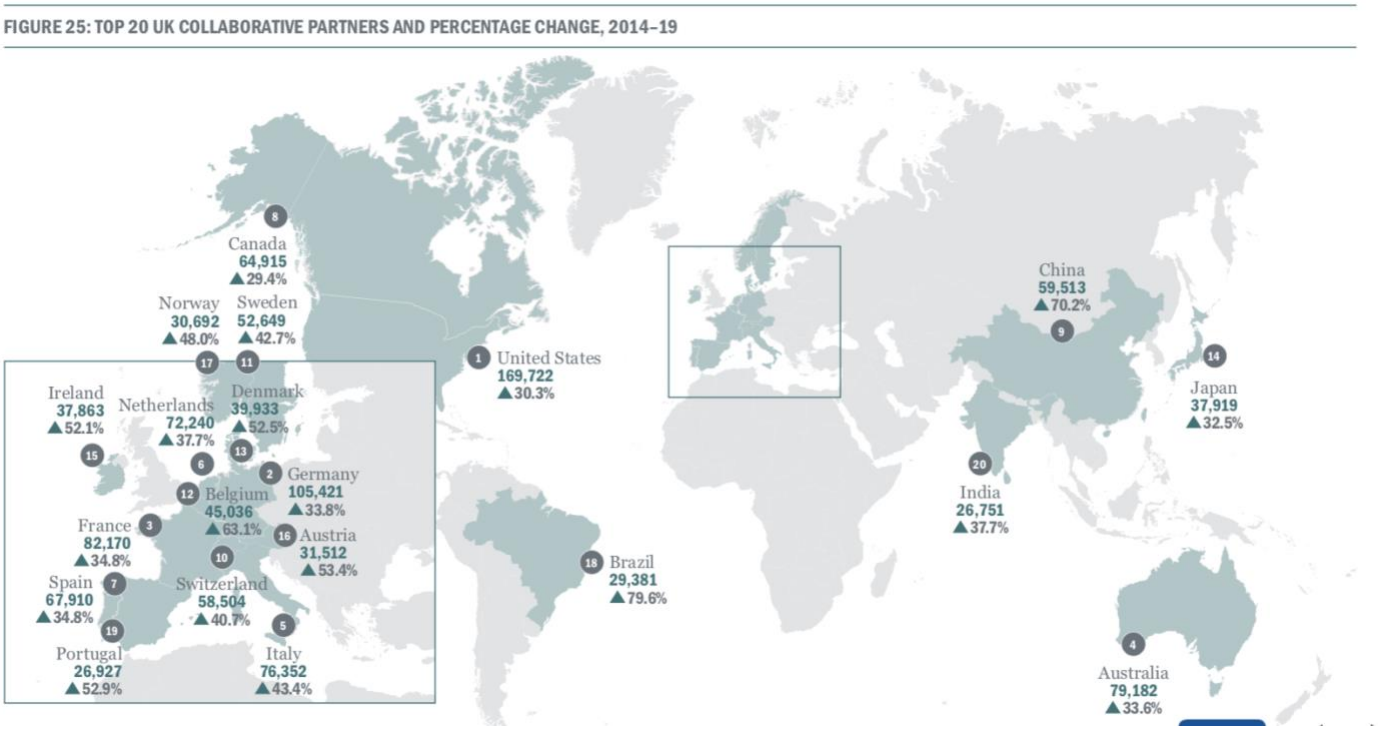
The higher education sector will support UKRI in developing new international agreements through gathering intelligence and qualitative information. Universities have a cross-disciplinary, birds-eye, practical view of opportunities for international collaboration thanks to their relationships with the higher education sector in other countries and this can be translated into strategic advice at an early stage and tailored to the countries involved in the negotiation. This advice will include a range of information with a view to make these agreements as comprehensive as possible and thus long lasting (Section 4.2.). A forum for strategic dialogue comprising government, UKRI and university representatives should be convened for institutions to feed strategically into this process.

The higher education sector, through UUKi, has an important role to play in supporting this activity, as demonstrated by its strong track record of fostering strengthened R&I relationships through its comprehensive network of global universities and higher education and research stakeholders. UUKi can support UKRI by providing sector insights, country-level intelligence and advice, as well as tailored insights on UK universities' R&I engagement with high-value, high-impact international partners. UUKi can also promote the UK's world-class offer in research and innovation, advocating for the UK as partner of choice with both established and emerging systems (see also Section 3.3).

2.3. Seeking out excellence anywhere in the world

One of the key strengths of the UK university research system is the variety of international partnerships that researchers have built up. University researchers have vast networks of research collaboration partners, enabling them to work with the best minds across the globe to create knowledge and better tackle the challenges faced at home and abroad. While there is a small number of countries such as the US, China and Germany where these links are strongest and more numerous, talent and excellent ideas are not limited to these countries (see figure two).

Figure two



Source: International Facts and Figures 2020, Universities UK International[7]

In recent years, researchers have benefitted from an increasing array of funding opportunities to support collaborative research projects with international partners, enabling these networks to grow and thrive. Horizon 2020 provides funding for UK researchers to work with European counterparts from over 40 different systems on projects spanning the disciplinary spectrum. Domestically, Official Development Assistance (ODA) research programmes such as the hugely successful Global Challenges Research Fund have allowed researchers to build new partnerships with lower- and middle-income countries. While primarily focused on capacity building, universities report that these partnerships have seeded a number of promising relationships with new partners in countries where there was previously little contact.

[7] More information on: https://www.universitiesuk.ac.uk/policy-and-analysis/reports/Pages/Intl-facts-figs-19.aspx

However, this strength has become an obstacle. Having established relationships with excellent global partners, UK researchers have frequently had difficulty in finding separate funding to enable them to work together at scale and beyond ODA capability building objectives. In a few cases UKRI may have a relevant joint call with a funder in the country of a collaborator, but more often than not, there are no joint arrangements, or the eligibility criteria rule them out, or there is no open call. This is not to undermine the role of joint funding pots. As stated above, they are valued by university researchers who have accessed them, but there will always be a limit to the number of such schemes that UKRI can feasibly run. This has led to a pattern of 'unfunded' excellent collaboration opportunities, where researchers on both sides of a partnership piece together small or partial pots of funding to work on complementary projects. This problem is less apparent when working with European partners given the availability of EU funding, but uncertainty over future access to EU projects has cast doubt over this.

'Via Canada's BrainsCAN initiative, Cardiff University researchers are able to collaborate with Canadian, Australian, Japanese and South Korean neuroscience and mental health researchers. This includes postdoctoral mobility and exchange supported by BrainsCAN and the Welsh government Sêr Cymru scheme. New, larger-scale funding opportunities would help maximise these valuable international partnerships, increasing visibility, influence and outcomes for the UK.'
Professor Kim Graham, Pro Vice-Chancellor Research, Innovation and Enterprise, Cardiff University

One of the few truly flexible international funding opportunities available to UK researchers is the co-investigator scheme that is operated by the Economic and Social Research Council (ESRC), Arts and Humanities Research Council (AHRC) and Medical Research Council (MRC). This allows researchers who receive ESRC, AHRC or MRC grants to allocate up to 30% of their funding to support the direct costs of an international co-investigator provided that it can be demonstrated that the co-investigator is essential to the project's objectives. This option is open to all nationalities and has been recently built into the cross-council UKRI call to fund research into the impact of Covid-19. A number of European research funding agencies, such as the Dutch NWO, already offers this possibility through the so-called 'money follows cooperation' option, raising the interesting possibility of matching co-investigator awards with counterparts in countries running similar schemes (see case study five).

Case study five – 'Money follows cooperation'

The Dutch Research Council (NWO)' s mission is to advance world-class scientific research that has scientific and societal impact by being a connector. NWO recognises that science transcends national boundaries, but funding is often driven nationally. One of the new ambitions in NWO's 2019-2022 strategy 'Connecting science and society' is cooperation for excellence and innovation in research. NWO is using the principle of 'money follows cooperation' to eradicate borders and facilitate bottom-up international cooperation in virtually all the research it funds.

'Money follows cooperation' creates opportunities to enhance the scientific and social impact of research projects by using expertise from abroad that is not available in the Netherlands. The money follows cooperation option has been implemented as a budget module in almost all NWO funding instruments, except in the NWO Talent Programme, large-scale infrastructure and some bilateral or multilateral programmes.

