University Knowledge Exchange (KE) Framework: good practice in technology transfer

Report to the UK higher education sector and HEFCE by the McMillan group

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Key messages

- Universities are motivated by impact on society and this is achieved through a wide variety of routes and mechanisms.
- Overall, evidence points to the UK university system operating at world class standard in technology transfer, though we should be aspirational in our practice.
- One-size-fits-all policies for technology transfer do not work; universities, technologies and places vary.
- Focussing on spin-outs as the measure of success in knowledge exchange (KE) in universities gives a distorted picture as universities need to pursue the most appropriate route to impact for the particular research/technology.
- Effective technology transfer usually incurs a net cost for universities.
- Universities that do more research do more technology transfer. Beyond this, metrics are insufficiently sensitive to identify the right policies to achieve high performance.
- Senior university leadership is essential for good technology transfer, in part because the governance of technology transfer raises challenges.
- The UK should worry less about comparing itself with others, and do more to pursue its distinctive innovative approaches – particularly, in the development of entrepreneurial eco-systems.

Executive summary

1. The review focussed on technology transfer: the processes of exploiting university intellectual property through spinning out companies or licensing. This is only one route to impact from the many being examined in the Higher Education Funding Council for England (HEFCE)/university knowledge exchange (KE) framework. We looked at technology transfer because of continuing debates about good practice in this area, not because it is a more important route than others.

2. We considered expert and overseas data and took in-depth international advice. We focussed particularly on the relationships between universities, academic entrepreneurs and investors and on good practice within the university community. We understand that further work is in train in the KE framework programme on research contracts, which should address issues we did not cover on licensing to industry. It was not in scope of our work to investigate the components to technology transfer outside the university sector, such as access to finance, which are appropriately addressed by Government.

3. Technology transfer is expensive, and universities do it to further their societal impacts. Universities cannot be indifferent on who pays because of matters of governance and sustainability.

4. Evidence points to the UK university system operating at world class standard in technology transfer practice. UK universities have put in place intellectual property

(IP) frameworks and have available good practice materials and a strong community of practice with international links in PraxisUnico. This is an environment which supports continuous improvement of standards of practice.

5. There are no one-size-fits-all policies that work for every technology, university or place. Universities (and countries) have to develop a strategy that fits their characteristics and circumstances.

6. Universities need to pursue the routes appropriate to the science/research in any particular case, which includes taking account of the characteristics of the specific technology and wider absorptive capacity. The concept of 'eco-systems' is important: the entrepreneurial conditions beyond the university which affect how proactive the institution needs to be to secure exploitation of novel-to-market technologies, and which also influence the appropriate institutional policies for entrepreneurship.

7. Universities that do more research tend to do more technology transfer. Beyond this, no country has found a way to identify determinants of effective performance. Outcomes of technology transfer are significantly skewed by a few blockbusters and success is likely influenced by a myriad of factors.

8. However, the global economy is increasingly knowledge based and the UK needs to be aspirational to set new standards. We need to be more confident about what we can do to excel and less pre-occupied by comparisons with others.

9. Leadership matters in technology transfer because one-size-fits-all policies do not work, and there are governance challenges. The role of university leadership is neglected in policy reviews. Technology transfer staff play important professional roles in managing risks and conflicts for their institutions, which may lead to them being unduly singled out for criticism.

10. One of the most important roles for university leadership is deciding the priority to be placed on technology transfer within the institution's portfolio of routes to impact. Many universities quite appropriately do no technology transfer. Funders should look for enduring commitment of leadership to KE mechanisms including technology transfer where appropriate. University senior management determine the important elements to effective technology transfer, notably appointments, reward and recognition policies. We propose that university senior management need to provide clear statements of their purpose and approach which should assist clarity of purpose within institutions as well as being available to funders or Government.

11. The strength of a university's eco-system should influence its entrepreneurial policies. There are some models from the USA (at Massachusetts Institute of Technology (MIT) and Stanford University) and emerging European initiatives. Universities in the UK are exploring the roles that they can play to strengthen their eco-systems, including novel financing instruments, such as the patient capital movement. There is an opportunity here for UK policy-makers, funders and

universities to work together to improve evidence and understanding of this agenda. UK Research and Innovation (UKRI), in conjunction with the Office for Students (OfS), could set a lead given their shared responsibilities for KE; this might include support of exploratory projects. HEFCE should also continue to monitor levels of inter-university collaboration and success of overseas shared-services models.

12. People are key to technology transfer. Universities need to continue to give attention to the entrepreneurial capabilities of their staff and students, although overall approaches need to be fit-for-purpose for the academic workforce as a whole. Funders should also support and encourage the UK's strong community of technology transfer professionals, which might be developed further with more focus on sectoral variations. HEFCE should identify, in the context of the KE framework, a mechanism for recognition of university performance in supporting entrepreneurs, especially at earlier stages in their careers. This may help universities in their wider efforts to incentivise and support impact contributions.

13. We ask that Universities UK (UUK) is consulted on the burden of what we propose in asking for leadership statements on commercialisation; and that HEFCE discusses the resonance of this recommendation with other funders. We suggest that UUK consider with the Leadership Foundation for Higher Education (LFHE) the points we make on governance in the impact agenda. We call on Government, funders and universities to work together to improve evidence on eco-systems development. We ask universities and sector/discipline-focussed stakeholders (such as research funders and learned societies) to work together to raise understanding of sectoral variations. Overall, we stress the importance of maintaining a culture in both policy and practice of experimentation, evidence and learning, to move forward.

Table of recommendations and next steps

Issue	Recommendations	Next steps/lead bodies
1. Leadership	University leadership to be invited to submit a statement on their governance arrangements on IP, clarity of research commercialisation policies and practices and approaches to maximising benefits to society,	HEFCE to consult with other funders and the Department for Business, Energy and Industrial Strategy (BEIS) on the value of this exercise, and approaches to implementation, UUK to advise on university view of the appropriateness of the burden likely to arise from implementation in

		comparison to benefit
	UUK, with support of HEFCE, to discuss with LFHE whether more could be done to support governors, leaders and managers to understand, interpret and execute appropriate approaches to balancing impact and income.	UUK/HEFCE
2. Eco-systems/collaboration	HEFCE and other national agencies to support development of an improved evidence base on eco-systems development, including novel financing. Additional investment in pilots would be valuable.	HEFCE to discuss with other national agencies and BEIS.
	HEFCE to continue to collect evidence on university collaborations in technology transfer/KE in Higher Education Innovation Funding (HEIF) strategies. HEFCE to seek evidence on achievements of overseas shared-services models and take account of and disseminate lessons learnt,	HEFCE
3.Entrepreneurial staff	Leadership statements above to include policies on support of academic entrepreneurship,	HEFCE and universities/UUK
	Exploration of a mechanism, such as a benchmark, for recognition of university performance in supporting academic entrepreneurs, particularly early career researchers.	HEFCE to discuss with universities/UUK and research and enterprise funders.
	Funders and policy-makers to do more to support PraxisUnico to make the annual PraxisUnico conference a must-attend for all UK university practitioners, and to attract greater overseas and private sector attendance.	PraxisUnico and HEFCE to discuss with funders and BEIS.

	PraxisUnico to explore ways to help less experienced or smaller scale technology transfer units to develop appropriately,	PraxisUnico
	University technology transfer practitioners to continue links with US counterparts, either through system-wide links (PraxisUnico and Association of University Technology Managers (AUTM)) or through relationships between individual universities on either side of the Atlantic.	PraxisUnico
	PraxisUnico to explore with funders and other stakeholders with technology sector expertise whether more could be done on good practice differentiated by specific technology sector. This supports the recommendation on help to less experienced or small units.	PraxisUnico
	KE framework to be taken forward in a way which supports and encourages continuing innovative, reflective and evaluative practice,	HEFCE and universities/UUK

Introduction

As part of its commitment to keeping the UK at the leading edge as a global knowledge-based economy, the last Government asked the Higher Education Funding Council for England (HEFCE) in 2014 to develop a knowledge exchange (KE) performance framework that would secure effective practice in universities on key productive elements in the relationships between UK universities and business in its various forms. The recent higher education (HE) White Paper re-affirmed the importance of the framework.

As part of the KE framework programme, a small group, chaired by Professor Trevor McMillan, the Vice-Chancellor of Keele University (the McMillan group was established to examine university approaches to supporting the exploitation of intellectual property rights (IPRs) that have been developed as a result of university-based research by university staff and students, which is commonly termed ‘technology transfer’. The group’s membership and terms of reference are at Annex A. This review forms only a small part of the overall scope of the KE framework and of the range of KE activities/routes to impact, but is an area that generates considerable policy comment from a wide range of parties.

Overall, there is much to lead to the belief that the UK university system is world class in its practice of technology transfer. International reviews, overseas expert opinion and various datasets support this. There is also academic analysis of the topic from world-class innovation research centres, some of which were represented on the group.

Nevertheless, we recognise that best practice – if ever identifiable and attainable – does not stand still. The quality and standards of our technology transfer impact on inventors, entrepreneurs, investors and industry partners. But above all, success in technology transfer is one way in which universities can contribute to the success of the UK as a knowledge-based economy. So we need to set ourselves aspirational goals.

