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Innovation and Industry: The Role of Universities

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Executive Summary

It is clear that the role of universities in innovation is more subtle than government policies have acknowledged. Universities that are active at the heart of successful technology clusters do not just spin out companies. They develop highly-skilled people who move between industry and academia; they incubate businesses and provide expertise; they produce knowledge that is used by technology businesses; they provide public space in which people from various overlapping branches of research meet. Some universities in the UK perform these functions successfully. But Government policy does not recognise their importance.

Research Funding

We recommend that the government abandons its attempts to base research funding upon impact. Attempting to turn scientists into innovators not only wastes resources but also threatens their role as curiosity-driven producers of the basic knowledge on which future innovations depend. We do not need scientists to be innovators. We need scientists to talk to innovators, constantly, habitually and informally.

Yet in a world of shrinking resources, maintaining a world class research base inevitably means making some difficult decisions about research concentration. HEFCE's 2008 Research Assessment Exercise (RAE), which allocated £1.6 billion of Government research funding to universities, spread money more thinly than ever before across the system. As a minimum we should look to achieve a return to something like the concentration achieved in HEFCE's previous RAE in 2001. There has long been a deeply entrenched view within UK academia that good teaching can only happen alongside research. In these straitened times it is now time to interrogate that assumption. We recommend that the government starts a debate with universities about the separate notions of research and scholarship.

Barriers to Working with Industry

Unfortunately, despite extensive government programmes aimed at engineering individual collaborations, it has actually become *less* easy to collaborate with a university since 2004. A survey by the Advanced Institute of Management Research (AIMR) and Imperial College Business School showed an increase between 2004 and 2008 in the percentage of firms reporting a wide range of problems that they considered a barrier to

interaction. The trend of universities attempting to make money from their research, and acting in a formalised and legalistic way is now becoming widespread, and damaging trust. University Technology Transfer Offices (TTOs), funded by HEFCE through the Higher Education Innovation Fund (HEIF), have become part of the problem. Nearly all universities now have one, and they employ almost 4,000 staff. Yet only a small percentage of these offices (between 4 and 6%) are active in filing patents, licensing or spinning out companies. It makes sense for the government to concentrate on supporting a much smaller number of TTOs in high-performing universities, principally (though not exclusively) those with a high volume of excellent research. Other institutions could then buy in expertise from these larger TTOs.

Promoting Open Innovation

We recommend the creation of more co-funded shared spaces where academics and industrial researchers can work together on research issues of common interest. These centres will, we believe, produce greater results for every pound spent over the long-run. The exact form and structure of these co-funded centres should remain flexible. What is clear is that they should be more than science parks, and should provide accommodation for start-ups, but also open collegiate networking between academia and business, between start-up companies and sources of expert knowledge.

There must also be further measures to encourage universities to engage with SMEs. We recommend a refocusing of government innovation funding on loans for incubators. These should be self-funding in the long-term and will generate interest from "spin-ins" – SMEs that start outside of the university but move under its roof to access its expertise.

We recommend that the government should aim to increase the number and scope of Knowledge Transfer Partnerships (KTPs), which place graduates and post-docs with companies for a period of between one and three years. They are a potentially powerful tool, but are currently inaccessible to the very people who need them. The application process is bureaucratic, consisting of an almost year-long decision-making process from three or more different funding bodies. Plus they require three years of accounts from an applicant business. We recommend a simplified procedure for KTPs, removing the accounting requirement, and placing funds directly with the Technology Stategy Board (TSB), who would then be in charge of the whole process.

We recommend that a number of funds should be brought under the auspices of the TSB, because we believe that as a single body it can provide much larger and more efficient funding as well as a joined up strategy. It has high potential and those who have worked with it are generally full of praise. However, there remains confusion about what it exists to do. We believe the Government should clarify the TSB's role and put it in a leadership position to streamline funding programmes in this area.

Introduction

The economic crisis has trained a new spotlight on our universities. Lord Mandelson, the Secretary of State for Business Innovation and Skills has declared that the recovery will be driven by "enterprise" and universities are expected to become a key part of a knowledge-based solution. It is certainly true that universities' role in innovation in vital. At their best they are powerhouses of ideas and intellectual exploration. However, efforts to enable the UK to capitalise more effectively on those ideas have traditionally been predicated on serious misunderstandings. This paper highlights these wrong turns, and suggests ways of focusing government incentives for universities more usefully.

For a long time it was assumed that any discussion of innovation and universities had to be all about spinning out companies. Furthermore, at the beginning of this century, the Government believed that, in comparison to the world's most innovative economies, such as the US, the UK was bad at spinning out companies from universities. It was not. In fact, UK universities could lay legitimate claim to global leadership in this area,[1] with universities such as Imperial College London, Cambridge, Oxford, Manchester, Southampton, Bristol and Bath all boasting significant successes. A 2007 study for Library House found that the top three UK universities received as much venture capital funding for their spin-outs as the top three in the US.[2] Indeed leading university IP experts told us that they often receive approaches from the US requesting expertise on how to spin out companies successfully.