The requested budget in the money follows cooperation module may be up to fifty per cent of the total requested budget. No additional funds can be secured via this scheme. However, money follows cooperation does provide the option of spending part of the costs from other budget modules on a foreign knowledge institute. This does not alter the budget ceiling. The main applicant receives the grant and is responsible for transferring funds from the grant to the co-applicant's foreign knowledge institute and for the financial accountability of the expenditure of the money follows cooperation part of the grant. The exchange rate risk lies with the applicant(s). Therefore, gains or losses due to exchange rates are not eligible.

When submitting a proposal, the lead applicant must convincingly demonstrate that the relevant expertise is not available in the Netherlands (unless NWO has signed an agreement with a sister organisation in the foreign researcher's country of origin). The lead applicant must submit this to an NWO evaluation committee for assessment. If the application is positively reviewed by the consortium, then NWO will also fund the researchers affiliated with foreign knowledge institutions. To be able to spend a grant on a certain knowledge institute, a researcher from that knowledge institute must always act as (co-)applicant. However, this foreign cooperation partner can never be the main applicant.

More university researchers could collaborate with excellent partners across the world at speed and in a dynamic way, if the co-investigator scheme is extended across all competitive UKRI research council funding streams. UKRI council budgets should be uplifted accordingly to ensure there is no adverse impact on the availability of domestic funding. This will enable researchers in all disciplines to benefit from the expertise of global counterparts without having to fit their plans around the limited number and timing of joint funding arrangements. This would also be an important signal to potential partners worldwide that the UK values the benefits of international collaboration. Co-investigator awards could potentially be leveraged against awards by other global funding agencies operating similar schemes.

CHAPTER 3

UK universities are key players in building the future UK economy, and will attract a growing share of international business investment in their local community

Universities play an important role in national and regional growth strategies worldwide as producers of graduates and innovation, both key inputs into economic growth. They are essential institutions to deliver the government's 'levelling up' agenda. A compelling body of economic evidence shows that an increase in the number of universities in a region is robustly associated with higher GDP and find that growth in enrolments generate start-up activity in nearby areas, including in the innovative high-tech sectors. It suggests that increased funding for university R&D will generate more innovation, skills and create translational opportunities for businesses through support for collaboration, knowledge exchange and technology transfer (see case study seven).

'Each part of the country has different needs and challenges. Universities are uniquely placed to work with industry to reshape local economies and develop regional investment hubs. They can widen and deepen innovation activity through direct improvements in skills, technology diffusion and research.' Professor Quintin McKellar, Vice-Chancellor, University of Hertfordshire

Case study seven - Universities and their local economy

There is a robust and increasing body of recent economic evidence showing that universities are key institutions that can help the UK to move onto a sustainable and inclusive growth path[8].

The overall economic impact of universities is examined by Valero and Van Reenen[9] (2018) using international data from the 1960s to today. They find that a 10% increase in the number of universities in a region is robustly associated with a 0.4% increase in regional GDP, even after controlling for country and time effects, population growth and regional trends. Universities increase local human capital in the workforce both by training students from the local area, and by pulling students into a region from elsewhere.

Stemming from the seminal paper by Jaffe[10], a number of subsequent papers have found strong evidence of localised innovation spillovers from university research. Some papers then relate increases in innovation to local economic outcomes using exogenous sources of variation to estimate a causal relationship[11], finding that economic spillovers are larger for sectors that are technologically closer to the university's specialisms. Universities can create innovation spillovers via formal or informal interactions between university research and businesses, and the innovative activities of staff, students and graduates.

Papers that analyse the effect of university research activity on area or business performance include for instance Guerrero et al[12] (2015), who find positive relationships between university teaching, research and spinoffs and the productivity of UK regions (at the NUTS3 level). Valero[13] (2018) finds that growth in universities in the UK (in terms of their size) generates start-up activity in their nearby areas, including in the innovative high-tech sectors. University growth also raises productivity in areas with a larger high-tech sector, and in general, the impacts are larger for universities of higher quality and research intensity.

A recent paper by Fang and Valero[14] (2020), finds that businesses closer to universities tend to have better management practices. The effect seems to be driven by universities raising the supply of skilled workers and hence reducing their cost. Businesses further away from universities employ fewer skilled workers and are worse managed, even after controlling for a rich set of observables and fixed effects.

The goal set out in the R&D Roadmap is to increase investment in R&D in the UK from the current 1.7% of GDP to 2.4% by 2027, with a longer-term goal of 3%. This is an ambitious target that will not only require further public investment but also a very significant increase in business investment since about two third of R&D comes from the private sector.

Over recent years, the policy emphasis has been to foster stronger linkages between universities and local businesses, local authorities, Local Enterprise Partnerships and other local actors, and develop shared

[8] Source: https://blogs.lse.ac.uk/businessreview/2018/11/21/universities-and-industrial-strategy-in-the-uk
[9] See https://www.nber.org/papers/w22501)
[10] Source: Adam B. Jaffe. Real Effects of Academic Research. American Economic Review 79. 5 1989
[11] See for example, https://en.falk.huji.ac.il/sites/default/files/falk/files/paper_17-05.pdf
[12] See: https://doi.org/10.1016/j.respol.2014.10.008
[13] See: https://www.nber.org/papers/w22501
[14] See: https://doi.org/10.1093/ej/ueaa005

regional development strategies. Building on the progress achieved, universities could go further in their civic mission and build increased innovation capacity by attracting more inward investment in the regions. There is potential for leveraging further UK university assets, which have been built over decades, for this purpose.

'Higher education is a key driver for economic recovery, and as an international university Heriot-Watt is uniquely placed to play a pivotal role in propelling sustainable growth. Advanced R&D, innovation, commercialisation and talent development sit at the foundation of our approach, driving job creation, inward investment and ultimately future prosperity. Core to Heriot-Watt's mission is the desire to help all our communities flourish. By harnessing our global networks and collective minds we have the ability to enable transformational change.' Professor Richard A. Williams, Principal and Vice-Chancellor, Heriot-Watt University

Universities are high profile international players with networks in other countries through students, staff and alumni, as well as direct relationships with overseas universities, businesses and even governments. Some of them have a footprint abroad through branch campuses and other infrastructure. Indeed, UK universities have more than 40 campuses and centres in 20 different countries. As a result, UK universities are confident operating overseas and typically have more connections across borders than other local actors.

However, if universities are to become more powerful vehicles for inward investment, they will have to build new capabilities to extend their reach, foster richer and more stable investment networks with companies that can be located anywhere across the globe. They will also have to deploy new efforts to persuade international businesses already in the UK to retain or deepen their R&D investment, or establish new research arms. This should be in addition to, not at the expense of, their civic mission to support local businesses, and this international effort should be aligned with regional development strategies to have a sustained economic impact. There should be a synergy between the civic and international missions of universities as it increases opportunities for inward investment, export opportunities, and the recruitment of talented and globally mobile employees.

'The University of Manchester's innovation strategy is closely aligned to the Greater Manchester Local Industrial Strategy. We place a high premium on bringing research and innovation partners to our region to establish close collaboration, taking advantage of our world-class researchers and facilities.' Professor Luke Georghiou, Deputy President and Deputy Vice-Chancellor, University of Manchester

3.1. Supporting international university-business investment networks

The international competition to attract business R&D is intense, with the wider policy and business environment offered by different countries a key consideration for decision makers. Against this backdrop, UK universities are a significant asset for the UK. They have the reputation to be some of the best innovation partners in the world, including in emerging markets where businesses are seeking to access cutting edge R&D and facilities. A wide range of examples show how universities of different sizes and specialisms across

regions of England and the devolved administrations have attracted overseas companies to do their R&D in the UK (see case study eight).

Case study eight - Attracting investment from businesses based in Japan, the US and the EU

Cardiff University – Takeda Partnership

Cardiff University's genetics and neuroscience experts have joined forces with one of the world's leading pharmaceutical companies to create new drugs to treat psychiatric disease. The Takeda Drug Discovery Partnership brings together Japan's largest pharmaceutical company with experts from Cardiff University's Neuroscience and Mental Health Research Institute and MRC Centre for Neuropsychiatric Genetics and Genomics.