We are grateful to HEFCE for supporting the work of this university-led group, and the work on the KE framework more generally. We were also grateful to gain detailed evidence in our work from two of our partners from overseas - Dr Lita Nelsen and Dr Kathy Ku, respectively heads of technology transfer at Massachusetts Institute of Technology (MIT) and Stanford University.

HEFCE's focus in the KE framework is on developing good practice within the university community, and our group was largely made up of university staff with different roles in technology transfer. We recognise that our work sits in the context of wider government policy on commercialisation and innovation, which will consider the views and interests of a wider range of players, for example, industry and investors. We hope nevertheless that our work will inform the deliberations of Government by providing more detailed evidence and insights on the university contribution to commercialisation.

Good practice is only useful if it can be put into operation on the ground, and hence as a next step we propose that key stakeholder bodies in policy and the HE sector are consulted on what we recommend, and that proposals are then put into action as part of wider development of the KE framework. We were a 'task and finish' group and our work in conducting this review is now done. We therefore identify lead bodies in the university sector – HEFCE, Universities UK (UUK) and PraxisUnico – to take forward these consultations.

Our report has the following structure:

- A description of the scope of the review in the context of KE overall (Paragraphs 1-14).
- A description of the legal and regulatory frameworks to the conduct of university technology transfer, and its main goals (Paragraphs 15-21).
- An examination of the evidence on the competitiveness of UK technology transfer practice, policy and performance, and conclusions on what the evidence tells us about the opportunities for further UK development (Paragraphs 22-82).

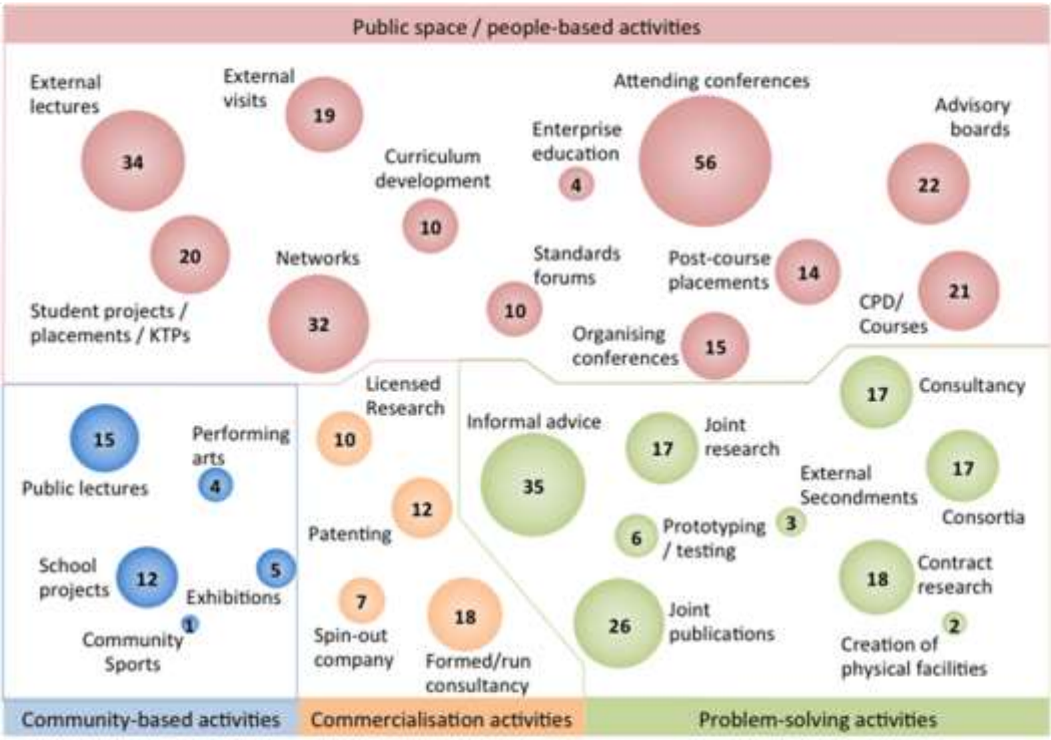
- Our conclusions on improvements needed, recommendations and next steps (Paragraphs 83-129).

Scope of the review

1. University-based knowledge/research can have significant impact outside academia in several different ways. This has been well demonstrated in KE strategies submitted by universities to HEFCE for Higher Education Innovation Funding (HEIF)[1], and most recently by the case studies that were submitted to the Research Excellence Framework (REF) 2014[2].

2. Universities pursue a wide range of routes to impact/KE mechanisms of various sorts, as the means to form partnerships with business and other users and hence achieve external world impacts. These can be illustrated through surveys of academics of the mechanisms they use to work with external partners (Diagram A[3]), or through institutional data from the Higher Education Business and Community Inter-action (HE-BCI) Survey[4] (Diagram B).

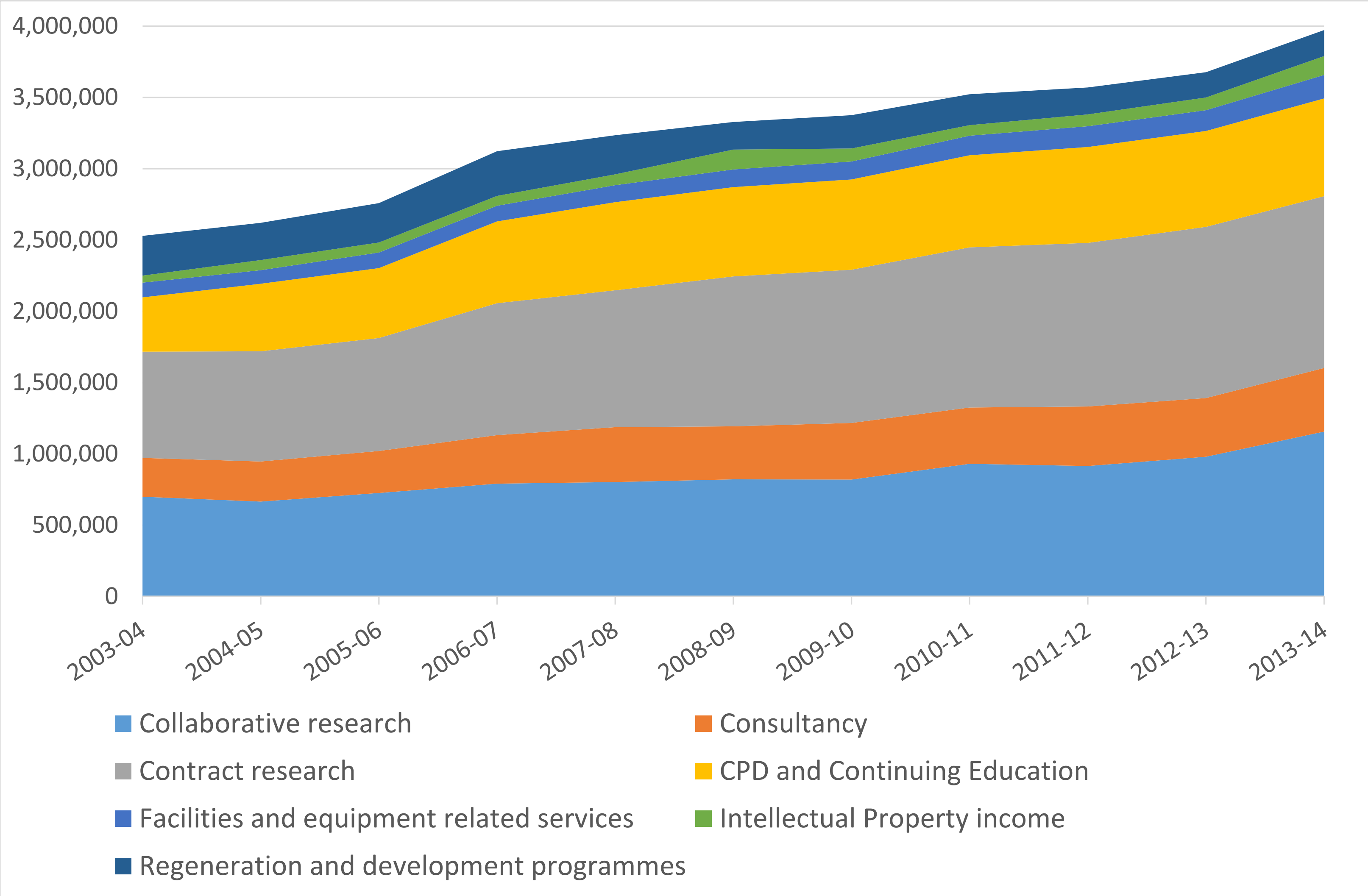
Diagram A Types and levels of KE engagement of university academic staff



Number in bubbles is the % of academics engaging at least three times over the past three years in that mechanism, or at least once in the past three years for commercialisation activities.