Yet despite this success, and the fact that the UK is one of the global leaders in basic scientific research, the INSEAD Global Innovation Index 2009 ranked the UK a disappointing 11th on university-business research collaboration.[3] The answer to this seeming paradox lies in the fact that there is a lot more to universities and business working together than the spinning out of companies. In the US, many successful technology-based businesses have had plenty of academic input, but few could really be described as academic spin-outs. Qualcomm was formed by a Professor, but not by a university. Amgen chose to locate close to research centres at Californian universities, but was not a university spinout. The presence of star scientists holding university positions vastly increases the probability of new innovative firms being formed in the vicinity,[4] yet university-owned IP and the firms formed around it are small in comparison to corporate IP.[5] The pattern is repeated in the UK. In the most successful technology cluster in the UK, Cambridge, only 16% of new technology start-ups have a founder from within academia or a research organisation.[6]

None of this serves to prove that universities are unimportant. In fact they are crucial. The government has acknowledged that the most successful technology clusters in the USA and UK are located in geographical proximity to centres of research excellence in universities, such as Stanford, University of California, MIT in Cambridge Massachusetts, Austin in Texas and Cambridge, UK. In his foreword to the NESTA *Connected University* report of April 2009, Lord Sainsbury, the former minister for science, stated that companies need to locate the key parts of their operations in knowledge and information-rich regions where there is the concentration of research, creative individuals and infrastructure needed for innovation. However, it is clear that the role of universities in innovation is more subtle than government policies have acknowledged. Universities that are active at the heart of successful technology clusters do not just spin out companies. They develop highly-skilled people who move between industry and academia; they incubate businesses and provide access to high-level expertise; they produce knowledge that is used by technology businesses; they provide public space in which people from various overlapping branches of research meet. Some universities in the UK perform these functions successfully. But Government policy does not recognise their importance.

In recent years the policy focus on spinouts has been reversed. University technology managers in a number of universities have told us that they are now discouraged from spinning out companies and encouraged instead to licence their patented technology out to businesses that can develop and market it. This paper does not take a view on the relative merits of those two paths to market, because we believe it should be up to the individual university and academic to decide the best path for each piece of knowledge.

Moreover, we believe that the licensing versus spinout dichotomy is too narrow. Both are "push" forms of knowledge exchange that assume that the university has identified which technology to commercialise and will do so through whatever means. They are formal methods of exchange that ignore the importance of informal networks and relationships. "Pull" models, which engage business at every stage in the research process and allow business to select which technologies to commercialise, are more effective. However, they require long-lasting networked relationships and trust, a commodity that we believe has been damaged by recent policy initiatives.

Supporting Basic Research

Academic research remains one of the shining lights of the British economy. The UK higher education system is one of the largest and most successful in the world, and includes more world-class universities than any other country apart from the US.[7] When it comes to research the UK punches well above its weight. We are the most productive country in the G8, both in terms of the number of research publications and number of citations per researcher.[8] As a starting point, this impressive record should be celebrated and safeguarded.

The bread and butter of academia has traditionally been basic or 'blue skies' research, which is essentially curiosity-driven and aims to increase understanding of fundamental principles. Such research may have no immediate commercial relevance, unlike applied research, which is specifically focused on applying existing knowledge or theories to particular problems, often for business or the state. In any political discussion of innovation, the initial temptation may always be to assume that the former, which is by definition more risky and harder to pin down, is less useful than the latter, which is focused on outcomes. However, such an assumption misses some crucial points about the way research and innovation works. As a senior Microsoft official recently pointed out, the economist Edwin Mansfield discovered 30 years ago that the return on investment in R&D falls as the budget for R&D shifts from basic to applied research.[9] Translational work of course adds value, but broad-based scientific discovery still underpins most commercially applicable inventions.

Nor is it as simple as funding effective and relevant basic research while cutting off funding for research that does not have commercial application. Such a prescription presupposes the ability to determine in advance what basic research has commercial application and what does not. There are many examples of cases in which the originator of an invention could have had absolutely no conception of the commercial applications of his technology. Often the originators do not even realise the full scientific impact of their invention. In 1888 when Austrian botanist, Friedrich Reinitzer, working at the University of Graz, made the accidental discovery of what were later termed liquid crystals, he could not have been aware of their later significance in display units, let alone that such display units could then be put into televisions, a technology that did not yet exist. The story of the circuitous discovery of Viagra, the treatment for erectile dysfunction, is another striking example. In the late 1980s scientists were searching for a compound to treat hypertension. The results of this initial study eventually led them to shift their work towards a potential treatment for angina and thrombosis. Yet patient trials of the new angina drug were unsuccessful and the work was close to being abandoned, when it was noted that after four or five days of taking the new drug patients were experiencing an unexpected side effect. Thus the hugely profitable drug Viagra was born, utterly by accident, in a process that couldn't possibly have been predicted.

The simple fact is that many breakthroughs would not happen without public funding. Basic research is characterised by a high degree of risk and uncertainty and left alone, the market will provide some, but not enough. **With signs that investment from charities and business are falling in the recession, and with politicians looking to science to deliver innovation, we believe the case for continuing to support basic research needs to be restated strongly. As the pressure mounts to find cuts in public spending politicians should not fall into the easy trap of shifting cash out of basic research and into applied or translational research thinking that it will deliver demonstrable outcomes faster.**

Picking Winners

Basic research funding in the UK is already 'directed' to some degree, with the seven research councils who are responsible for distributing government funding for basic research projects in the UK, currently co-funding multidisciplinary research in six broad 'global challenge' areas. These are: energy, environmental change, global security, ageing, the digital economy and nanoscience. This pooling of resources under broad overarching themes seems sensible – particularly given that no one discipline will be able to solve these complex issues – but with the proviso that we must also maintain funding for research that will feed into future challenges and technologies that we have not yet even dreamed of.

Worryingly, there are signs that the government may look to become more prescriptive with research funding and seek to target specific areas of research more narrowly. Lord Drayson, the Minister of Science, asked in a lecture to the Foundation for Science and Technology in February 2009 whether the time had come for the UK "to make choices about the balance of investment in science and innovation to favour those areas in which the UK has clear competitive advantage".[10] He noted that the research councils had already begun to do this, but added: "My question is whether we need to go further". Senior university figures close to the government have told us that Lord Drayson has privately suggested that focusing on key areas may be a good way to protect the science budget at a time when the Treasury is looking for areas to cut.