Established in 2018, the £4m investment was specifically designed to bring together Takeda's experience and expertise in drug discovery with Cardiff's expertise in genetics, genomics and neuroscience to enable rapid translations of basic scientific research for clinical benefit. The partnership offers Takeda unprecedented access to the university's extensive patient and population cohorts, human brain imaging and expertise in generating human stem cell and brain tissue models as well as establishing South Wales and Cardiff, in particular, as a magnet for attracting international investment and research expertise in life sciences and precision neuroscience.

The partnership has seen the creation of ten new posts with advanced training and skills combining academic research and industry standard processes in drug discovery. In addition, the university's close links with Takeda has helped stimulate new negotiations for further research collaborations, provided support for early career researchers and helped leverage for several new grant applications. The partnership is helping to establish the university as a major centre for international mental health research alongside other major announcements like The Wolfson Centre for Young People's Mental Health, a £10m dedicated research centre focusing on reducing anxiety and depression in young people.

University of Strathclyde – EnMovi partnership

Med-tech firm EnMovi Ltd is a joint venture between US-based OrthoSensor and McLaren Applied Technologies and focuses on the development of data analytics, machine learning and mobile applications to support its wearable orthopaedic sensor devices. EnMovi Ltd is establishing its £8 million Research and Development centre in Glasgow in January 2020 and will create 19 new high-value jobs with the support of a £2.5M Research and Development Grant from Scottish Enterprise.

The University of Strathclyde has a long-standing relationship with OrthoSensor through the provision of strategic equity investments into the company, established research relationships with the departments of electronic and electric engineering, biomedical engineering, and computing and information sciences and industrial connections with key players in medical technologies including Stryker. As a result of this relationship, the University of Strathclyde worked closely in partnership with OrthoSensor and Scottish Enterprise to bring EnMovi as a 'spin-in' to the university. Being based in the university's Inovo building – a state-of-the-art business location adjacent to the Technology and Innovation Centre – ensures the company is ideally-placed for further collaboration with academics, companies and key partners within Strathclyde's HealthTech Cluster and innovation ecosystem.

Discussions are currently underway between the university and EnMovi regarding new collaborative opportunities in connected healthcare as the EnMovi team is established and expands. Identification of the growth potential within the life sciences sector is closely aligned to the University of Strathclyde's focus on industrial clusters, leading industrial engagement, and capabilities and expertise in HealthTech.

Newcastle University - Siemens partnership

Siemens is a multi-national company with headquarters in Germany specialising in industry, energy and health care, and infrastructure & cities. Newcastle University is one of Siemens' Global Principal Partners. The Centre for Energy Systems Integration (CESI) is one of the collaborative research programmes that Siemens supports as an underpinning strategic partner contributing £7.1m to the Centre.

CESI published research on blockchain in which Siemens was a partner and has been widely cited nationally and internationally, including by the US Congressional Research Office for a strategic policy briefing to US Congress. Siemens won the contract to build and operate the first and largest multi-vector smart energy system in the UK at Keele University. CESI Academics worked with the Siemens Engineers to investigate the energy systems integration concepts that could be explored within the design. CESI now sit of the Advisory Committee of the project.

The Urban Sciences Building (USB) is one of CESI's demonstrators for local energy systems research. The USB is a flagship building for urban sustainable development that, in collaboration with Siemens, is a 'living lab' for how buildings can function as power plants. This facility has made possible research on the performance of the building using data from digital sensors, hosting Newcastle's first electric vehicle fuelling station, and a cloud-based, open Internet of Things (IoT) operating system (MindSphere) that connects estates and academic research on IoT from various universities in the UK to identify the opportunities of this technology, including as a tool for remote energy storage asset control and operation. CESI demonstrated the technology within the EPSRC Energy Storage Test Bed which is within the USB demonstrator.

University of Exeter - Shell partnership

The global energy company Shell has established a strong partnership with the University of Exeter working with Professor John Love and the Exeter Microbial Biofuels Group (EMBG) since 2005. Building on this relationship, in 2017 Shell and the University of Exeter signed a Research Framework Agreement, currently exceeding £5M, to support the acceleration of the development and commercialisation of advanced biofuels and renewable chemicals from synthetic biology.

In early 2013, Shell Biodomain re-located from the UK to new laboratories in Houston, Texas, but chose to continue the UK partnership with Exeter due to the EMBG's impact on innovation and strategic business planning resulting in potential savings exceeding $500M at Shell. The EMBG are exceptionally well-integrated with Shell's in-house research team and guide biofuels innovation, introducing, validating and disseminating new technologies throughout the company, and providing critical, impartial and evidence-based research, which contributes to Shell's techno-economic planning.

A combination of broad academic scoping, creative innovation and rapid testing within commercially defined parameters adds core scientific competency at Shell and lowers the barriers to entry for new technologies. The collaboration has produced a number of scientific breakthroughs resulting in high quality intellectual property and patents. These discoveries have been fast-tracked for implementation and pilot scale-up projects at the Shell Technology Center in Houston that prototype future production platforms and lay the foundation for commercialisation of advanced biofuels.

The Shell-EMBG partnership has supported 25 full time scientific researcher positions and is bolstered by regular bilateral staff exchanges of up to 18 months. Shell Biodomain also sponsor two undergraduate internships and two postgraduate Masters by Research annually. Each student receives a stipend from Shell of $64,000 per year, totalling over $1.6M in Shell support for students at the university. The students gain invaluable experience in industrial research, commercial imperatives and business practice, and Shell staff gain closer access to the interdisciplinary academic network in and beyond the University of Exeter.

A critical factor for success is to establish trusted relationships with decision makers e.g. chief technology officers, chief engineers and chief executives who make the case for R&D within their business and direct it, including where it is done and how it will drive business success. It requires getting an in-depth understanding of business needs to make offers that are tailored to their development strategy, including skills transfer. This service is extensive and must be sustained over time and at distance before reaching the point where investment flows to the university and the local community. Universities will therefore have to build new capabilities to provide more of this high value-added service and extend their business outreach.

A new national policy priority for international knowledge exchange should be created and aimed at universities across the four nations of the UK. For English universities, additional funding in the Higher Education Innovation Fund (HEIF) should be specifically dedicated to support universities to take more risks and expand their networks with businesses located elsewhere in the world. HEIF is a proven mechanism to develop knowledge-based interactions between English universities and a range of organisations. It presents the advantage of successfully combining stable and transparent processes, performance-based levels of funding through metrics captured in the Knowledge Exchange Framework (KEF) and the flexibility universities need in order to decide how to allocate their funding internally for the best results. According to UKRI, HEIF delivers a strong return on investment, with £9.30 generated for every £1 of funding. Additional international HEIF funding should focus on bringing investment from businesses with limited or no footprint in England, and in a way that is aligned with both regional development and university strategies. Inward investment flows can be integrated as metrics within the KEF to assess the performance of universities in delivering on this priority in the longer run.

'Boeing, Aubert Duval and Timet are founding members of our Advanced Forming Research Centre, a core component of the new National Manufacturing Institute Scotland. Our photonics and quantum clusters have been built on Scottish Physics collaboration with Stanford University and with the establishment of the first UK Fraunhofer Centre in Applied Photonics. Our experience shows that international collaboration and exchanges bring academic success, inspire the creation of multi-national teams and deliver tremendous benefits to our local and national economies.' Sir Jim McDonald, Principal, University of Strathclyde

International knowledge exchange should be given similar prominence, as well as a transparent and equivalent level of funding for universities across the devolved nations. It is critical for inclusive economic growth that there is sufficient resource for international business engagement across the UK and the capacity for all universities to bring in private investment in R&D, including small and specialist institutions that have the potential to attract new investors. (see case study 11).

This policy priority should also be geographically targeted and reflected in other funding structures. Enhanced funding to support inward investment in parts of England and the devolved administrations that are high on the government's 'levelling up' agenda should be introduced as part of the Research Partnership Investment Fund (RPIF) and the Strengths in Place Fund (SIP). This can take the form of dedicated international calls in which universities, or consortia of universities, in targeted areas can put forward collaboration proposals involving co-investment from overseas businesses in research facilities, in technology and skills demonstrating the potential for this investment to be self-sustaining and delivering wider local economic benefits in the longer run. It will be important for these international calls to be inclusive and to consider co-investment bids from smaller institutions with specialised expertise, for instance

in creative technologies or in agri-tech (see case study 11 and case study 12) , with the view to build up local clusters in areas that need it the most. Preparing proposals with overseas businesses is more complex and time consuming than proposals with businesses already based in the UK, therefore these calls should be communicated well in advance if they are to generate high quality bids.