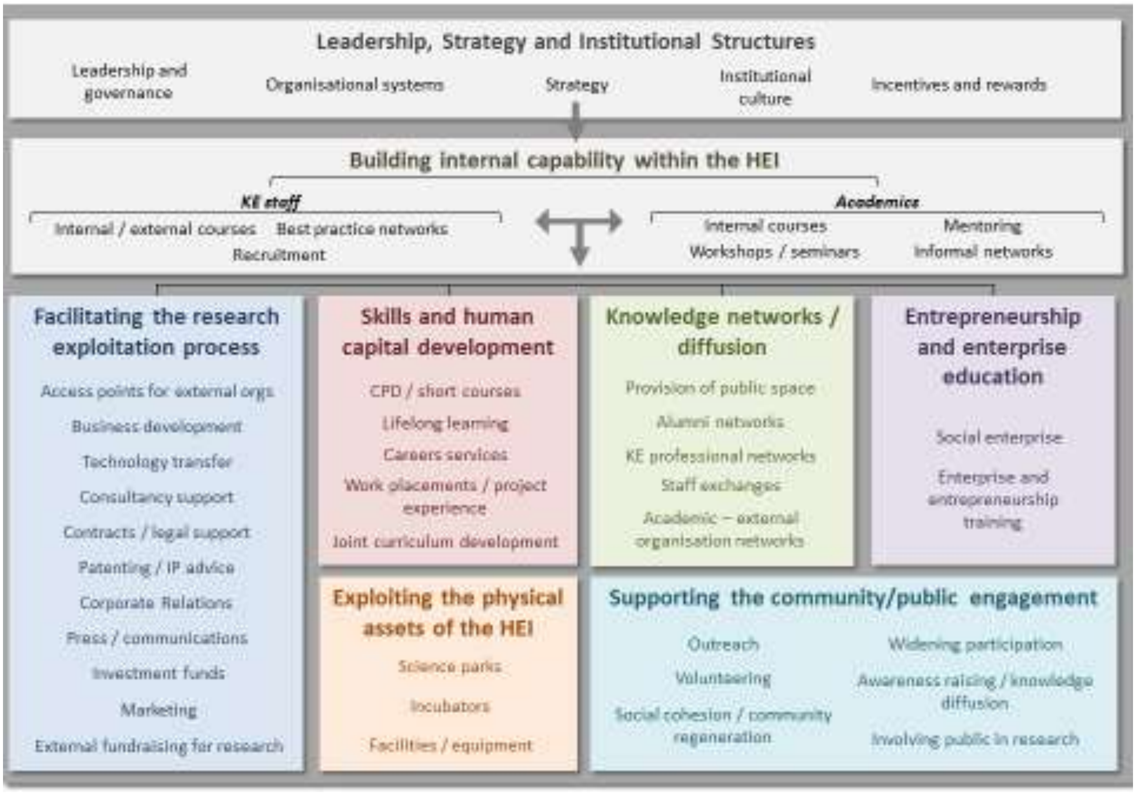
PACEC 2012

Diagram B Types and levels of KE income streams UK £000s Real Terms)



3. The HEFCE/universities KE framework programme (described in Annex B) addresses all KE mechanisms, and the institutional capacity and capabilities needed to support these (Diagram C).

Diagram C Higher education KE capacity and competencies

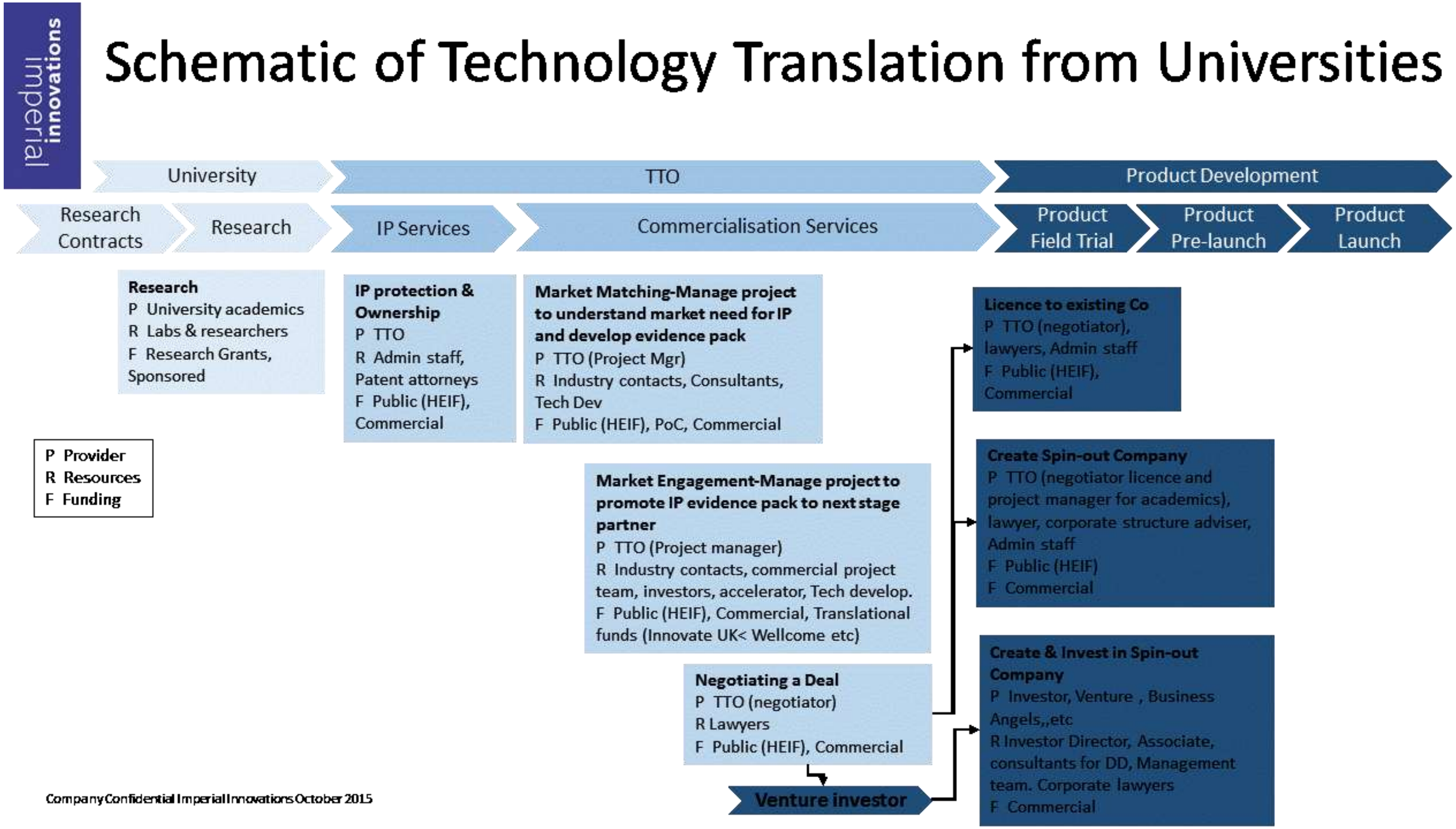


T Coates-Ulrichsen, Centre for Science, Technology and Innovation, University of Cambridge

4. We have drawn on research studies from Research Consulting on good practices and IP Pragmatics on benchmarking, being published in September, which were commissioned by HEFCE for the KE framework.

5. Our work was focussed only on technology transfer (Diagram D), which we defined for the purposes of this report as the commercialisation of university-owned research outputs through the licensing of IPRs (patents, copyrights, know-how, databases and design rights) to existing companies and setting up new spin-out companies. These are ‘technology push’, rather than ‘market pull’ mechanisms.

Diagram D Technology transfer processes



6. We looked primarily at the processes of forming new companies to exploit a technology - what is called in the UK 'spinning out' - and particularly the inter-play between universities, academic inventors and investors.

7. HEFCE is considering further work as part of the framework on research contracting and we recommend that this includes licensing technologies to existing industries, which we did not cover fully in this review. This might address: conflicts that may arise between assigning IPRs to partners in research agreements and availability of intellectual property (IP) for exploitation through technology transfer; valuing early-stage IP and IP not yet generated; and the contribution made to research and development (R&D) partnerships from licensing IPRs.

8. Annex C provides more information on history and policy on ownership of university IP as context to this review and to the topic of IP exploitation and wider intellectual asset management more generally.

9. As can be seen from Diagrams A and B, technology transfer is a relatively small element to KE, and collaborative and contract research, as examples, are far more widely used impact channels. There is though inter-play between impact channels, such as technology transfer leading to opportunities for joint research.

10. It is immediately clear that the 'best' way to exploit research can vary considerably and it must be stressed that by focussing specifically on the exploitation of existing IP through processes of licensing and spin-out company formation we are not suggesting that this is the only or best route. Indeed we would specifically argue that to only evaluate spin-out company formation as the measure of KE from universities is misleading and dangerous in the sense that it misses most productive approaches overall. A theme that runs throughout our report is the significant differentiation between universities in their KE mechanisms, entrepreneurial capabilities and technology sector specialisms, which means that "one-size-fits-all" policies are not appropriate.

11. However, it is clearly important that when appropriate universities are able to encourage, facilitate and support the formation of spin-out companies by their staff. We have therefore examined these processes in different environments to enable us to identify key features of success.

12. A great range of factors affect what is the 'best' way to exploit research in any particular case. This includes the type of technology being generated and its novelty, the amount of additional development required to fully deploy it in the marketplace, the types of organisations involved in deployment and the target application markets. One of the most important factors is the level of absorptive capacity in the target markets/wider economy for the technology – the knowledge, skills, capabilities and access to finance of businesses and other enterprises to adopt and put into practice research outputs and know-how. Different routes to impact – collaborative research

with business, licensing to an industry partner or spinning out a technology where no industry partner yet exists – may need to be adopted according to levels of absorptive capacity. The international comparisons we draw later in this report reflect different levels of absorptive capacity and technology specialisations in different countries, which have implications for levels and forms of research commercialisation. Raising levels of absorptive capacity may then be a vitally important component of wider KE, such as through channels of executive education or skills development.