However channeling research funding in this way is dangerous. Industrial activism may be the flavour of the moment, but as we stated in our recent report, *'Innovation and Industry: The Role of Government'*, over the last half a century government attempts to 'pick winners' by throwing resources behind particular sectors, technologies or companies have failed in the past and will fail again. Science is no exception. To cite just one example (though there are many), in 1986 an advisory council to the then Conservative government forecasted a series of research areas which were likely to pioneer the drive towards innovative discoveries in communication technologies. They did not include particle physics – yet this discipline led to the creation of the World Wide Web at CERN (the world's largest particle physics lab) just a few years later in 1989.[11]

In simple terms, a reduction in research grants will have a major impact on the ability of particular departments to attract and retain internationally leading research staff. One of the biggest problems with selecting areas of economic priority is of course that if you get it wrong, and run down a discipline that later turns out to be important, it is very difficult to recover critical mass. As the Institute of Physics pointed out in a recent submission to the Select Committee on Innovation Universities and Skills on this issue, the shortage

of trained people in nuclear physics and engineering (an area the government turned its back on for many years out of political expediency) are now threatening the UK's plans for new nuclear build and decommissioning.[12]

Picking winners may also have an adverse effect on student recruitment in shortage areas such as science and maths. As we showed in our recent report '*Science Fiction? Uncovering the real level of science skills at school and university*', numbers of students studying most of the traditional science subjects at university have remained worryingly low over the past decade.[13] The number studying medicine has increased dramatically in the last ten years (+14,142 students) and broad groupings of undergraduate courses such as mathematical sciences and computer sciences have also seen healthy gains. However, the number enrolled in Biology, Chemistry and Physics has barely changed despite huge efforts to promote the importance of STEM. It is imperative that the government continues to provide adequate incentives and opportunities for young scientists. There is a danger that students will be put off studying a STEM subject if they see that there is little government support for their area of interest. As the Campaign for Science and Engineering has pointed out, space science has proved a great lure for students, but if the Government chooses to withdraw funding for astrophysics or particle physics such subjects may well come under threat.[14]

We recommend that the government refrains from directing basic research funding and channeling investment towards areas it believes will deliver an economic return. Attempts to pick scientific winners have failed in the past and will fail again.

Research Impact

While once the debate about research funding used to be all about excellence, now a new word has become central to the government's rhetoric - impact. The origin of this new obsession is easy to trace and understand. Science funding has risen considerably under this government, and by 2010/11 total research spend (including research council grants, quality-related funding from the funding council and research capital spend) is set to reach around £5.8 billion. But welcome though such significant spending is, the Treasury now wants 'proof' that this investment is bringing decent returns. As Professor Geoffrey Crossick, Warden of Goldsmiths, University of London, summed up in a lecture on knowledge transfer in October 2009:

"Scientists have so insisted upon the economic importance of their research, using it as a means to unlock considerable additional funding, that they're now being asked to show the economic impact as if it's the main purpose. My lesson is…beware of how you persuade government of why you matter, because they might just believe you."

The notion of impact is, in essence, not a bad one. Few would disagree that researchers should be spending public money on doing things that matter and could make a difference to the economy or to society. However, politicians and officials looking for hard and fast proof of returns will always be frustrated by the considerable time lag involved. Innovation is about growth in the long term, and the experts we spoke to all concurred that bringing an idea to market could take anywhere from eight to 15 years. As we have seen, the true significance of research can take decades to emerge. And the real problem of course comes in how you pin that impact down, and whether the process of attempting to do so has unintended consequences.

The government is introducing various incentives for researchers to focus on impact. The most significant of these is the proposal to use impact as a major criterion for the allocation of £1.76 billion a year of HEFCE research funding under the new Research Excellence Framework (REF). From 2012, a hefty 25% of research assessment will be based upon the "contribution to demonstrable economic and social impacts" of the research submitted. This is a significant gesture, intended to speak loudly to the academic community about what now matters to government, and ministers are clearly hoping that this will prompt a major culture change amongst academics who have been trained to focus on publishing papers above all else. However, it is a regrettable move.

Almost 7,500 academics, including a large number of distinguished scientists and six Nobel Laureates, have signed a petition opposing this. The petition states:

The REF proposals are founded on a lack of understanding of how knowledge advances. It is often difficult to predict which research will create the greatest practical impact. History shows us that in many instances it is curiosity-driven research that has led to major scientific and cultural advances. If implemented, these proposals risk undermining support for basic research across all disciplines and may well lead to an academic brain drain to countries such as the United States that continue to value fundamental research.[15]

The REF will at least judge impact retrospectively, as it assesses research that has already been done (though this does not completely avoid the time lag problem already discussed). More bewilderingly, the research councils are now asking researchers to predict the impact of their research before they have even started it when applying for a research grant. In theory researchers can simply write 'not applicable' on the impact part of their application form, although many fear this will harm their chances of getting a grant in an incredibly competitive market. There is a danger that while trying to drive a positive cultural change – one in which academics are more outward-looking – the research councils will actually drive a negative cultural change, in which academics are more risk averse, treading familiar ground that they know will bear fruit.

In his recent 15-year framework for Higher Education, which clearly sets out the new impact agenda, Lord Mandelson acknowledges that "the outcomes of research pathways are often impossible to predict with any precision and research can take a long time to generate economic impact". However, immediately after this he asserts: "The point is that we need to harvest every possible economic and social benefit from research that has been done and be far more conscious of the links between funding decisions and our long term national interest."[16] The second statement is in tension with the first, and ignores the fact that our long term national interest almost certainly depends upon scientists taking risks. Like other previous policy initiatives in this area, the government is failing to distinguish science from innovation and trying to turn scientists into innovators. The framework fails to recognise that scientists produce knowledge, which commercial innovators then turn into useful products that improve productivity.