In addition, the UK's departure from the EU will lead some established businesses to relying on EU supply chains to restructure their current investment portfolio. Universities will deploy new strategies to retain and anchor their R&D investment in the UK. In this changing context, a dedicated flexible mechanism should be put in place to consider and discuss more widely proposals for anchoring high-value R&D activities in the local economy. These proposals will set out ways to capitalise on existing strengths and dependencies in universities to inform business R&D location decisions and avoid a 'domino effect' should some big businesses take decisions to relocate some of their activities outside the UK.

Evolving these different funding streams concurrently will set a new strategic international direction for the UK innovation system. It will contribute to stimulating business investment to meet the government's ambition, bringing in innovative businesses that are not operating in the UK, making the most of the potential identified in emerging markets, and retaining and creating high quality jobs in the local economy.

3.2. Retaining international entrepreneurs in the UK

There is no better place to start a business than within universities' ecosystems because they provide innovative environments, i.e. secure, highly-networked, with a diversity of expertise and ideas, for young entrepreneurs at a time of their lives when they are willing to take risks. International students are a boon for start-ups and make a disproportionate contribution to entrepreneurship and innovation (see case study nine).

Case study nine – International students and cutting-edge companies

Recent 2020 research into 545 start-ups by Creator Fund, a venture capital firm[15] found that almost 60% of university start-ups in the UK have founders who came to the country to study. The start-ups surveyed were also more ethnically diverse and geographically dispersed across the UK than new ventures in general. Eight of the top 15 universities for creating student start-ups are from outside south-east England, with a significant amount of activity in Scotland.

Similar trends have been also observed elsewhere. According to research by the National Foundation for American Policy[16](2018), nearly one-quarter of US billion-dollar start-up companies had a founder who first came as an international student. International students who become founders of US billion-dollar start-ups have created an average of more than 1,400 jobs per company in the US. It concludes that entering the United States as an international student has shown to be a good avenue for both immigrants and America for starting successful US companies.

This international population enhance the dynamism of local business clusters with promising entrepreneurs, improving productivity, competition and economic resilience. They attract bigger overseas

[15] See: https://www.thecreatorfund.com/state-of-student-startups
[16] See: https://nfap.com/wp-content/uploads/2019/01/2018-BILLION-DOLLAR-STARTUPS.NFAP-Policy-Brief.2018-1.pdf

investors and global companies that are highly interested in the availability of investible propositions at an early stage, which in turn attracts other young entrepreneurs in a virtuous circle for the local economy. Keeping more of these international students who are entrepreneurs in the UK should be part of a national strategy supporting inward investment and economic growth (see case study 10).

Case study 10 – Creating innovative environments for entrepreneurs in high tech sectors

QTEC at Bristol University[17]

Bristol's Quantum Engineering CDT offers a training and development experience for those wishing to pursue a career in the emerging quantum technologies industry or in academia. Students are given the opportunity to put their knowledge of science and engineering into practice from the outset. The approach to learning – through peer-to-peer teaching, group lab projects and research challenges – creates an environment that supports students in the development of leadership skills and in the creation of personal support networks, and offers a first-class foundation for developing and completing a PhD project.

The centre's core staff are world-leading scientists and engineers. This is supplemented by access to a broad technology base as well as a network of both academic and industrial partners across the world, with whom students collaborate by way of secondments and conference attendance. Industrial partners include BAE Systems, D-Wave Systems, Google, Hewlett-Packard, IBM, ID Quantique, Microsoft, NASA.

QTEC has been fuelling the growth of the digital communications sector in the region. It directly generated 31 start-up companies and created 360 new jobs. QTEC companies have raised over £18m capital, including equity from Venture Capitalists and business angels. The centre attracted international companies like HP Labs and Toshiba to base their research in Bristol.

DARTeC at Cranfield University[18]

The new Digital Aviation Research and Technology Centre (DARTeC), being constructed at Cranfield University, is a world-class centre for the research and development of cross-sector digital integration solutions.

Opening in 2021, DARTeC will examine the integration of drones into civilian airspace; increasing the efficiency of airports through technological advances; creating safe, shared airspace through secure data communication infrastructures and increasing the reliability and availability of aircraft utilising self-sensing/aware and self-healing/repair technologies.

Although the construction of the building is not yet complete, the DARTeC partners are already collaborating on several research projects, many of which are helping the aviation industry 'build back better' from Covid-19. Even before the pandemic took hold, work in the Passenger Experience Laboratory in DARTeC was underway examining future concepts of aircraft cabin design that sought to minimise the spread of infectious diseases. These concepts include implementation of touchless surfaces to avoid indirect contamination, sanitising surfaces with UV light, or even using ultrasensitive chemical detectors to identify the presence of pathogens and unwanted particles in the air. Technology may also have a key role to play as part of the airport experience, where biometric, camera, and computer vision technologies could combine to track passengers through the airport ensuring safe travel.

[17] More information on: http://www.bristol.ac.uk/qtec/
[18] More information on: https://www.cranfield.ac.uk/centres/digital-aviation-research-and-technology-centre

DARTeC is co-funded by Research England, Cranfield University and an industry consortium of leading international aviation organisations, including Boeing, Saab and Thales. The centre is a £67 million investment in state-of-the-art facilities that will leverage both the university's airport and its newly opened autonomous vehicle research facility.

EHL at University of Salford[19]

Energy House Laboratories (EHL), established as a group for more than 10 years, is a group of facilities and capabilities focused on the consumption of energy in the domestic and small commercial sector. The unit consists of three existing laboratories: the Smart Meters Smart Homes Lab, focused on digital and IoT, the Thermal Lab, focused on materials, and the award-winning Salford Energy House, which is a whole Victorian House within a large environmental chamber. This will be joined by Energy House 2.0, which is a £16m facility currently under construction for completion in early 2022. The unit is funded through a mix of commercial and government contract research.

The unit offers an inter-disciplinary range of services, ranging from building physics and building performance, to data analytics and occupant engagement. The Salford Energy House and Energy House 2.0 offer a unique approach to understanding building system performance by addressing integration at the whole house level. It has been used to explore the energy efficiency of existing homes with companies such as Saint Gobain, as well as understanding complex domestic energy systems with the interaction of renewables, batteries, electric vehicles and smart meters, with companies such as Octopus Energy and Honda.

EHL provide regional policy advice and sit on national regulatory and standards groups. It has recently formed a partnership with the University of Manchester, Manchester Metropolitan University, Scottish Southern and Electric and the Greater Manchester Combined Authority to be part of an Energy Innovation Agency.

GRID at Heriot-Watt University[20]

GRID is a new ground-breaking facility at Heriot-Watt University to advance global research, innovation and discovery. The new facility, opened in 2019, has been designed to create cohesion between academic disciplines, industry partners and the global community. The building provides a dynamic environment for start-ups and spin outs. The GRID connects Heriot-Watt's global ecosystem internationally to campus locations in Dubai and Malaysia, supporting and attracting diverse global minds and opening up new global markets.

For instance, Celestia UK, specialists in the advancement of state-of-the-art antenna systems, used for tracking satellites, recently made the Heriot-Watt University Research Park its permanent base in Scotland after a successful five-month residency at our GRID facility.

Establishing the business at the Research Park, which is the largest science park in Scotland's capital, will enable Celestia to embark on its next development phase, which includes setting up a new lab and assembly facilities, as well as providing a larger base to deliver cutting edge innovation in satellite-on-the-move user terminals and gateway systems. A £2.5 million R&D award from Scottish Enterprise will enable Celestia, supported by Heriot-Watt University, to develop a new electronic scanning antenna and subsequently, 18 new jobs in Scotland.

[19] More information on: https://www.salford.ac.uk/our-facilities/energy-house-labs
[20] More information on: https://www.hw.ac.uk/uk/edinburgh/grid.htm

GEIC at University of Manchester [21]

The University of Manchester Graphene Engineering Innovation Centre (GEIC) is a world-class, £60m facility to support the rapid industrial development and scale up of graphene and other 2D materials applications in partnership with the University of Manchester. The facility was co-funded by the Abu Dhabi company MASDAR and the UK government. Since it opened two years ago, it has attracted a wide range of industrial partners ranging from multinationals such as Airbus and Astrazeneca to local SMEs and innovative start-ups. It has also acted a magnet for inward investment with partners from Australia (First Graphene, a leading graphene supplier), Brazil (Gerdau, a steel manufacturer) and China (TungHsu, an optoelectronics manufacturer) establishing R&D activity in the laboratories.