13. We have found in our enquiry that approaches to technology transfer specifically are significantly affected by more localised conditions – what are referred to internationally and in expert literature as 'eco-systems'. Effective eco-systems have very particular characteristics of specialisation in specific technologies and industry sectors, with critical mass developed over time, and supportive framework conditions.

14. Recommendations we make later in this report address both improvements universities can make in their technology transfer practices, and also the contributions that universities can make to improve eco-systems developments.

Why do universities do technology transfer?

15. A central policy debate in technology transfer, and indeed wider KE, is whether universities are motivated by the impact they make on society, or the income they can generate. <u>We were all unequivocally of the view that universities do technology transfer as part of their mission to deliver impact for society (including the economy).</u> Universities have always had missions that reflect societal contribution, but we all recognise that delivering impact is a continuing high priority for Government and funders, and this is reflected in national policies, most notably the inclusion of impact in the REF.

16. There is long-standing debate on whether technology transfer can generate additional revenue for universities, as one way that institutions can build a sustainable future that is less dependent on public funds. Governments and funders stress the importance of university activities overall being sustainable in the longer term from a range of sources of income. However, technology transfer tends to be expensive and very few – if any – universities worldwide make money from technology transfer. Technology transfer is generally a cost to universities[5], not a source of additional revenue, though it can lead to other revenues or benefits.

17. The focus on impact does not mean therefore that universities can be indifferent to who pays and who benefits from technology transfer. There are significant costs to universities which need to be met and it is appropriate that those who benefit should contribute. Not least because the willingness of beneficiaries to pay is one important signal of perceived value and likely impact. It is difficult to imagine pursuing effective

technology transfer without an understanding of commercial value. We should not regard impact and income as a dichotomous decision. There are likely many instances when higher education institutions (HEIs) should be charging market rates, and hence making income, so as not to distort the market, and which will lead to significant impacts. There are other cases where income should be sacrificed in order to ensure the knowledge that has been generated is diffused into the system to areas where it can be effectively exploited. This then leads to the implication that the capabilities of university staff in judging the right 'rates' is crucial, and hence the importance of both leadership oversight and quality of professional practice in technology transfer, which we discuss later in this report. Some of the same issues apply in wider translational practice, such as in healthcare, though without the same private sector market issues.

18. Universities need to undertake technology transfer within the context of their legal and regulatory duties as publicly funded charities. Universities must pursue their charitable purposes, which must be broadly beneficial for the public and not give rise to more than incidental private benefit. The main charitable purpose of universities is education, which includes undertaking research and making it publicly available. Generally the law points toward universities maximising income from technology transfer and commercialisation in order to reinvest resources into teaching and research, as the means to deliver public benefit.

19. The European Commission (EC) now recognises the development and support of internal capacity and capability for knowledge transfer as a non-economic or public benefit in State aid regulations. However, many forms of KE described earlier in this report are economic activities with potential implications that use of public funds for these could constitute illegal aid. Generally, State aid regulations point towards universities exercising great care in relation to any use of public funds in ways that can distort markets, including in technology transfer[6].

20. Generally then, there are real tensions and dilemmas for universities in reconciling the necessarily non-linear engagements needed with wider society to maximise impact, with the fairly linear view embodied in legal and regulatory frameworks. In our recommendations later in this report we consider ways to tackle governance issues raised in technology transfer.

21. It is unlikely that we can ever resolve the issue of whether universities strike the right balance of impact and income and timescales, given the multitude of different routes to impact and multitude of different agreements being signed at any time. In our recommendations, we focus on providing greater assurance to Government on university leadership's commitment to delivering impact in sensible balance with co-investment with partners, through institutional statements.

Evidence – how well does the UK do technology transfer?

22. We summarise here the evidence we considered related to the international competitiveness of UK technology transfer in terms of:

a) The technology transfer practices used by UK universities and nationally: This includes examination of legal arrangements in different countries for ownership of the IP arising from university research/knowledge. It also includes international comparison reviews of the extent and adoption of good practice in different countries, and availability and adoption of good practice within the UK system.

b) The specific technology transfer policies put into place by universities, and nationally, and the factors that determine what are appropriate policies in specific circumstances: Although practices may be similar, policies will vary due to internal (university characteristics) and external (wider economy) factors, such as the absorptive capacity of partners, maturity of university and innovation/technology systems, entrepreneurial eco-systems developments and technology sector specialisation.

c) UK performance in technology transfer and the outcomes and impacts achieved: Performance comparisons need to take account of both quality of practice, but also the legitimate differentiation in policies of different universities, places or countries – leading to differences in both intended and achieved outcomes and impacts. This affects national systems-wide comparisons as well as comparisons between universities. There are methodological challenges in making robust systems-wide or institutional comparisons due to the extreme skewing of outcomes of technology transfer, and the wide range of potentially relevant input/activity factors (reflecting the various dimensions to policy we identify).

23. We provide further detailed evidence that informed our analysis in Annexes C and D.

24. Although we examine extensively national differences, we need to keep in mind that there is a continuing trend toward international systems of innovation, as well as increasingly global flows of research funding, activity and talent. These trends will impact on technology transfer.

Technology transfer practice

International comparisons of IP practices

25. As a starting place we compared countries in their practices for ownership and management of IP generated from university research/knowledge – see Annex C. The three main options are ownership by the state/government, the university or individual academics and students (an intermediate model of regional hubs and spokes is examined in Paragraphs 35-40). Most countries are aligning around the

model adopted in the USA under the 1980 Bayh Dole Act of university ownership. While no approach is perfect, university ownership seems by far the most workable model.

26. In 2008, the EC published a code of practice on knowledge transfer and reported on the state of development of knowledge transfer offices in Europe in relation to implementing the code in 2013[7]. The UK was second in Europe in terms of level of compliance with the EC good practice code, with only Austria at a higher level of development.

27. Comparison studies of UK-US university KE practices[8] have concluded that UK and US approaches to technology transfer are broadly similar, and that the two countries share similar challenges. The USA is looking to the UK for good practice as much as the UK looks to the USA.

28. We gathered detailed evidence on the practices of MIT and Stanford who are regarded as pre-eminent worldwide in technology transfer, including visits to the UK to provide expert opinion by Dr Katharine Ku and Dr Lita Nelsen, the heads of technology transfer at Stanford and MIT respectively. We found significant similarities in the practices adopted by these universities with UK counterparts, but significant differences in specific policies, as discussed in Paragraphs 46-51.

<u>Comparisons between UK universities on IP practices and sharing good practice</u>

29. How similar are technology transfer practices between UK universities? And should they be more standard?

30. A 2010 research study for HEFCE of UK university approaches to IP exploitation[9] concluded that IP framework policies have been established by virtually all HEIs who engage in some form of IP exploitation. These typically follow a common framework for organising and managing the IP exploitation process and articulate who and what is covered, the procedures for commercialisation and exploitation, the incentives and revenue sharing schemes, and the appeal processes.

31. Research Consulting have compiled a database of 250 good practice documents from more than 50 UK and overseas expert sources. Although the database is intended to cover all forms of KE, the bulk of materials is focussed on technology transfer. Technology transfer is a well-developed and examined practice area in the UK, and UK practice has been informed by international experience, particularly from the USA. Dr Lita Nelsen of MIT was a founder of the UK professional training programme for technology transfer originally formed as Praxis and now run by PraxisUnico.

32. Research Consulting suggest that communities of practice that develop soft skills alongside good practice materials may be particularly valuable. Leadership in technology transfer practice in the UK is focussed around two lead bodies only – the

UK Intellectual Property Office (UKIPO) and the university practitioner body PraxisUnico. This concentration of good practice is likely to make awareness of good practice materials and professional support widespread in the university system.

33. PraxisUnico's practical guides address licence agreements, options and spin-out companies, and PraxisUnico also provides a wide range of training courses focussed on the needs of KE practitioners. The UKIPO is the primary source of template agreements relevant to spin-outs and licensing, and is responsible for several key studies and guidance documents. Some of these materials are generic (for example, the IP Finance Toolkit, IPR valuation checklist, template non-disclosure agreements and skeleton licence agreements), but others have been tailored to the needs of the HE sector, and are hosted in a dedicated collection - https://www.gov.uk/government/collections/ip-for-universities-guidance-tools-and-case-studies.

34. While good practice materials provide sound reference points in relation to the technical and legal perspectives on technology transfer, Research Consulting suggest that very few materials provide comprehensive guidance on approaches to market assessment and opportunity evaluation. This is likely to reflect the level of professional judgement and sector/market-specific knowledge required to undertake these tasks effectively. Research Consulting also note relatively little good practice on the relationship between spin-outs, licensing and academic entrepreneurship.

Overseas comparisons in collaboration/shared services in technology transfer

35. We examined in detail overseas practices of collaboration in technology transfer and shared services models (with other universities), as well as UK evidence: summarised in Annex D. In particular, we looked at regional 'hub-and-spokes' models adopted in some countries that are newer to technology transfer.

36. The Organisation for Economic Co-operation and Development (OECD) examined[10] the theory that hub-and-spokes models "allow the bundling of inventions across universities, lower operation costs, and access to personnel with superior commercialisation expertise". They concluded that the jury remains out on whether shared-service models work. Hub-and-spokes models "may lead to higher co-ordination/communication costs, competition amongst institutions, and capacity constraints of TTO personnel".