We recommend that the government abandons its attempts to base research funding upon impact. Attempting to turn scientists into innovators not only wastes resources but also threatens their role as curiosity-driven producers of the basic knowledge on which future innovations depend. We do not need scientists to be innovators. We need scientists to talk to innovators, constantly, habitually and informally.

Research Concentration

In a world of finite – and shrinking – resources, maintaining a world class research base inevitably means making some difficult decisions about research concentration. Key figures within Lord Mandelson's new department, DBIS, have been debating behind the scenes whether the government should state explicitly the number of research universities that the country can afford to fund.[17] The government should be commended for biting the bullet on research concentration – a subject that excites a great deal of controversy. But it is wrongheaded for politicians or Whitehall officials to fix a number, and one hopes that the fact that there was no mention of this in the recently published framework means that this unhelpful centralist notion has been dropped. Instead the government must aim to judge the excellence it should fund with criteria that will avoid dilution of resources. This should probably involve recognition of the percentage of research active staff submitted for assessment by a department (with an assumption that an excellent department will submit at least 80% of staff). This would mean that a brilliant research department in a university that is not known for its research record (typically referred to in the sector as an 'island' or a 'pocket' of excellence) would receive funding, but one star researcher within a department that is less than excellent would not.

There is a danger that the impact agenda will cause an unintended dilution of research resources, as the notion of impact is rather nebulous, and universities who are producing less than excellent research may nonetheless be able to make a compelling case on impact. One senior government advisor we spoke to countered this by saying that impact would be judged alongside research excellence and therefore this problem would not arise. However, some vice chancellors from leading research universities we spoke to remained unconvinced.

HEFCE's 2008 Research Assessment Exercise (RAE), which allocated £1.6 billion of Government research funding to universities according to a complex assessment of quality, spread money more thinly than ever before across the system. The research-intensive Russell group institutions received a 3.3% increase in funding on 2001, compared with a 120% increase for the 28 former polytechnics represented by the modern university lobby group Million+. [18] In total England's former polytechnics had £36.4 million to spend in 2008-09 based on the 2001 RAE allocations, but by 2009-10 thanks to the new 2008 allocations this rose to £84.3 million.[19] Some 25 institutions were awarded funding for the first time in the 2008 RAE. This seems unlikely to have been the Government's intention. In February 2008, a year before the new allocations were announced, John Denham, the then-Secretary of State for Innovation Universities and Skills, said: "I am in no doubt that our world-leading position - and our ability to sustain institutions that are world class across a wide range of disciplines - depends on an appropriate concentration of research effort."[20] The 2008 allocations appeared to fly in the face of this statement. This redistribution of funding risks seriously damaging research excellence in this country. As a minimum we should look to achieve a return to something like the concentration achieved in the 2001 RAE.

Central to the debate about research concentration is the issue of what makes a real university. Almost all British universities currently market themselves as research-led institutions, and research is generally regarded by academics as crucial to promotion and esteem. Hence, last year the funding council found that when it came to accounting for their time some staff were rebadging activity as research when it clearly had no sponsor, was not part of a scheduled research project, and had no outputs.[21] Such obfuscation is clearly unacceptable and suggests that in some cases the prevailing culture in universities is seriously skewed. There has long been a deeply entrenched view within UK academia that good teaching can only happen alongside research and that all departments in all universities must therefore be research-based. In these straitened times it is now time to interrogate that assumption. It is one that many academics in the US, where excellent liberal arts colleges focus on teaching and not on research, find bewildering. Of course, it is clear that those who enter academia to teach do not do so because they envisage it as a sort of extension of secondary school. Instead, quite rightly, they want to be part of an evolution of knowledge. We recommend that the government starts a debate with universities about the separate notions of research and

scholarship. It should consider whether we need a system which acknowledges teaching, research and scholarship; in which academics can contribute to the growth of their subject without the constant pressure to publish; and in which universities concentrate more strategically upon their individual strengths.

If we are to maintain a world class research base the government must continue its commitment to concentration of research funding. As a minimum we should look to achieve a return to something like the concentration achieved in HEFCE's previous Research Assessment Exercise in 2001. There has long been a deeply entrenched view within UK academia that good teaching can only happen alongside research. In these straitened times it is now time to interrogate that assumption. We recommend that the government starts a debate with universities about the separate notions of research and scholarship.

Absorptive Capacity

The absorptive capacity of firms – their ability to capture new technology and either use or develop it – is a driver of innovation that is as important as production of that knowledge.[22] Comparing regions of the UK, there is a strong correlation between absorptive capacity and Gross Value Added,[23] indicating that improved absorptive capacity is both beneficial and necessary in order to maximise the impact of innovation. R&D expenditure and the stock of existing innovations[24], the capacity to access knowledge and innovation, the capacity to anchor external knowledge and innovation, and the capacity to diffuse new innovation and knowledge in the wider economy,[25] and the level[26] and diversity[27] of human capital are the known drivers of absorptive capacity.

Geographical proximity to an outstanding knowledge base is important, as the UK government has acknowledged. Abramovsky and Simpson found that pharmaceutical firms locate their R&D operations near to frontier chemistry research departments, and that in other industries those companies that are in proximity to universities are more likely to engage with them.[28] While falling travel and communication costs now render it less important for formal forms of exchange such as patent citations, Branstetter discovered in the 1990's that knowledge spill-overs were primarily a domestic phenomenon.[29] Abramovsky and Simpson found, consistent with several other recent studies, that spillovers now occur more from knowledge passed through a network than through formal mechanisms.[30] Further evidence suggests that informal knowledge exchange is the most efficient. This was confirmed by several Policy Exchange interviews with experts and network-makers who stressed the importance of these informal knowledge-exchange mechanisms.