The creation of the Office for Talent is an opportunity to launch a new initiative to keep the best of this entrepreneurial talent in the UK. This should take the form of a national entrepreneurship prestige programme that is competitive and rewards successful applicants with a four-year work visa associated with seed corn grant towards pilot research and scoping work. Universities, or consortia of universities, would act as sponsors by putting forward international talent with the highest potential and, if successful, providing them with a uniquely supportive environment to maximise their chance of success. This will include the provision of skills, knowledge and experience in their accelerators, such as in-house funds, physical space, IP advice, mentorship, business plan competitions, pitching days, student enterprise societies, networking sessions etc., as well as full integration within the local business network. The programme could potentially give more weight to applications from parts of the UK that are government priority in the 'levelling up' agenda and could be administered strategically at regional level by consortia of universities.

'Encouraging more international student entrepreneurs to start and grow their business here would provide a huge boost to the South West region and would encourage trade engagements across the world in an area with currently limited global engagement. We can also grow our own talent if UK students have access to international PhD programmes. This will help foster long-lasting international research collaborations.' Sean Fielding, Director, Innovation, Impact and Business, University of Exeter

It will be important for the programme to include from the outset a second stage enabling some of these start-ups to scale up. Strong connections should be established with other existing programmes offering venture capital or loans, for instance with Innovate UK scheme offering loans to micro enterprises at highly innovative late stage with disruptive ideas and a clear route to commercialisation. The higher education sector is willing to work with Innovate UK to design a new entrepreneurship programme that will fully contribute to local economic growth.

For the future of UK research and innovation, it is vital that the pathways to global talent remain open and that the international student pipeline is cultivated. The government's target to increase the number of international students studying in the UK to 600,000 a year by 2030 in the International Education Strategy[22] provides a foundation for growing the pool of global talent. The government should reconfirm its commitment to this aspiration in the forthcoming refresh of the International Education Strategy. This will

[21] More information on: https://www.graphene.manchester.ac.uk/about/geic/

[22] https://www.gov.uk/government/publications/international-education-strategy-global-potential-global-growth/international-education-strategy-global-potential-global-growth

help ensure that the UK is able to draw on the widest possible pool of international graduate talent. Similarly, as the UK treads a new path outside of the EU, there is an opportunity to draw on the networks that UK universities already have to help create new partnerships with current and future research leaders across the globe. UK institutions currently deliver higher education programmes to nearly 700,000 students in more than 200 territories through transnational education partnerships.

3.3. Fostering collaboration between universities and other strategic actors

Nearly all countries worldwide seek to promote foreign direct investment to support growth. The nature of, and need for, investment promotion undertaken has changed over time, from disseminating information about the country's investment opportunities and business climate to more sophisticated activities gathering business intelligence.

Against this backdrop, the promotion of the UK as a location of choice for doing R&D is fragmented between different representations overseas (Department for International Trade, Science and Innovation Network across FCO and BEIS, UKRI offices etc.), and comprehensive information on what the UK offers to foreign investors is hard to navigate. Other countries (such as Germany, The Netherlands or Norway) have moved to a simple coherent model in which businesses and individuals that are interested in engaging with opportunities have a single point of contact[23]. The UK should consider moving towards a more strategic innovation promotion model to raise its profile and visibility.

The objective of a 'One Front Door' model should be to make it as easy as possible for high-tech and R&D driven businesses that are potential investors in high value-added activities to access information and contacts. It will require the development of a rich single platform promoting the innovation networks across regions of England and the four nations of the UK, including university assets and research specialisms, high-quality scientific infrastructure, skilled labour, technology and start-up clusters and public knowledge centres. This model could usefully be extended to include research opportunities. As a starting point, the material collected in the Science and Innovation Audits[24] should be used and formatted for promotional purposes. This may be done under the umbrella of the GREAT Britain campaign as a separate and multi-faceted strand focused specifically on R&D.

'The University of Sussex was invited by the Department for International Trade in 2018 to showcase its extensive public and private partnerships in Nigeria as a model to other UK universities seeking to develop progressive outreach work and partnerships in the Global South. We need to be much more strategic and joined up in our efforts to promote the UK as a partner of choice for research and innovation.' Professor Richard Follett, Associate Vice President, University of Sussex

If they are to be effective, engagement events abroad, i.e. delegations, roadshows, fairs, and other missions bringing together businesses and universities should be well-prepared business exercises based on intelligence to select prospective companies. Tailored presentations as well as informal networking should be part of the engagement programme. They could have a strategic focus (see case study 11) on countries,

[23] See for instance the German research platform: : https://www.research-in-germany.org/en.html
[24] https://www.gov.uk/government/collections/science-and-innovation-audits

technologies and regions of the UK that are government's priorities. The trade negotiations between the UK and priority countries currently taking place should also be made more of an opportunity to strengthen the links between UK universities and businesses in these countries. UK representation overseas should be mobilised to mediate and facilitate relationships building, especially in emerging markets. Over the next 12 months at least, more thinking will need to be developed on how to make the best of digital technologies to engage remotely.

Case study 11 - International engagement for art, design and creative institutions

The UK is a global force in teaching, fostering and applying creativity. This strength is underpinned by the UK's higher education sector, and its universities and colleges focused on teaching and research in art, design and the creative industries.

In autumn 2019, UUKi coordinated a programme of work with a broad range of institutions to think through and develop new international opportunities in the arts and creative industry sector. This consisted of a roundtable that brought together representatives from universities and creative enterprises and a creative industries-focussed delegation to Wuhan, China, including University Arts London, Arts University Bournemouth, Rose Bruford College, University of East London, Goldsmiths University of London and University of Exeter. Discussions were also held with the UUK small & specialist institutions Network, Guild HE and the United Kingdom Arts and Design Institutions Association (UKADIA).

Collectively, these activities provided a space for universities and businesses to share ideas, discuss current strategies and to consider opportunities and challenges relating to the international engagement in in the creative industries. The delegation involved close collaboration with UKRI, with the visit tied in to the UKRI UK-China Research-Industry Creative Partnerships call, and provided unique opportunities for universities to engage with representatives of 30 leading businesses working in the creative sector at a specially-convened UK-Wuhan Industry Roundtable.

These activities demonstrated the acute desire on the behalf of arts, design and creative industries-orientated institutions to develop their international profile and engagement, and maximise the opportunities for a sector critical to the UK's future success.

The higher education sector through UUKi is willing to engage with DIT, the SIN network and other key government actors to put together and implement a national innovation promotion strategy that will be more coherent, collaborative and effective in directly reaching out to potential investors with the aim of generating R&D investment projects in the UK.

CHAPTER 4

UK universities draw on broad and stable institutional partnerships across the world, and will expand their global reach through increased cooperation and mobility of researchers and students

International partnerships bring together different perspectives, expertise, and insights, adding value to UK research and education. The overwhelming majority of international partnerships are created at a faculty or individual level and based on a common interest in a particular discipline or topic in research and teaching. However, some partnerships are university-wide and developing these strategic institutional partnerships to their full potential will bring wider benefits for the UK.

'Formal links between the university of Bristol and Kyoto University started in 2008 and this partnership has gone from strength to strength. Co-authored publications with Kyoto University have increased by 46% over the period 2014-2018 and the citation impact of these publications is increasing over time. Through these ties, Japan has become a priority country. We want to ensure that we are well placed to collaborate with the best researchers in Japan.' Dr Jon Hunt, Executive Director Research and Enterprise, University of Bristol

Strategic partnerships with counterparts tend to be the deepest and the broadest. They are multi-dimensional and cover a range of activities in research and in education, sometimes also including professional services e.g. libraries. Successful institutional partnerships deliver sustained increase in excellent research publications and access to research and business innovation networks that are otherwise hard to access. They contribute to attracting high quality researchers and students in the UK and make it

easier for UK researchers and students to work and study overseas through mobility arrangements. The most advanced partnerships make it possible to access funding opportunities and facilities in partner countries through joint research programmes, research centres and other infrastructure (see case study 12).