37. The actual practices of universities in most countries seem to move away from shared services over time. This is true of American examples where technology transfer capacity is often developed initially, for example, in large state university systems, with capacity being devolved to individual university campuses as the system matures. There are also Australian and European examples where shared capacity is trialled, but where there remains a dynamic to duplicate some capacity at institutional level.

38. Our impression is that universities everywhere come to the view that close working between academics and technology transfer professional staffs on the ground is most effective to deliver improved entrepreneurial culture. Commercial, collaborative vehicles introduced by governments in other countries may play a part (such as in improving regional innovation financing), but it is individual universities that nurture the entrepreneurial ambitions of their staff and students. As universities gain more experience in technology transfer, they seem to differentiate their specific policies further, reflecting their particular entrepreneurial characteristics and eco-systems.

39. In the UK, there seems to be evidence of widespread use of collaborations of various sorts. Collaboration in terms of shared learning in communities of practice, such as PraxisUnico, is also clearly important, and is firmly embedded in the UK.

40. Annex D also suggests that many countries are making rapid changes to university systems, innovation systems, and the like, with a focus particularly on changing IP ownership and introducing more entrepreneurialism of various sorts. It is a lesson of innovation systems theory and policy development that trials of new approaches are important. However, this does not mean that new approaches will work. Controlled experimentation which involves evaluation and feedback is important, with willingness of systems to learn and adapt, and to share results on what works and what doesn't. This is true for governments as much as for individual universities.

Technology transfer policies

41. Although evidence[11] demonstrates similarities in the technology transfer practices of UK universities, such as through establishing IP frameworks, the same evidence notes that there is no single 'best practice' model of how HEIs organise and manage the exploitation of their IP. This reflects the diversity of mission, aims and objectives, research/technology portfolio, capabilities of academics and commercialisation staff, and the learning that has taken place from previous experiences. The detailed policies of individual universities then vary. This is true not just of the UK, but also of a very mature university technology transfer system such as that in America.

42. This also holds at national level: policies for technology transfer, and wider KE, in different countries reflect national characteristics, such as of the economy.

<u>Absorptive capacity and wider industrial conditions</u>

43. The USA has long had a strong focus in its national policies on entrepreneurship and technology transfer. The emphasis in Europe, including the UK, is rather different, with a stronger focus on a wide range of KE mechanisms and impact routes with goals of improving competitiveness conditions as well as producing new technologies. This reflects that the UK (and Europe) are subject to the so called European Paradox[12]: competitive/innovative economies with strong university/research systems that do not generate the levels of licensing activity achieved in USA. The US has higher levels of business R&D, more high-technology

R&D and more venture capital, and hence much higher absorptive capacity for university cutting-edge technology. All these factors affect opportunities to license technologies, and to scale up technology companies.

44. As a consequence of the differences in levels of absorptive capacity, the roles of technology transfer offices, or rather KE offices, differ between UK/Europe and the USA[13]. This is described in more detail in Cambridge comparison studies for HEFCE[14]. US universities are more likely to be able to take direct routes to impact through licensing to an existing company with high absorptive capacity (although approaches even in the USA will vary by different regions), whereas UK/European companies will take broader routes. Detailed policies for KE/technology transfer will then differ.

Maturity of systems

45. Annex D highlights evidence on the different levels of maturity of university, technological and innovations systems development in different countries. Europe and Japan really only began to embed 'third mission' or societal impact within their universities after 2000, as part of much larger change agendas to make their universities more autonomous and to develop innovation system approaches in their economies. Specific policies are then likely to reflect different levels of maturity, such as the use of regional hub-and-spokes models in some more immature systems.

Eco-systems

46. The evidence we considered from MIT and Stanford University focussed particularly on the major influence of their eco-systems – Kendall Square and Palo Alto (Silicon Valley) – on their entrepreneurship policies. The universities have not felt the need to form companies themselves, nor to raise venture funds to support spinouts, nor to assist spin-outs once formed. Faculty and students involve themselves as private matters in entrepreneurship, working with the eco-system around them. This approach is reflected in the terms upon which Stanford and MIT licence their IP. They licence on an arm's-length basis to companies that can best take forward technologies, irrespective of faculty or student involvement in these companies. They take cash upfront or in more front-loaded royalties and milestones, with a view to testing that the company is serious to take the technology to market. They take a low percentage of return in the form of equity, to avoid conflicts of interest with faculty, and they sell off equity as soon as possible.

47. In the view of Stanford and MIT, there are very few places – if any – in the UK that can offer the type of eco-system that they enjoy, and hence their technology transfer policies are not generally suitable here. Dr Katharine Ku and Dr Lita Nelsen of Stanford and MIT advised us on UK university policies "A direct comparison with terms given by MIT and Stanford is therefore simply not appropriate."[15]

48. The successes of Stanford and MIT have led many to suggest we should adopt some of their detailed policies here. One such example is the proposal to standardise the equity stakes share held by UK universities in spin-outs to the c10% stakes maxima at Stanford and MIT. Stanford and MIT advised against this, as fitting with their particular circumstances – their eco-systems, not the UK's.

49. Another proposal discussed in the UK has been greater use of anti-dilution provisions in the shares that universities claim in spin-outs (so called 'golden shares'), also used to some extent at Stanford and MIT. The advice from counterparts from Stanford and MIT chimed with our own views, that terms and conditions need to be fit-for-purpose for the particular technology, university and eco-system. Anti-dilution provisions are not widely adopted yet in UK and so may not be honoured by later stage investors, who ask for them to be removed. However, innovation in technology transfer, particularly in innovation financing, is vitally important, and so we should welcome ideas like 'golden share' and test them out.

50. We note that the policies (and performance) of MIT and Stanford stand out in the USA system, not just in comparison with UK. Many USA reviews and studies, for example, suggest that taking equity in spin-outs is recommended over royalties. This is due to uncertainties and delays in gaining returns from licenses over equities, and legal complexities of monitoring licenses[16]. Technology transfer policies are sensitive to regional/local conditions, and US universities in stronger and weaker areas of absorptive capacity pursue very different approaches.

51. There is relatively little discussion in the UK about spatial dimensions to technology transfer. Annex D provides some information on European models which have a regional dimension to technology transfer, particularly financing. However, USA models may be more relevant here (as an EC study put it[17], UK universities "lack the financial power of private and large public US universities, they are closer to the latter than most continental European ones, both in terms of administrative autonomy, access to a flexible academic labour market for scientists and expertise in dealing with IP issues").

Sectoral variations

52. Technology transfer policies need to take account of the characteristics of exploitation for different technology sectors. Different technology transfer sectors have different exploitation pathways: illustrated at a high-level in Diagram E from Professor Erkko Autio at Imperial College London Business School.

Diagram E Technology sector differentiation in technology transfer

Aspect	Life Science	Physical Science
Driving Force	"*Science*"	"*Engineering*"
Innovation Mode	Linear, sequential, based on *discovery*	Interactive, based on *recombination*
Nature of Need	*Exists*, solutions missing	Often *emergent*, plenty of alternative solutions
Nature of Market and the Innovation Process	Structured, established, sequential	Often emergent, changing, interactive
Type of Research Contract	*Long-term*, basic research	*Short-term*, application development
Key Bottleneck	Scientific *discovery*	*Customer adoption*, positive feedback
Role of IPR	Basis of *licenses*	Determines business model, *mode of market entry*

Professor E Autio, Imperial College Business School

53. Some examples of the different policies needed in different technology sectors (though there are many more) are:

a) Engineering hardware: In this sector, industry-sponsored research is important, though not primarily for IP acquisition. Companies do not want to acquire the single/few patent platform technologies arising from publicly funded research in universities as their interest is in scale/large patent portfolios. University patents are then exploited through spin-out company formation. The proof of concept support needed for such spin-out companies is low, but equity returns are also low. The process of exploitation is non-linear and iterative, with constant re-design and variations in speed in the process. The market and university approaches are not well aligned, as universities will not operate with the same scale and speed as the commercial sector. The route to market is not mapped out and deal structures vary considerably. University technology transfer will typically have the following features:

- Universities are likely to need to put in a lot of processing effort to commercialise these technologies. However, working with industry and investors is likely to be challenging (not least because negotiations have to start with a blank sheet of paper, rather on the basis of established deal structures that exist in, for example, human therapeutics), and returns will be low.
- Industry-sponsored research in universities will be an important impact route.
- There are likely to be lower levels of licensing income (compared to other sectors).