Countries that have a higher rank in academia-industry R&D collaboration, such as the US, also have higher absorptive capacity of businesses.[31] Networks are crucial, not least because they build trust[32] and enable information to be passed more freely, with this diffusion of knowledge increasing absorptive capacity. We therefore believe that long-term relationships that lead to a large number of informal interactions will positively affect absorptive capacity, and the more universities are encouraged to build these relationships the better businesses will be able to absorb their knowledge.

Barriers to Collaboration with Industry

Countries that, after allowing for the UK's advantage in capital markets and regulatory environment, have a better innovation performance than the UK are far ahead in university-industry collaboration. The OECD working paper, "*Open innovation in a global perspective*" shows that the UK is 22nd out of 26 countries for the percentage of innovating firms collaborating *at all*, and, out of those firms, a relatively small percentage collaborate with a university – 33%, as opposed to 53% in Germany and 75% in Finland. (The US was not included in the data.) Worryingly the OECD concluded: "The UK innovation system has a small percentage of firms co-operating with public research organisations; this is surprising considering the strong scientific performance of these organisations."[33]

Unfortunately, despite extensive government programmes aimed at engineering individual collaborations, it has actually become *less* easy to collaborate with a university since 2004. A survey by the Advanced Institute of Management Research (AIMR) and Imperial College Business School showed an increase between 2004 and 2008 in the percentage of firms reporting a wide range of problems that they considered a barrier to interaction.[34] Following this, in 2008 the Association of the British Pharmaceutical Industry noted a significant fall in the number of PhDs being carried out collaboratively with a company,[35] confirming a trend which it says began in 2003 of universities and industry collaborating less.[36] Both reports highlighted the assignment of intellectual property as a particular obstacle.

"When I joined, the university and the sponsor spent 18 months negotiating who would own any intellectual property I produced through my Chair here. In my line of research it's not even possible to produce intellectual property."

- *University professor in a business-funded Chair at leading university*

"Academics always have an over-inflated idea of how much their ideas are actually worth and try to nail their IP down far too early. That hasn't changed."

- *Vice Chancellor of a research intensive university.*

Patents granted to UK universities doubled in the period 2000-01 and 2005-06 and, accordingly, licensing income tripled.[37] In its own terms this can be presented as success if universities exist to produce patents and make money. However, universities are publicly-funded to contribute to intellectual, economic and social progress. A practice that increases their income but prevents industry from accessing their knowledge is counterproductive. The Council for Industry and Higher Education notes that exchange is most helpful when universities do not attempt to act obstructively over IPR,[38] and as we have already noted information passed through informal networks in which trust is high is more effective.

Sadly, the trend of universities attempting to make money from their research, and acting in a formalised and legalistic way is now becoming widespread, and damaging trust. Knowledge has to be diffused in order to benefit the economy. While basic science underpins inventions, few inventions consist only of basic science. Furthermore, networks and relationships built on trust ensure that knowledge is passed around more effectively. It is clear that the endless government rhetoric about the importance of commercialisation and impact has confused academics and university managers, leading to a desperate rush to pin down intellectual property far too early, and hampered innovation in the process.

Professor Paul Wellings, Vice Chancellor of Lancaster University, recently published a review for Government on Intellectual Property and Research Benefits. He flagged up confusion over what universities' primary purpose is when it comes to IP and research.[39] The report said: "It would be helpful for universities, businesses and government funding agencies if DIUS made a clear statement about the purpose of research commercialisation." We agree wholeheartedly. It is essential that ministers clearly state that the purpose of industrial collaboration is not for universities to make money, but to create wider economic and social benefits for the UK.

The government appears to have listened to this suggestion, but its response has not yet been sufficiently robust to arrest this money-focused culture. Lord Mandelson's higher education framework states that the generation of university revenue "can be an important and legitimate, but secondary consequence." It added: "The Government encourages university management to consider whether their negotiation teams sufficiently consider the broader benefits of research agreements."[40] This is a step in the right direction, but at a time when government rhetoric is all about impact and when every university has an office intent upon pinning down IP (as we discuss later) a much more unequivocal approach is needed.

Technology Transfer Offices

University Technology Transfer Offices (TTOs) are funded by HEFCE through the Higher Education Innovation Fund (HEIF), and are responsible for protecting intellectual property using patents and copyrights, licensing innovations and assisting in spinning out companies. They have become a massive growth industry in their own right. Nearly all universities now have one, and they employ almost 4,000 staff.[41] Yet many of the experts we spoke to from academia and business argued that the quality of these offices was enormously variable. They argued that these offices often control rather than facilitate interaction, attempting to maximise revenue from it. This means that they often drive a culture that is actually harmful to collaboration while trying to do exactly the opposite. Some observers have attributed the more harmful behaviour of TTOs to inexperience among the people staffing them. This is unavoidable when the government funds every university to have such an office, as the supply of good people is limited. One head of a successful TTO in a major research university told us that they had left a key position unfilled rather than recruit someone who might damage the relationship-building and bridging they considered to be crucial to their role.

Some universities, particularly at the research-intensive end of the spectrum, have TTOs that do not take a legalistic approach, instead concentrating on brokering relationships between business and academia and running them as businesses in their own right. For example, Imperial Innovations raised £66 million worth of funding when it was listed on the stock exchange in 2006. The company has a team of 38 people from industry, investment and entrepreneur backgrounds. Other strong examples include Cambridge Enterprise, Isis Innovation (the technology arm of Oxford University) and University of Manchester Intellectual Property (see below).