Case study 12 - Building strategic institutional partnerships with universities in China, Australia, the USA and the EU

The Royal Agricultural University – Qingdao Agricultural strategic partnership

After two years' preparation, the Royal Agricultural University (RAU) and Qingdao Agricultural University (QAU), in Shandong Province, China, achieved China Ministry of Education approval for their new Joint Institute in April 2020. Initially focusing on undergraduate double degrees in agriculture, environment, food production and logistics, the Joint Institute is designed to develop into an integrated centre for research, knowledge exchange and teaching in agri-food technology and systems. The initial aim of the Joint Institute is to make full use of the strength of the two universities to produce high quality graduates with all-round abilities to meet the requirements of economic and modern agricultural development in China and the rest of the world. With this in place, collaborative research in the field of agri-technology will be developed, again focussing in particular on the development of Chinese agriculture and food supply chains.

The Joint Institute, which will work in both the Chinese and English languages, will underpin QAU's potential to drive change in agriculture and food systems, both regionally and internationally. Fee income per student has been agreed at four times the normal tuition fee rate in China, giving the Joint Institute sufficient net income to catalyse research and knowledge exchange. The provincial government has also provided 67 hectares of land for the Joint Institute, on which it will establish new laboratories and teaching spaces, as well as an experimental farm. The Royal Agricultural University will contribute through internationalisation of both teaching and research, ensuring that the Joint Institute is at the leading edge of developments in education, agriculture and food security.

As a result of this success, Shandong Province has committed to making QAU a flagship university that can attract high quality faculty, researchers and students, from across China and internationally. Using RAU's established expertise in enterprise and entrepreneurship, QAU will act as a national hub for agri-tech businesses, generating inward investment of both economic and human capital into Qingdao and the wider Shandong Province. At the centre of this will be a replication of the success that RAU has enjoyed in the UK through its Farm491 agri-tech accelerator unit. Farm491 supports companies through membership, which provides access to a network of mentors, investors, service providers and farmers, as well as active in-house support to help businesses establish a plan of action in order to increase the probability of success. The Joint Institute will provide the foundation for a similar approach in China – the first in Shandong Province.

The Warwick-Monash strategic partnership

In 2012, as part of its commitment to internationalisation, the University of Warwick embarked on an innovative partnership with Monash University in Australia. The Monash Warwick Alliance is inspired by the vision of harnessing the collective strengths of two leading research-intensive universities to meet the complex challenges of our global community. It has achieved significant breadth, scale and impact, reinforcing each university's position at the forefront of excellence and innovation in research and education.

In research, the Alliance unites interdisciplinary teams with complementary expertise, and supports them from project inception, through to proof of concept and beyond. The Alliance has enabled over 100

collaborative projects, led by diverse talented researchers, and enhanced by shared infrastructure assets and data sets. Over 700 articles have been co-published focusing on a range of global challenges from improving women's rights in war zones to eliminating drug-resistant superbugs. Dozens of PhD students have worked on joint research projects in, and across, disciplines including arts, science, engineering, medicine, and social sciences. The level of excellence achieved to date has led to successful industry collaborations and multiple external grants.

In education, the Alliance harnesses and shares best practice among staff and delivers enhanced learning experiences to students through globally linked teaching, co-developed international curricula and uncapped international exchange opportunities. Over 1000 students have studied abroad through the Alliance. The award-winning International Conference of Undergraduate Research (ICUR) has enabled hundreds of students to share and discuss their research with peers across the globe, equipping the next generation of researchers with a global mindset.

The Liverpool-Georgia strategic partnership

The University of Liverpool's partnership with University of Georgia (Athens, Georgia, USA) is a university-wide partnership covering education and research collaboration. The research programme provides matched seed funding for initial proof of concept work as well as PhD mobility. Between 2014-19, the partnership leveraged over £8.5 million in external research income.

For instance, one of the areas of research collaboration is a project to reduce the prevalence of human trafficking in West Africa, supported by the US State Department APRIES Programme to End Modern Slavery. The project draws on the expertise of University of Georgia and Liverpool as well as networks in Sub-Saharan Africa. The project has recently been boosted by an additional $15.75 million from the US Department of State.

The York-Maastricht strategic partnership

The York-Maastricht partnership is a major strategic investment between the universities of York and Maastricht, intended to develop a deep and lasting relationship and built around excellent research, teaching and knowledge exchange. Key to the partnership are shared institutional values, with both universities founded on the basis of academic excellence and increasing access to higher education, and both committed to social responsibility and the power of universities for social good.

Both universities have invested €3m over the next three years to support dynamic research collaborations between the two institutions, and create innovative education opportunities for students. The first round of research projects has seen the partnership support €2.2m of research across nine joint projects including:

- understanding how immune cells regulate their metabolism and use this to tackle diseases like breast cancer and the parasitic disease leishmaniasis, in which York and Maastricht already have world-leading expertise;
- utilising world-class scanning technology to understand how information flows through the brain and applying this to our response to ageing and mental health challenges;
- investment to support responsible data science, designing new approaches to handling personal data to restore public trust and confidence in how major corporations handle personal information;
- a partnership between York and Maastricht's centres of excellence in global development will investigate development transformations in the context of the United Nations' Sustainable Development Goals and their challenge of 'Leaving No One Behind'.

In the education space, the partnership has been developing joint programmes – initially at the Masters and PhD levels – that bring together academics from both universities to create programmes which are interdisciplinary, truly collaborative and make the most of technology-enhanced learning to bring together cohorts in both cities. The partnership's first programmes are due to launch in September 2021.

Deepening partnerships is a substantial commitment over the long run involving significant reciprocal financial investment to mature and formalise the relationships, capitalise on complementary strengths and define shared objectives. Rules and regulation barriers can be complex to navigate to agree common standards. In some cases, an overseas office is necessary to effectively manage the partnerships. As a result, each UK university can only support a limited number of these partnerships and many are not as developed as they should be to reap the full benefits.

'International collaboration with leading partners around the world is key to achieving research excellence and addressing global challenges. As a result, building high quality and impactful international partnerships is a key element of our academic strategy at the University of Leeds. We have decided to open a University of Leeds office in Brussels which demonstrates our firm commitment and confidence in continuing to build strong research and education partnerships with EU institutions and industry in the post-Brexit world.' Professor Hai-Sui Yu, Deputy Vice-Chancellor, University of Leeds

After the UK's departure from the EU, and with the intensified use of digital technologies to interact remotely, providing more opportunities for universities to scale up their institutional partnerships in a strategic and lasting way should be better integrated within the national system.

4.1. Boosting the international mobility of researchers and students

Promoting the mobility of research students and early career researchers will make an impact on research networks through encouraging universities to invest more resources into driving ambitious institutional strategies. Experience shows that a second order effect of these institutional strategies is that this can also lead to higher international mobility for graduate and undergraduate students over time (see case study 12).

'The new Joint Institute between the Royal Agricultural University and Qingdao Agricultural University in Shandong is designed to develop into an international, leading-edge, integrated centre for research, knowledge exchange and teaching in agri-food technology and systems.' Professor Neil Ravenscroft, Pro-Vice Chancellor, Royal Agricultural University

PhD students are key nodes to build up institutional partnerships because they act as bridges between research groups across borders, which in turn brings talent to the UK and leads to more international research collaborations. This is especially valuable at a time when mobility is restricted due to the Covid-19

pandemic. Institutional partnerships make it possible for universities to design internationally collaborative PhDs. They can take different formats depending on regulatory constraints at both institutions, from dual PhDs resulting in two degrees, to one jointly awarded PhDs, and PhDs with supervisors drawn from both institutions (see case study 13). Students can spend time at either institution as directed by the science with funding provided for travel and other costs.

Case study 13 - Designing international PhDs

Dual PhDs at University of Leeds

The China University of Petroleum (CUP) consists of two universities: CUP (East China), located in Qingdao and Dongying, and CUP (Beijing), regarded as the best universities in the field of petroleum-related subjects in China. UPC's research strengths complement research areas of corrosion, tribology and fluid mechanics of the University of Leeds (UoL) Institute of Functional Surfaces (iFS) and Institute of Thermofluids (iTF).

In 2017, UPC (Qingdao) and UoL began to develop their relationship with the goal of enhancing research capacity and quality at both institutions, raising UoL's profile in petroleum-related research in this part of China, and creating a foundation for developing strong links with Chinese companies in the sector. The key mechanism for developing this partnership has been the supervision of PhD students jointly between UPC and UoL. This began relatively informally, with a group of six UPC PhD students joining the iFS at Leeds in 2018 as visiting students. The hosting of UPC students, and more importantly the joint supervision which this involves, is a very effective way to quickly amplify the research dialogue between key research staff at Leeds and UPC. Although the projects are still ongoing, this partnership with UPC has already led to a number of co-authored papers.