- There are likely to be larger numbers of spin-out companies formed. However, the external investment attracted to these, and income from sales of shares, are likely to be lower than in other sectors.
- Potentially, there may be a more contentious relationship between university technology transfer, investors and industry in this sector due to the tensions from different approaches of the different stakeholders.

b) Human therapeutics: Technologies emerging from universities in this sector can be at too early a stage for industry to pick up. The level of proof of concept funding needed to develop technologies in this field is daunting – in the £500K-£5M range. (Stanford experts noted that finding proof of concept funding in this sector was a struggle even in Silicon Valley.) Technology transfer in this field is far more linear and regulated than in Engineering and Physical Sciences, and that may fit better with internal university processes of moving through long-term research into commercialisation. Linked to this, there is better common/shared understanding across stakeholders about the route to market and the appropriate structure of deals. University technology transfer will have these features:

- Publicly funded, fundamental research is vital.
- A lot of processing and investment effort is needed from university technology transfer staff.
- Spin-out companies are important but a struggle to capitalise, needing a lot of work from universities.
- High external investment into spin-outs has been achieved.
- High equity returns (to investors, and sometimes to entrepreneurs and universities though this depends on the levels of dilution of equity) may be achieved, affecting sales of shares data.
- Relationships between university technology transfer, investors and industry may be fairly harmonious.

c) Software: Universities create a great deal of new software, which is often protected as copyright not patent, and is typically exploited through licensing. Investors are as likely to be interested in the capability of the team generating the technology as the IP. This technology typically does not need large amounts of proof of concept funding prior to interest from venture capital. There is also significant venture capital interest in this sector due to the short timescales needed to bring a product to market and to gain a return on the investment. The commercialisation process has the characteristics of high volume/attrition rates, no need for patent investment, an active investor cadre, and a need for speed. The process very often flows through academics and students with low processing effort by university technology transfer staff. Key features include:

- The need for lower processing effort by university technology transfer staff.
- There is strong potential to license the technology in this sector, though there can be an issue about whether this is worth it, given the high numbers of low-margin licences.
- There are likely to be higher spin-out company numbers in this sector than in others. However, less external investment is needed. The technology may

generate lower levels of external investment and lower sale of shares income; though there may be lower dilution of equity stakes than for therapeutics, with higher rewards as a result for entrepreneurs and universities.
- It is likely that the commercialisation process will be less challenging between university technology transfer, investors and industry in this sector, as long as the appropriate balance is struck between people and IP impact channels.

54. These variations affect policy and performance, and hence any metrics and quantitative comparisons. They may affect the reliability of quantitative comparisons between universities, and even between countries. If university X or country X specialises in Engineering and Physical Sciences, and university Y or country Y in Life Sciences, their technology transfer metrics will and should look very different. This is a key point relevant to making comparisons of technology transfer data of any sort.

55. We have relatively little data on levels of university technology transfer activity broken down by technology sectors. The US technology transfer professional body Association of University Technology Managers (AUTM) no longer collects data disaggregated by sector, and the UK HEBCI survey[18] is not disaggregated beyond institutional level.

56. The US National Academies conducted a major review of technology transfer in 2010, 'Managing University IP in the Public Interest'[19]. The review cites an academic survey which found that 52.5% of licensing activity by USA university technology transfer units was in Life Sciences, with up to 100% in some universities[20]. Analysis of UK academic patenting [21] suggests activity here is also becoming increasingly concentrated in pharmaceuticals/biotechnology sectors. Although this is a global trend, it is more pronounced in the UK. Universities are responsible for 25% of inventor patents in the pharmaceutical sector in the UK (and for 6% of patents in other technology sectors), against a global average of universities of 10-12% of pharmaceutical patents[22].

57. Both the study of UK academic patenting and the 2016 National Centre for Universities and Business (NCUB) survey of academic KE activities[23] suggest that Engineering and Physical Sciences academics are most likely to participate in academic entrepreneurship activity[24]. US and UK evidence[25] shows that a very small number of academics participate in technology transfer activity and are responsible for most results.

58. It may be noteworthy that institutional technology transfer priorities are most focussed on Life Sciences disciplines, whereas Engineering and Physical Sciences academics predominate in their interest in entrepreneurship.

Technology transfer performance

International, system-wide performance comparisons

59. HEFCE publishes annually in the HE-BCI survey report comparisons with selected countries on selected indicators where comparable data is available. The latest year of HE-BCI data we examined is in Table A.

Table A: Commercialisation activity in 2013-14 for the US, UK and Japan

	US AUTM	**UK HEBCI survey**	**Japan UNITT**
Total research resource (£M)	35,722	7,043	14,715
IP income including sales of shares in spin-offs (£M)	1,290	131	18
IP income as % of total research resource	3.6%	1.9%	0.12%
Spin-off companies formed	747	147	18
Research resource per spin -off (£M)	48	48	817
Patents granted	5,163	976	4,776
Research resource per patent (£M)	7	7	3.1
Industrial contribution (£M)	2,330	508	64
% industrial research	6.5%	7.2%	0.4%
US cashed-in equity and UK Sale of spin-off shares (£M)	20	49	3.6
(Cashed-in equity and sale of spin-off shares) as a % total research resource	0.06%	0.7%	0.2%

HEFCE, HE-BCI Survey report 2013-14

60. As well as sharing HE-BCI data with America and Japan, HEFCE also provides data to the EC so that Europe-wide comparisons can be made. Table B provides comparisons from 2013[26].

Table B: Performance by research expenditures (euro M) to produce one output

	European universities/research organisations	United States	Ratio (EU/US)
Invention disclosures	3.3	2.1	1.6
Patent applications	6.6	2.3	2.9
Patent grants	10.4	9.7	1.1
US Patent and Trademark Office patent grants	47.1		
Start-ups established	30.4	68	0.4
Successful start-ups	16.4		
License agreements	7.5	7.5	1
License income (euro M)	81.1	24.4	3.3
Research agreements	0.6		
Total reported research expenditure (euro M)	41,072	45,631	

Sources: United Nations University Maastricht Economic and Social Research Institute on Innovation and Technology; European KT Indicator Survey years 2011 and 2012 combined

61. Table A suggests significant strengths of UK universities[27]. UK universities are well connected to industry and they appear effective in IP processes, as well as spin-out formation. Table B shows that UK strengths are similar to those of Europe more widely. The main difference between UK and USA performance lies in the area of licensing to existing industries, which reflects points we made earlier on differences of absorptive capacity between USA and UK/Europe. (Japanese data, which we have not examined in detail, probably reflects the immaturity of their university system in doing technology transfer, as well as their very different industrial characteristics.)

International institutional comparisons

62. The 2014 MIT study identified leading-edge entrepreneurial universities in the opinion of global innovation experts. US universities, MIT and Stanford, were ranked at Numbers 1 and 2 in the world, but UK universities Cambridge, Imperial and Oxford followed in rankings. Technology transfer performance was a significant element in the judgements, but this was set in the context of a wider understanding of the university as a centre for entrepreneurship and as part of a broader innovation eco-system. An aspect of the university role is as a convenor of debates around research and its applications, which provides an important context to technology transfer. The MIT study highlighted particularly the importance of the inter-play between a university and its eco-system in effective technology transfer.

63. A study by Cambridge researchers[28] looked at institutional performance within the US (and UK) systems. US research expenditure is highly concentrated, with the top 10% of US universities in terms of research expenditure accounting for 38.65% of all university R&D. This top 10% of US universities account for a similar proportion of technology transfer performance. There are though much greater variations in technology transfer performance within this top 10%. Gross licence income performance ranges from $104M to $1M (£73.4M to £706K). The UK university system is much more concentrated than the US and shows similar trends in technology transfer. The top 10% of UK universities by research income account for 65% of total research income, and 61% of gross IPR income. The range within this top 10% is from £42.99M IPR income to £178K.[29] (We note that US universities are larger in terms of both total income and research income than those in the UK[30].)

Comparisons between UK universities in technology transfer performance

64. Do we have reliable systems to make comparisons between UK universities in technology transfer performance?

65. IP Pragmatics in their report to HEFCE for the KE framework suggest three indicators for the purposes of benchmarking technology transfer:
- Numbers of disclosures normalised by research income (as a process not a performance indicator).
- Licensing income per research income.
- Number of active spin-outs per full-time equivalent (FTE) academic.

66. IP Pragmatics stress that significant work is needed to ensure that any indicators make fair comparisons, comparing like with like. HEFCE is testing initial indicators to check that these are meaningful and appropriately normalised and presented (such as in cluster/benchmarking groups of universities with similar characteristics). Fair comparisons need to take into account objective factors (which feature in differential policies of different countries and institutions) that affect metrics.

67. HEFCE will be taking forward IP Pragmatics' recommendations to produce initial indicators in a discussion document in Autumn 2016. It is important to stress that we do not think these indicators are informative outside of a cluster-based approach that compares universities with similar profiles. Hence we do not present or analyse actual data in this report. We cannot of course assume that all UK universities are uniformly performing well in technology transfer. This is unlikely here, just as it is unlikely in America or in any other country. So benchmarking, if done in a sophisticated way, may help. We discuss in Paragraphs 31-34 the strength of the UK technology transfer community as a mechanism to raise standards overall.

Other comparisons and benchmarks

68. There is expert literature which draws comparisons between the success of university spin-outs and other sectors, for example with private sector companies spinning out subsidiaries[31]. However, universities and corporates spin-out different types of technologies, with universities focussed on more radical and disruptive technologies that may transform markets, and corporates not spinning out until a given technology has taken off commercially. Both university spin-outs and corporate spin-outs seem to be successful, but in different ways; and both benefit from their parent organisations, but in different ways. These comparisons may be helpful to develop shared understanding between universities and industry, but do not tell us anything about success within university technology transfer practice.

Trends over time in UK technology transfer performance

69. We have also looked at UK university performance over time – have we improved or not in technology transfer? A time-series of data relevant to technology transfer from the HE-BCI survey is presented in Table C.