In his review for government Professor Wellings argued that universities with large research incomes from HEFCE and the research councils tend to be the ones with the strongest performance in research commercialisation and related forms of knowledge transfer. He demonstrates that despite most universities having a TTO, only a small percentage of them (between 4 and 6%) are active in filing patents, licensing or spinning out companies.

Case study: University of Manchester Intellectual Property (UMIP)

UMIP manages the University of Manchester's vast intellectual property output in the fields of life sciences and technology. The university has a generous scheme to share the proceeds of intellectual property output, allocating 85% to the academic and 15% to the university. Clive Rowlands, UMIP's CEO, does not take the view that UMIP is there to balance the university's £700 million budget. UMIP receives a budget every year from the university commensurate with its contribution. Although it does not set out to profit-maximise, viewing its role in the context of the university's contribution to the national and regional economy, UMIP does cover its costs as the generous sharing of IP proceeds encourages academics to share and enter the commercialisation process. Several university spinouts benefit from the services provided by the University of Manchester Incubator Company, which has produced companies such as Renovo, the leading biotech firm specialising in the treatment of scars.

The HEIF fund which supports these offices has been earmarked to increase to £150 million in 2010. Due to the size of this fund, and the fact that it is spread very widely around the sector, it naturally drives behaviour. Given that we have stated that innovation should not be primarily about making money for universities, it is unhelpful that the formula for HEIF funding measures the success of external relationships by the income generated. This must change. In addition, as the government spreads this pot of cash so widely in its determination to turn all academics into innovators, the amount universities can secure from it is capped. In the HEIF 4 funding round, announced in 2008, 36 institutions received the maximum of £1.9 million. This cap is arbitrary and should be removed.

We are unconvinced that supporting a TTO in every university is a good use of public money. Indeed the policy seems to be actively harming innovation in many cases. Experts we consulted from academia and industry believed that in many cases universities could function perfectly well with one member of staff in a central office (not necessarily a stand-alone technology office) who understood how to seek advice and make connections in this area.

It makes sense for the government to concentrate on supporting a much smaller number of TTO centres in high-performing universities, principally (though not exclusively) those with a high volume of excellent research. Other institutions could then buy in expertise from these larger TTOs – and removing the cap would allow good TTOs to build capacity so that they could respond to such demand. Professor Wellings' review suggested that the Government could fund regional TTO hubs. We do not agree. This is an artificial, top-down response that does not focus on scaling up success. However, the government should consider Professor Wellings' suggestion that it devotes a proportion of HEIF to vouchers for such a service. We envisage that HEIF funding could be reduced considerably under this model, enabling the transfer of money to support relationships rather than transactions, as we outline below.

University Spin-outs

Spin-outs are often not the best way to develop technology, because they are an example of the push model of technology transfer, with the university deciding what to commercialise and sending it out, rather than businesses assessing what university technology is of use. However for certain technologies that have a visible commercial application, spin-outs may be the best vehicle. As discussed at the beginning of the report the UK has a real claim to leading the world in this area, and Government innovation policy must seek to build upon that.

Spin-out experts we spoke to said that one common error was to get investors involved too early. One

reason that this happens is that it is difficult to access proof-of-concept funding from the state. This sort of funding is crucial because it enables academics to advance a promising technology that is too raw for venture capitalists, without diluting their stake. As one senior figure who has spun out a large number of companies explained: "If the government puts some cash in at the beginning it changes the risk ratio. It makes sense for government to sponsor things that no one else would sponsor. The further back you go [in the spin out process] the riskier it gets."

The Technology Strategy Board (TSB), which was established in July 2007 to promote "technology-enabled innovation" across the UK, is the ideal vehicle for distributing proof of concept funding. The TSB has £200 million a year in funding, but it is still very much an evolutionary body and there remains a great deal of uncertainty about exactly what its role and priorities will be. At present there are too many other government proof-of-concept funds in too many different places and they are generally too small. One expert told us that there were currently 55 funds attempting to bridge this gap, 45 at regional level, amounting to £40 million in total. Each fund tends to have different rules, and often they are regional or technology specific. Such a labyrinth is totally unnecessary and unacceptable. This funding should be brought together under the auspices of the TSB, to make it as easy to find and access as possible. The TSB should also consider the case for increasing the funding available.

Several programmes for follow-on funding for spin-outs exist, in the "valley of death" between the proof-of-concept and the full commercialisation stage that attracts private venture capitalists. The proliferation of these programmes is confusing, and each individual fund too small to make very significant investments. Again it makes sense for the TSB to control this funding. They should consider adopting the United States National Institutes of Health model, in which they invest in the early stages (with proof of concept funding) and then invest again if the recipients achieve clearly defined milestones in the product development and exploitation process.

As we highlighted in '*Innovation and Industry: The Role of Government',* business angels have become more important as a source of early stage financing in the UK. But by the standards of the US, there are simply not enough of them, and they are not investing enough. Further measures are needed to increase the supply of capital they provide. We have recommended an extension of the Enterprise Investment Scheme so that it provides tax relief on preference shares, which are less risky than equity for angels. In addition we have argued that the Government should reform the Enterprise Management Incentive, which currently allows tax relief for angels – but, unhelpfully, only if they work more than 26 hours a week.

One major issue that spin-outs face is the lack of experienced and talented start-up managers. Everyone we

spoke to who had been involved in spinning out a university company identified this as a serious problem. Successful TTOs could play a much greater role here, building up pools of talented individuals who can move between companies, building up their experience and sharing their knowledge of the common pitfalls of the start-up. Imperial Innovations, for instance, already see constructing management teams (rarely with the academic founder as CEO) as a key part of what they do. They have a good network available and argue that the current adverse economic climate offers a unique opportunity to pull in good people who might avoid the risk of a start-up operation in more comfortable times. In addition, research shows that business angels contribute positively to the businesses in which they invest, especially when they have experience of the sector in which the company operates. Therefore making the environment more attractive for these investors should also open up new avenues of talent and expertise for universities.