The joint supervision of PhD students is now formalised, with a recently agreed dual PhD programme. This allows PhD students to graduate with a dual PhD, represented by separate awards from both UoL and UPC, following two years' study and research at each institution. The dual PhD agreement is the basis of a planned International Doctoral Training Centre with the UPC, which will attract students funded by the China Scholarship Council and industry.

Jointly supervised PhDs at Imperial College London

The Imperial-Technical University of Munich (TUM) Joint Academy of Doctoral Studies (JADS), is a collaborative doctoral programme that brings together two of Europe's most innovate universities to jointly train the next generation of UK and German researchers. The first cohort of students starting in 2020 will focus on AI, data science, imaging and robotics applied to healthcare. Matched PhD students from each institution will work on a joint PhD project with a supervisory team of academics from both institutions and industrial partners from the UK and Germany.

The JADS programme aims to boost the UK's research and innovation landscape by developing future scientific leaders and innovators with access to world-leading academic supervisors and state-of-the art facilities at both institutions. TUM is an important partner because it is one of the most influential institutions in the field of artificial intelligence (AI) and has significant industrial partnerships with companies working at the interface of data science and engineering, including Siemens, BMW, and Airbus. This partnership will allow Imperial students and staff to gain access to greater collaborations, expertise, and impact than could be achieved as one institution.

Further, JADS will provide international complementarity to Imperial's new UKRI Centre for Doctoral Training (CDT) in Artificial Intelligence for Healthcare. In the future, Imperial and TUM aim to expand the programme into other innovative new research areas including chemical biology, digital chemistry, machine learning, synthetic biology, and advance materials – rooted in CDTs hosted at Imperial.

Joint PhDs at The University of Exeter

The QUEX Institute of Global Sustainability and Wellbeing (QUEX) was launched in 2017 as a high-profile strategic partnership between the Universities of Exeter and Queensland. QUEX seeks to address major global challenges through interdisciplinary collaborative research; split-site PhD supervision: academic, student and professional staff mobility; high impact policy publications; and engagement of industry and community. Central to achieving the QUEX vision is nurturing a strong pipeline of the next generation of researchers, who benefit from the combined strengths of both universities. 10 scholarships have been made available each year, attracting the best students from around the world to study jointly at both institutions on projects linked with the QUEX Institute. The first 10 studentships attracted over 700 applications. Although students register with a lead institution, they have a supervisor at both universities and are required to spend at least 12 months at the partner institution. The QUEX students benefit from research training, career development and entrepreneurship opportunities, and are able to experience research and build networks across two leading higher education systems, helping to strengthen connections between research groups at the partner universities.

Seed funding has also been allocated to new collaborative research projects, and 15 Professional Services Fellowships awarded to promote sharing of best practice and staff development. Since QUEX began, grants worth £13.5 million have been won which involve collaborators from the two universities, and 32 articles have been published or are in press, many with PhD students as co-authors. Future plans involve post-doctoral opportunities, double degrees and start-up internships.

The eligibility of international students to all UKRI-funded postgraduate studentships from the start of the 2021/22 academic year announced by UKRI over the summer is welcome and provides an important signal that the UK wants the researchers of the future to choose the UK. However, UKRI could go further.

The Centres for Doctoral Training and the Doctoral Training Partnerships run by UKRI should seek to extend their global outlook and raise their reputation by providing more capacity to support truly international research projects. This should not be done at the expense of supporting domestic research but rather by allocating additional funding to specifically support collaborative PhDs with high quality partners, institutions, or industry overseas, where partners co-invest in the research or provide access to facilities, infrastructure or fieldwork not available in the UK. This will result in increasing the number of excellent international co-publications as well as the mobility of research students. The cohort approach currently used domestically by UKRI, although valuable, may not be agile enough to capture the best opportunities as they arise. More flexible and frequent calls than the current cohort structure will have to be considered if universities are to put forward the right candidates.

The Rutherford Fund, launched in 2017, was a one-off £100m commitment providing scholarships to researchers from both developed and emerging research powers such as India, Brazil and Mexico. In the light of this experience, a more strategic version of this Fund should be designed. Only a small slice of this Fund (about £2m) aimed to provide a strategic support to institutions.

'The Rutherford Grant was a stepping-stone for the University of Warwick in the creation of the EUTOPIA consortium of universities, which has been awarded a range of large EU collaborative grants amounting to €12.6m. It also catalysed external funding for its strategic partnership in China and was used as blueprint for the creation of the Fernandes Fellowships supported by a private donation.' Gillian Olivieri, Associate Director of International Strategy and Relations, University of Warwick

This revised Fund should have a longer-term objective and be open to all countries. It should focus on early stage researchers who are at a point in their careers where they are the most mobile. Applications should demonstrate how the bids are part of a wider university strategy to scale up institutional partnerships with counterparts and highlight how they will build on the research collaborations initiated through the Fund to generate further sustained cooperation with an institution overseas in the future (case study 14). At an operational level, a minimum lead time of six to nine months between the funding award and the fellowships beginning will be necessary. This will enable UK universities to work with their international partners to identify the most suitable candidates and will provide the selected researchers with the time to make the necessary arrangements for their relocation to the UK. Some financial support for researchers with dependents should be considered if the scheme is to be more inclusive and gender balanced.

UUKi is willing to help shape the design, communication and delivery of mobility programmes through engaging with networks of universities and ensuring that they develop lasting opportunities to enhance partnerships in the long term, for instance through matchmaking, intelligence sharing and other bespoke support. UUKi can also support the delivery of opportunities to help facilitate new partnerships at institutional level, such as a revised Rutherford Fund, if suited to its capacity and scope.

Case study 14 – Experience from the Rutherford Fund Strategic Partner Grants

In 2018/19, Universities UK international (UUKi) awarded Rutherford Fund Strategic Partner Grants totalling £2.34m to 24 UK universities and funded 120 Rutherford Fellowships for early career researchers from over 60 partner institutions in 18 countries.

Participating UK universities reported that these grants significantly contributed to the establishment of long-term connections with international partner institutions, and 98.5% of UUKi Rutherford Fellows surveyed confirmed they intended to continue collaborating with researchers at their host UK university after their fellowships finished. As a direct result of being awarded a grant, universities secured over £1.28m during the grant period through joint research grants, donations and institutional commitments to continue collaborations with partners.

For example, Northumbria University secured a British Academy GCRF Sustainable Development Award (£262,000) involving one of their Rutherford Fellows from their strategic partner, An-Najah University in the Occupied Palestinian Territories, as co-investigator. Since receiving the grant, the University of Hull integrated their Rutherford partner, the Geological Survey of Japan, in their existing £5.5 million EPSRC & NERC Centre for Doctoral Training in offshore wind energy and the environment, ensuring continued collaboration between the two institutions. The grant was a stepping-stone for the University of Warwick and its European Rutherford partners in the creation of the EUTOPIA consortium of universities, which has been awarded a range of large EU collaborative grants amounting to €12.6m. It also catalysed external funding for its strategic partnership with Shanghai Jiao Tong University (SJTU) and was used as blueprint for the creation of the Fernandes Fellowships, supported by a private donation.

The effectiveness and efficiency of processing and delivering visas, including short term visas, is a pre-requisite for the success of these mobility initiatives. For instance, some Rutherford fellows reported that the process of applying for a UK visa took more than eight weeks from their initial application to receiving their visa. Others had their initial application for a visa rejected and had to re-apply before having it granted. It is of essential for the reputation of both the UK and universities that visa considerations are fully thought through as part of any delivery mechanism supporting international mobility.

4.2. Making system-to-system agreements comprehensive

Negotiations led by UKRI as 'lead agency' on over-arching agreements with other willing countries to facilitate the delivery of joint-research programmes should seek to be as comprehensive as possible. This is the best guarantee from the outset that these agreements will build ever-increasing collaborations across borders and therefore will be lasting over the long term.

UKRI should aim to reduce frictions that result from specific conditions or requirements that make setting up international research degrees and mobility of staff and students difficult and/or costly. The mobility of graduate and undergraduate students should be part of the discussion, especially since the outward mobility of UK students is a concern after the UK leaves the EU. In some countries there will be possibilities to leverage new funding and resources through reciprocal agreements on international PhDs cohort-based approaches e.g. China Scholarship Council, Canada MITACS programme.