Table C Trends in UK technology transfer

£000s Real Terms All UK	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
License Income	39,412	44,625	50,068	47,202	51,789	62,713	62,589	64,850	71,459	76,478	82,058
Sale of spin-offs	9,278	25,796	19,540	21,145	23,666	75,377	27,936	8,410	10,814	11,877	49,059
Total	**48,690**	**70,421**	**69,608**	**68,347**	**75,455**	**138,090**	**90,525**	**73,260**	**82,273**	**88,355**	**131,117**
Specialist IP Costs	*18,975*	*19,278*	*20,309*	*24,101*	*23,911*	*30,864*	*31,793*	*33,078*	*32,905*	*34,564*	*34,177*
Patent applications	1,308	1,648	1,536	1,913	1,898	2,097	2,012	2,256	2,274	1,942	2,086
Patents granted	463	711	577	647	590	653	827	757	826	955	976
Formal spin-offs established	167	148	187	226	219	191	273	268	191	150	147
Formal spin-offs still active after three years	688	661	746	844	923	982	969	999	998	975	970

70. Rapid increases in technology transfer indicators in the early years of HE-BCI data collection probably reflect improved reporting, and support given by the Science Budget for technology audits to appraise backlogs of potentially exploitable IP.

71. Since 2008, technology transfer performance has been more variable. In some part this reflects global economic conditions. The OECD has noted that the annual growth rate in patent applications by universities around the world fell from 11.8% to 1.3% between 2006 and 2010[32].

72. We can also anticipate that performance has varied because UK policy-makers and the UK university system have developed policies for KE that are more appropriate to our market conditions[33]. Overall, KE income as measured in the HE-BCI survey has risen to £4bn. This is in line with UK policy to pursue a wide range of routes to impact, to exploit a range of technologies, raise absorptive capacity and develop eco-systems.

73. Evidence that different universities are playing to different KE strengths include:

- Trends in HE-BCI metrics, analyses of HEIF strategies and evaluations of HEIF and KE performance.
- A recent study on the availability of proof of concept funding in the UK[34], which noted that many universities were now not doing technology transfer in favour of investing in other forms of KE which suited their strengths, while universities that specialise in technology transfer have become more successful, for example in gaining follow-on funding, including from private sector sources.
- Evidence from the 2016 NCUB academic survey[35] showing changes in the levels of use of different KE mechanisms by academics, which may be reflective of increased differentiation in institutional strengths.

74. The UK Government and funders have taken increased interest in leveraging in research funding from a range of sources in order to build critical mass and improve KE. One such example is the UK Research Partnership Investment Fund. It is likely that universities will assign rights to exploit IP rights to partners in shared investments, leaving less unassigned IP that needs to be exploited through technology transfer processes. Hence the direction of UK Government policy on research is also likely to lead to reductions in levels of narrowly defined technology transfer activity in future, in the interest of improvement in research capacity and exploitation of various other impact routes.

75. Tracking IP that is exploited through joint research activities of various sorts will therefore become increasingly more important to universities, to advance the impact agenda, than focussing on IP exploited through technology transfer.

Conclusions

76. We draw the following conclusions from our examination of extensive evidence on UK technology transfer in the context of international comparisons:

- The UK university system appears to operate at world-class standards of practice, with other countries looking to the UK, as this country looks to others (with USA having longest history). We cannot assume our universities are of uniform standard (indeed uniformity does not exist in any country), but there is considerable strength in the UK system in terms of availability of good practice and a strong professional practice community, with overseas links.
- There are experiments in shared-services provision of technology transfer overseas, though often as part of a trajectory towards more institutionally differentiated approaches.
- Specific technology transfer policies adopted in any country or by individual universities are shaped by internal (institutional) and external (demand) factors – absorptive capacity, maturity of systems, technology sector specialisation, eco-systems development. There are no one-size-fits-all policies that are appropriate to every individual country or individual university.
- For the UK, there is relatively little evidence on variations in technology transfer in different discipline/technology sectors, and on eco-systems/spatial developments, which could inform effective policies. There is also relatively little good practice information on academic entrepreneurship.
- Subject to caveats on specific policies varying (which will affect intended and achieved outcomes and impacts), the UK university system compares well at national, aggregate level in comparisons of performance of various sorts. There are also examples of strong individual institutional players in the UK university system, who compare well with counterparts overseas.
- UK universities have increased their KE activity over time, but technology transfer has not grown as fast as other routes to impact. This is appropriate to characteristics of the UK economy and differentiation in university KE contributions, and hence features in UK KE policy. Technology transfer activity in the UK is fairly concentrated in a small number of universities.

77. All evidence suggests then that the UK university system is competitive in technology transfer. At the very least, the UK shares similar problems of technology transfer with other leading university systems round the globe[36].

78. In our recommendations, we have therefore focussed not on solving a problem, but on seizing an opportunity.

<u>Methodological endnote</u>

79. International comparisons of KE metrics are very difficult because different countries use different terminologies[37]. Definitions of technology transfer metrics are more common across countries, making comparisons apparently easier.

80. No country has found an approach to isolate specific drivers of performance in technology transfer. One challenge is the extreme skewing in any measurable outcomes of success in technology transfer. Stanford University, for example, noted that only three out of 10,000 technologies that it has licensed over 30 years have delivered significant revenues. A recent feature from Columbia University technology transfer experts[38] noted that approximately 0.5% of all currently active USA university licences generates over $1M per year. The second challenge is the myriad of factors that may influence success. This can affect not just comparisons between universities, but also country-wide comparisons. A study for NESTA (a UK charity focussed on innovation policy and practice) by the Manchester Institute of Innovation Research[39] of international policies and practices on IP noted that even country-wide evidence can be distorted by extreme skewing of technology transfer data. For example, in Australia, one university accounted for 66% of all IP income earned in 2001 and 2002, and in Europe, omitting two universities reduced income by 70%.

81. USA has had the longest history of examining performance, such as in the 2010 National Academies review. This review concluded that there were very striking differences between US universities on technology transfer metrics, but could come to no conclusions on causal factors.[40] The US Academies noted in particular that the most important output metrics to capture long-term value for society were not available. A 2014 study by MIT[41] came to a similar view that "additional metrics are required to shift the characterisation of a 'successful entrepreneurial university' away from those who have 'got lucky' with one or two successful research commercialisation 'blockbusters'. UK commentators[42] have come to similar conclusions that benchmarking technology transfer is very difficult. This is despite a vast literature in the UK and USA about technology transfer[43].

82. It seems unlikely then that metrics can ever be used to give a determinative view of good and bad technology transfer performance, and hence of the 'right' detailed technology transfer policies to adopt.

Conclusions and recommendations – how do we improve technology transfer?

Conclusions

83. We believe that we need to focus on three areas to achieve our potential in technology transfer, and put ourselves ahead of world standards:
- University leadership needs to very clearly articulate its commitment to delivery of impact, including how it supports effective technology transfer. This includes clear consideration of the governance challenges.
- We need better evidence and understanding amongst Government, funders and the university sector about how we can develop further our distinctive eco-

systems, including innovative approaches to finance, as well as on differential approaches to commercialisation needed in different technology/discipline sectors.
- We need to continue to appoint, develop and support academic and professional staff who are entrepreneurial and who recognize the benefits of technology transfer.

Leadership

84. Research Consulting's review of good practice materials for HEFCE highlighted that national policy reviews are often focussed particularly on government policy and technology transfer professional practice. The role of university leadership and senior management in technology transfer and wider KE is usually left out of these reviews. **The group's first conclusion is that university leadership plays a vital role in successful technology transfer – and this role is not well understood in policy reviews, and needs to be highlighted further.**

85. One of the most important decisions that needs to be made by university leadership is the extent to which technology transfer specifically is important to the university. Many universities will appropriately focus on other routes to impact, and may do no technology transfer at all. Government and funders must not drive universities to convergence, but support differentiation.

86. Success in technology transfer is most likely achieved by long-term commitment and sustained effort, which makes it important for university senior management to make a considered strategic judgement on its importance for the particular institution. A proper strategic decision based on insight on the institution's underlying technological and entrepreneurial capabilities should be a fairly enduring one. All funders should look for this type of long-term commitment in their appraisals of university approaches to KE. HEFCE should expect to see this in HEIF strategies. Research Councils should expect to see this in their KE schemes. Research charities should look for this kind of long-term institutional commitment, as should funders of entrepreneurship, such as the Royal Academy of Engineering and the Royal Society.

87. The consequence of rejecting one-size-fits-all approaches is that the leadership of each university that focusses on technology transfer has to decide on the overall strategic approach that suits its characteristics and context. Much of this will be operationalised through key staff (both academic and professional) and structures. It will also need to be monitored and incentivised through the setting of appropriate key performance indicators (KPIs), budgets, policies, procedures, rewards and recognition. Leadership is also responsible for encouraging an appropriate culture supportive of entrepreneurship, encouraging good working between academic and professional staffs and collaborative, innovative and reflective practice.

88. Policy circles outside of universities can become unduly focussed on structures. University structures in the UK, as with overseas counterparts, reflect practical matters like legal/regulatory issues, scale of the institution, research intensity, technology specialisms and the priority attached to technology transfer. We do not believe university structures should be a matter for national policy. The majority of UK universities[44] have some form of research and KE department responsible for all forms of commercialisation, with a few larger ones having several specialist offices. Many universities will establish one or more subsidiary companies, related to charitable status. Universities need to ensure that all units (such as technology transfer, research contracts and corporate/business partnerships units, centres of entrepreneurial learning, business schools, investment communities and incubators) work together to aligned goals, both to support the commercialisation process and the wider institutional entrepreneurial culture.