Open Innovation

The model we should aim for is open innovation between universities and businesses. Open innovation describes a model whereby businesses appreciate that external sources bring knowledge and expertise, and seek to integrate them into their innovation processes. IP that does not fit the individual business model, rather than being jettisoned, is taken up by others, as was the case with Xerox's Graphical User Interface (GUI), which was taken up by Apple in exchange for shares. The open innovation model has been shown to be a major factor contributing to Silicon Valley's position as the top technology cluster in the US.[42] Open innovation benefits the innovation ecosystem because fewer ideas are abandoned completely. Although individual companies have to share knowledge, which may seem anti-competitive, the development of that knowledge will make the company look good and enable it to attract star researchers. It means that business can take up ideas whose economic potential the university didn't realise.

The UK is slightly behind the curve on open innovation[43]. This means that we should not bury our heads in the sand on IP ownership issues. The experience of countries such as the US and Denmark shows that assignment of intellectual property does incentivise researchers to produce innovations and develop them.[44],[45] This suggests that, if they are looking to maximise the impact of their knowledge, universities should be generous in assigning IP to individual academics. Indeed, this has shown some success in individual institutions in the UK.[46] However, this answers only the ownership question between university and professor, not that between university/professor and business. Yet in systems characterised by trust, such prescriptions are not necessary.[47] Nor, in a process as uncertain as R&D, can everything be prescribed by contract.

How do we build open innovation networks?

We don't encourage any further attempts to increase licensing "US style." This misunderstands the nature of American success in this area[48]. The major contribution of US universities has been the exchange of people: academics working with companies while also holding a university position,[49] or cycling in and out of business and academia, taking advantage of society's better appreciation of the link between the abstract and the practical. Furthermore, licensing implies university-produced knowledge that has had no input from business until the licensing (or spinout) stage. If this happens, commercialisation should not be discouraged, but the open innovation model engages business at a much earlier stage.

One way of encouraging open innovation is to develop co-funded shared spaces where academics and industrial researchers can work together on research issues of common interest. There are three key reasons why co-funded shared spaces can drive innovation in a cost-effective way.

First, the long-term relationships will build trust and networks, allowing information to flow more freely. As the boundaries between basic and applied research[50] and between different disciplines of research[51] become more blurred, it is ever more important that scientists and innovators can work side by side.[52]

Second, the shared space would be attractive to the "soft company" model of innovation that has proven so successful internationally. Soft companies provide R&D consulting without a specific product in mind - whereas hard companies are based around a product. Because they perform more R&D, soft companies generate more ideas by chance, producing spin-off technologies. With multiple projects running under the same roof, it is easier to share researchers informally for short periods of time to work on new ideas.

There is ample proof that soft companies are desirable. The Small Business Innovation Research (SBIR) procurement programme in the US has generated thousands, among them Amgen, Qualcomm and Symantec, with small investments. In the UK, the model is particularly popular in Cambridge - where, for example, the Technology Partnership, which describes itself as "not a consultancy" but "a hands-on implementer of new business strategy with a strong focus on technology and development", has created 300 jobs from an investment of a mere £2 million. Companies such as Cambridge Silicon Radio for instance have spun out of R&D consultancies. But more could be done to encourage the soft company model – including through shared spaces and the expansion of the UK Small Business Research Initiative procurement programme recommended in our recent report, *'Innovation and Industry: The Role of Government'.*

Finally, once these centres generate a critical mass of technologies, the innovation ecosystem – consultants, angels, venture capitalists, procurement visits by large customers – starts to build up and makes it easier for new ideas to follow.

We recommend the creation of more co-funded shared spaces where academics and industrial researchers can work together on research issues of common interest. These centres will, we believe, produce greater results for every pound spent over the long-run. The exact form and structure of these co-funded centres should remain flexible. What is clear is that they should be more than science parks, and should provide accommodation for start-ups, but also open collegiate networking between academia and business, between start-up companies and sources of expert knowledge.

In the UK the Engineering and Physical Sciences Research Council, the Biotechnology and Biological Sciences Research Council and the Technology Strategy Board have funded four "Innovation and Knowledge Centres" that fit this model. These centres have leveraged university and business funding – a model that should be emulated. They aim to be "a shared space and entrepreneurial environment in which researchers, potential customers and skilled professionals from both academia and business can work side by side to scope applications, business models and routes to market." However, this scheme is small: the government has invested only £10 million, which pales into insignificance when compared to the £150 million that will be spent on supporting TTOs which often get in the way. The government should consider scaling up investment in co-funded centres, using money diverted from HEIF and from the RDAs, in order to increase capacity and reach.

Collaboration with SMEs

There must also be further measures to encourage universities to engage with SMEs. In 2007 seven universities received 50% of their income from SMEs.[53] Unfortunately during the course of our research we have been told of universities that proclaim their disinterest in SMEs, and SMEs who find it difficult to access university facilities. Of course, if the goal is to make money, SMEs are unattractive. However, new firms can have a large impact,[54]and if the emphasis shifts away from universities making money from innovation they would be more likely to interact.