Consideration should also be given to existing networks of transnational partnerships that already include postgraduate research degrees. UK universities have more than 40 campuses and centres in more than 20 different countries, and in 2018-19 there were over 6,000 students studying UK postgraduate research programmes overseas in 153 countries and territories (some examples in case study 15). Taking a more strategic view on how to leverage this footprint overseas could reduce research costs since infrastructure is already in place and impact could be increased through links with local institutes, authorities and businesses that have been established.

Case study 15 - International postgraduate research programmes in India and Taiwan

The University of Liverpool established a collaborative agreement with National Institute of Mental Health and Neurosciences (NIMHANS) in 2014. NIMHANS is ranked as the 4th best medical institute in India and a leading centre for mental health and neuroscience.

An active research programme in brain infections and maternal mental health has leveraged over £10 million from UK and international funders (Medical Research Council, Wellcome Trust, Bill and Melinda Gates Foundation, Department for Biotechnology, India and India Council for Medical Research Council.)

A dual PhD programme supports joint research between the partners, supported with institutional investment. Students start in India or the UK, with a minimum of 12 months overseas. This allows students to draw on different research environments and provides access to research data that they would not gain from studying in a single institution.

****

National Tsing Hua University (NTHU) is a leading research-led university based in Hsinchu, the 'Science City of Taiwan'. The University of Liverpool has had a successful partnership with NTHU since 2013 with

a programme of collaborative research underpinned by a dual PhD programme. Currently, there is a cohort of approximately 14 students per year split evenly between the institutions working on multidisciplinary challenges. An annual workshop brings together academics and students from both institutions. This forum enables new research areas to be defined and helps to forge new collaborations.

Students spend a minimum of one year at each institution, and receive a studentship comprising a fee waiver and contribution to living costs. The costs associated with the studentships are split between the institutions. As well as benefiting from a rich cultural experience, students can draw on large scale national facilities of both countries and create a worldwide network of contacts across two continents.

Finally, negotiations led by UKRI should seek to strengthen existing transnational university alliances in those countries and create new alliances of universities through seed funding wherever appropriate. These formalised alliances will help deepen the level of inter-university cooperation that is necessary to go to the next stage and achieve a sustainable impact. They should have the long-term aim to increase the quality and competitiveness of all the institutions involved, therefore reinforcing and extending the excellence of the science base across more UK universities. As a starting point, they could be structured around cross-disciplinary themes of mutual interest identified in the funding agreements. A range of models is possible (see case study 16).

These different considerations will be captured in the strategic advice the higher education sector offers to put to UKRI as lead agency prior to starting negotiations and will be tailored to the countries involved.

Case study 16 - Transnational university networks

The Young European research university Network (Yerun)

The founding goals of the Network are to strengthen and develop cooperation in the areas of research, academic education and service to society among a cluster of highly-ranked, young research universities in Europe on an equal basis and for their common benefit.

The YERUN Research Mobility Fund Working Group organizes research workshops and a mobility scheme for researchers from YERUN members to create critical mass in areas where large scale investment is needed, and to encourage the cross-fertilisation of ideas and promote the wider dissemination and impact of YERUN institutions' research findings.

Joint programmes support collaboration in education across universities and promotes enhancement and innovation of a research-led education to the benefit of students. YERUN is committed to using the network to maximise exchange and development opportunities for the benefit of staff and students of members.

The Nordic Centre in China

The Nordic Centre in Shanghai is a network of 29 universities from Denmark, Norway, Iceland, Sweden, Finland and China. The aim of the Network is to drive and facilitate collaboration between researchers and students in the five Nordic countries and China. Located at Fudan University, one of Asia's top universities, the Nordic Centre has served as a vehicle for research and education within all kinds of disciplines since 1995.

The Network provides funding for research stays in Shanghai for researchers at from Nordic member universities, and for Fudan scholars' stays in the Nordic Region. It has office spaces for visiting scholars from member universities, who come for stays of various durations. It also provides funding for seminars, workshops, and conferences when it involves researchers from more than one member university.

The Worldwide University Network (WUN)

The Worldwide Universities Network (WUN) is an alliance of 22 research-intensive universities. WUN provides financial and infrastructural support to member universities to foster international research collaboration and facilitate academic mobility.

The Network has been running for 20 years and provides support to establish collaborative research that falls within four globally significant themes:

- Responding to climate change
- Public health
- Global higher education and research
- Understanding cultures

WUN also invests in education. At graduate level it does this through its Research Mobility Programme which provides opportunities for early-career researchers, including postgraduate and postdoctoral students, to gain specialized experience in an international context, and broaden their professional networks. At undergraduate level, WUN is introducing initiatives that will bring students from multiple partner universities together for shared research experience.

WUN has members on all six inhabited continents. York, Leeds, Bristol, Southampton and Sheffield are the UK partners.

African Research Universities Alliance

In July 2020, UKRI announced an African Research Universities Alliance (ARUA) partnership research programme to tackle global challenges such as disease, poverty, climate change, fragile states and food insecurity. This ARUA-UKRI research program has two strands: capacity building to support the 13 ARUA Centres of Excellence and research excellence to support four multidisciplinary and multinational projects addressing the UN's Sustainable Development Goals (SDGs).

The awards for the Centres of Excellence will enable the development of expert hubs where leading researchers, alongside a new generation of researchers, collaborate and undertake world-class research across priority themes. The four joint research excellence projects will help forge new relationships and synergies between the ARUA Centres of Excellence and UK-based GCRF researchers, who together will build on existing activities to develop new proposals and projects aligned to the SDGs. Both aspects of the research programme will help strengthen and expand Africa's crucial research base.

CONCLUSION

The UK's ability to capitalise on its cutting-edge science and innovation assets will be critical to future prosperity and societal wellbeing. The government indicated that funding for Research and Development will be prioritised and that extending the UK's global reach is at the heart of the government's vision for the future economy.

UK universities could work more, better and faster with global collaborators in academia, industry and other institutions. They could take greater advantage of opportunities, drawing on their international networks of excellent partners (Chapter 2), their role in building innovation capacity in their local economy (Chapter 3) and their institutional partnerships across the world (Chapter 4). However, this requires taking a strategic system view in which international connections are hardwired into the structure of the domestic funding system, rather than treated as an add-on or an afterthought (Chapter 1).

The change suggested in different connected parts of the system will offer substantially deeper and more wide-ranging international associations, whether bilaterally or multilaterally, and not at the expense of the domestic science and innovation base. Some of the recommendations are relatively straightforward and should be effected as soon as possible, especially considering that the UK has left the EU and that the transition period is coming to an end. Others treat more complicated issues and will take more time to be implemented. Each university will determine the extent of its involvement in each part of the system depending on their specialisms, networks, location, objectives and constraints, but collectively they form a powerful institutional force to attract talent and investment to the UK whilst delivering global solutions to global problems.

ACKNOWLEDGEMENTS

Special thanks to the representatives from the following institutions for their contributions:

Arts University Bournemouth
Bath Spa University
University of Birmingham
Birmingham City University
University of Brighton
University of Bristol
University of Cambridge
Cardiff University
Coventry University
Cranfield University
University of East Anglia
University of Essex
University of Exeter
Glasgow Caledonian University
University of Greenwich
University of Hertfordshire
Heriot-Watt University
Imperial College London
Keele University
University of Leeds
University of Leicester
University of Liverpool
University of Manchester
Manchester Metropolitan University
Newcastle University
University of Nottingham
Queen Mary University of London
Royal Agricultural University
University of Salford
University of Southampton
University of Strathclyde
University of Sussex
Swansea University
Ulster University
Warwick University
University of York

About Universities UK International

Universities UK International (UUKi) represents UK higher education institutions (HEIs) globally and helps them flourish internationally. To do this we actively promote UK HEIs abroad, provide trusted information for and about them, and create new opportunities through our unique ability to act at sector level. We draw on UK university expertise to influence policy in the UK and overseas, delivering information, advice and guidance to facilitate mutually beneficial collaboration between UK HEIs and a broad range of international partners.

www.international.ac.uk

Contact

Peter Mason, Policy Manager – Europe (Research & Innovation)

Universities UK International

Peter.Mason@international.ac.uk