We recommend that universities be encouraged to develop incubators that aim to be self-funding and will generate interest from "spin-ins" – SMEs that start outside of the university but move under its roof to access its expertise. Incubators embed the growing SME within the university, make it easier for academics and SMEs to meet, provide a public-space function for the university and can create a cluster effect. [55] Due

to the longer gestation period of pre-revenue start-ups, incubators need public funding initially. Some incubators do exist already, and costs have tended to be relatively low. For instance, the London Development Agency gave £3 million to set up an incubator at Imperial (with £4 million co-funding from the university) and South West RDA gave £360,000 towards a more modest incubator at Bath University. In future funding could be in the form of a loan until the incubator is self-funding.

We recommend a refocusing of government innovation funding on loans for incubators, managed by the Technology Strategy Board (TSB).

Our interviews suggested that a key problem with existing incubators is that often the SMEs resident in them cannot afford the expertise of the academics of the universities within which they sit[56]. Hence, the loans for incubators should also be accompanied by a considerable expansion of the innovation voucher scheme. These vouchers, currently funded by the RDAs, enable SMEs to buy support from knowledge-based institutions so that they can explore potential opportunities for future collaboration in developing new products, services and processes.

The value of innovation vouchers currently vary – inexplicably - according to region. In some regions vouchers are worth up to £3,000, while in others they are up to £10,000. Similarly, the size of the fund varies by region. For instance, Yorkshire Forward is distributing 50 innovation vouchers of up to £3,000 every month until February 2011.[57] Whereas Knowledge Connect, which gives out vouchers for the LDA, has a budget of £5.61 million to give out 477 innovation vouchers, of either £3,000 or £10,000.[58] We recommend placing this scheme under the auspices of the TSB, which would iron out these regional inconsistencies. The TSB should also examine more innovative ways to navigate financial issues within this scheme, such as payment in equity, which will make it easier for SMEs to afford the expertise of an academic.

Exchange of People

A further way in which both the impact of universities, and the demand for interaction, can be increased is via the exchange of people. Businesses are more likely to seek help from an academic if they know one, for example if there were an academic on the board or if the company had been founded by an academic in the first place.

In fact, exchange of people could arguably be described as the key differentiating feature of systems such as those in Finland or the USA. In Finland, 95% of engineering PhDs are completed in collaboration with a company.[59] In the US, UCLA researchers found that the presence of a top-flight university had a strong effect

on the creation of biotech firms between 1976 and 1990, but it was not through spinouts or licensing, or even through collaborative R&D. These start-ups were the result of scientists who remained on faculty staffs while establishing businesses on the side or engaging in close consultations with established companies, and of scientists moving from academia into biotechnology businesses. The presence of a star scientist increased by 10% the probability of a start-up in the same geographical area.[60]

To encourage exchange of people in the UK we recommend that the government should focus on boosting the numbers of PhDs undertaken collaboratively with companies. In particular they should aim to increase the number and scope of Knowledge Transfer Partnerships (KTPs), which place graduates and post-docs with companies for a period of between one and three years. During 2007/08 £27 million of grant support was committed to new KTPs.[61] This was a considerable drop from the £36.5 million spent in 2005-06. KTPs encourage networks between academia and industry, developing leaders of the future who may go into academia or business but will be comfortable relating with both worlds. They are a potentially powerful tool, but are currently inaccessible to the very people who need them in order to maximise societal impact. The application process is bureaucratic, consisting of two stages and an almost year-long decision-making process from three or more different funding bodies including RDAs, the TSB and Research Councils. Furthermore, they require three years of accounts from an applicant business. Such a policy is counterproductive because the habit of interacting with a university needs to be ingrained in the next generation of high-technology high-growth businesses, and these may not even have existed for the required time period.

We recommend a simplified procedure for KTPs, a procedure that would remove the accounting requirement, and that would place funds directly with the TSB, who would then be in charge of the whole process. Tolerance of more flexible payment methods including payment by equity should, again, also be considered, even if only a few universities took them up at first.

RDAs

RDAs have been tasked with delivering networking events and knowledge exchange programmes because geographical proximity is important. While this is to a degree true, in reality geographical boundaries prove problematic. As a leading industry figure told us: "Regional blinkers about what global companies want is problematic. There is a global demand for innovation. There is an unbelievable supply of innovative ideas. But somehow there is an inability to put both together. Companies just want problems solving, they don't care where it happens – they just want the best." While some RDAs are not closing their programmes off to extra-regional firms, they are by their nature unlikely to encourage firms and universities from opposite

ends of the country to talk.

University relationships with RDAs remain extremely mixed. The pro vice chancellor for research at one of Britain's top research universities told us that his institution had vowed never to interact with their RDA again, because the experience had been so frustrating in the past. One vice chancellor described working with his RDA on a major project as "a life-shortening experience." Northern RDAs tend to be praised as a cut above the rest, with institutions further south feeling alienated by the regional agenda.

We recognise that some RDAs can be seen to have understood the innovation agenda and risen to the challenge. However in many cases there is no obvious rationale why these programmes must be delivered regionally. In many cases, such as the application process for KTPs, they simply add another layer of bureaucracy and delay that could ultimately harm innovation. We see no strong argument for RDAs continuing to fund innovation, and suggest that they are removed from the process entirely.

RDAs have provided effective in providing funding for facilities. For example, they have funded successful incubation facilities at Manchester, Bath and Imperial College London. While incubators should eventually be self-funding, the initial capital investment in the building is too big with too uncertain and time-delayed benefits for business, so such investment is vital. **We recommend that this facilities funding be continued but managed nationally by the TSB to avoid regional bias, and merged with the Large Facilities Fund to enable larger investments.**

We have recommended that a number of funds should be brought under the auspices of the TSB, because we believe that as a single body it can provide much larger and more efficient funding and a joined up strategy. It has high potential and those who have worked with it are generally full of praise. However, as we have noted, there remains confusion about what it exists to do. We believe the Government should clarify the TSB's role and put it in a leadership position to streamline funding programmes in this area.

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