89. Universities have to make choices on the balance of impact and income they pursue in different forms of KE, reflecting their judgements on priorities, legal issues and likely scale of benefits and taking account of different timescales. Leadership choices will then inform detailed KPIs set for specific professional units. We believe that quantitative metrics in technology transfer are not sufficient, and KPIs should include qualitative indicators, such as levels of engagement and satisfaction of key stakeholders (including entrepreneurial faculty and funders), repeat business (such as with investors and industry) and evidence of impact (REF impact case studies). Members of our group noted that many university research and KE or technology transfer units already adopt qualitative, 360 degree and stakeholder reviews.

90. We have concluded that the UK university system operates at world-class standards of practice in technology transfer, and this is in part due to the contribution of university leadership, working with their academic and professional staffs. However, we believe that Government and funders need better assurance that university leaders are leading technology transfer. The Wellings Review, Intellectual Property and Research Benefits, conducted in 2008 for Government was the last enquiry that specifically looked at technology transfer and particularly focussed on the leadership dimension. **The main recommendation of our review, following Wellings, is that university leadership should be invited to submit a statement on their governance arrangements on IP, clarity of research commercialisation policies and practices and approaches to maximising benefits to society.**

91. Institutional leadership statements on research commercialisation might be implemented most easily as part of HEFCE's examination of institutional KE strategies that forms part of the HEIF allocations process. It would be important that this should not be presented in a way to give incentive to distort priorities of universities that specialise in other forms of KE. HEFCE has supported this group, but they are not the only funder interested in technology transfer. **We expect HEFCE to discuss with other funders the appropriate method to operationalise our recommendation.**

92. Such statements would have the advantage of ensuring clarity of purpose and approach within institutions as well as without. They may also be useful to investors and users as a means to communicate and increase understanding of the role of universities in technology transfer.

Governance

93. One of the reasons why leadership in technology transfer is important is that it raises governance challenges, related to the legal and regulatory frameworks to universities and the wide range of unusual risks involved (discussed further in the next section: End Note Paragraphs 126-129).

94. The 2008 Wellings Review recommended that universities should be asked to review governance arrangements for IP. Good governance of technology transfer requires a balanced understanding of the likely risks, and appropriate focus on accountability of the executive for strategy and delivery. Poor governance can lead to undue bureaucracy and complexity and delays in technology transfer operations.

95. The impact agenda is by no means unproblematic in relation to roles and responsibilities of university governors/charitable trustees. For example the issue of striking the right balance between income and impact is one on which governors need to have a clear view. **We believe that UUK, with support of HEFCE, would be best placed to discuss with the Leadership Foundation for Higher Education (LFHE) whether more could be done to support governors, leaders and managers to understand, interpret and execute appropriate approaches to balancing impact and income.**

Eco-systems

96. **The group's second major conclusion is that we should be aspirational in our approach to technology transfer, and seek to devise policies that put us ahead of the world.**

97. One of the most interesting areas of our review has been around developing understanding of the importance of **the inter-play of universities with their eco-systems as a critical feature in technology transfer policies.** National policy discussions in the UK on technology transfer have a tendency to dwell on minutiae of terms and conditions of licenses or company shares, for example, the equity stakes policies of Stanford and MIT. The interesting question is not **what** the equity shares are at any particular university, but **why** one university uses one approach over another. Our examination of the whys, suggests that this flows from the characteristics of the university, its technologies and eco-system. We benefitted from a joint paper[45] which Dr Katharine Ku of Stanford and Dr Lita Nelsen of MIT submitted to us to inform the review to understand the nature and importance of the eco-system:

“Through the decades of these spin-out activities, an ‘entrepreneurial eco-system’ has developed in the communities surrounding MIT and Stanford, making it far easier for entrepreneurially inclined researchers to find help in forming spin-outs. (The answer to the frequently asked question at MIT ‘Does the Institute have an incubator?’ is ‘Yes, it’s called the city of Cambridge.’)

“Each of the two regions now has dozens of early-stage venture capital companies investing in very early-stage technology-based companies, all hungry to find new opportunities. The investment partners are usually trained in the technology fields in which they invest, and are willing to help ‘put the company together’, rather than wait until a management team and business plan are presented to them. Law firms, accounting firms, business advisors, etc understand the needs of embryonic companies and are often willing to donate their time to them in the hopes of having them as paying clients when the companies mature. There are private ‘innovation centers’ willing to rent small amounts of space to beginning companies, for anywhere from a month to several years, providing shared facilities and an opportunity to mingle with other beginning companies. Some even rent fully equipped laboratory space. Finally, the various clusters of same-industry small companies (biotech, IT, clean tech, etc) grow within themselves the experienced small company managers who can serve as the CEOs of the next crop of spin-outs.”

“Are US university spin-out processes really better than those of UK universities?”

Lita Nelsen and Katharine Ku

98. If we are to provide assurance to Government that university leaders are leading effective technology transfer, then we need to raise awareness and understanding in university management, but also policy-makers and funders, of the critical importance of, and dimensions to, eco-system development.

99. Appreciation of the university's eco-system is vital to university leadership of technology transfer in two ways. First, it informs decisions on the approach, including resources, the institution might devote to eco-system development, working with other partners. Second, it informs decisions on institutional policies for support and reward of entrepreneurial staff. The desirable outcome of eco-system development is that the university need do very little, and entrepreneurialism will flourish naturally through engaged academics and investors and the like. But the lesson of Stanford and MIT is that this is only achieved after many, many years of hard work from both the university and its eco-system partners.

100. Our group looked at one example of eco-system development at Imperial College: we benefitted from the Imperial West/White City Cluster Report. The development of Silicon Valley has been attempted in many other countries and has generally failed,

reflecting the high level of distinctiveness and path dependency in cluster development. The Imperial College analysis though highlighted that there is a great range of different types of eco-system developments, and purposeful activities of key participants – Government, corporates or universities – can make a difference.

101. As well as relevance to technology transfer performance, the issue of eco-system development is important to a range of UK Government policy interests, including rebalancing the economy, productivity, devolution and university-business collaborations. The UK has taken an interest in innovation systems theory and practice, including at national and regional/local levels, and in technological and industrial sectoral approaches. The Department for Business, Innovation & Skills (BIS)'s work on Science and Innovation Audits[46] is relevant here. Compared to the USA, and increasingly Europe, the UK has taken less interest in spatial approaches to entrepreneurship, particularly technological entrepreneurship. There are a range of different factors that must come together in successful entrepreneurial eco-system development, including:

- Research/knowledge producing high-quality new ideas.
- The availability of absorptive capacity, talent and skills (technical and management) to work on these ideas and successfully deploy them in the marketplace.
- Availability of funding and space for proof-of-concept and incubation to test practical application.
- Access to venture funding (which may often be localised) and a risk-tolerant culture.
- Access to, and relationships with, markets with vanguard users for rapid growth.
- Opportunities for exits through initial public offering or acquisition by large technology companies.
- An entrepreneurial culture including role models and mentors.
- Availability of professional support services (such as legal or business support) specialising in early-stage venture and technology commercialisation.
- Availability of, and access to, the necessary complementary assets required for the full-scale development and deployment of the core technology.

102. While universities have a role of increasing importance in innovation systems development, they play a particularly notable role in entrepreneurial eco-systems.

103. A critical partnership in technology transfer is with investors of various sorts. The UK is generally regarded as having a weak investment base for innovation and technology[47] that affects business R&D, technology start-ups and scale-ups, and not just universities. An interesting feature of the shared-services models being explored in continental Europe (Annex D) is the focus on providing proof-of-concept funding through these vehicles, and linking to wider sources of investment capital, such as through regional banks.

104. In the absence of Silicon Valley/Kendall Square type eco-systems presently, UK universities have been pro-active in nurturing a wider and more diverse base of

investors, reflected in the 'patient capital' movement as one example (described in a briefing document published by HEFCE http://www.hefce.ac.uk/media/HEFCE,2014/Content/Knowledge,exchange,subjects,and,skills/Good,practice/Patient_Capital_A_new_way_of_funding_UK_Science.pdf. Investors have also proposed innovative models such as 'golden share'[48].

105. We have learnt a lot from American university experts about their eco-systems, and we outline in Annex D many experiments that are taking place in other countries. However, we need to develop our own UK-centric models, including different approaches in different parts of the UK with different eco-system characteristics. Some universities have started on this journey, but there would be considerable value in better evidence for the university sector as a whole. **As a starting place, HEFCE and other national agencies should support development of an improved evidence base on: universities and eco-systems; the different types of university contributions to eco-systems; and the types of innovative approaches, such as patient capital, that can be particularly formative.** We hope this is a topic that could be pursued particularly in the future in the new body to be established, UKRI, working with the OfS – the latter having a critical role in the country's absorptive capacity and shared responsibility with UKRI for KE.

106. **Additional investment by Government in pilots on eco-system development, including novel approaches to technology financing, could deliver considerable value.** This might be an early opportunity to cement joint working between UKRI and the OfS. Collaboration between universities is valuable in pilots as a means to share learning. It is vitally important that pilots are evaluated and results fed into wider learning.

107. Better evidence would support university leaders in making fine-grained decisions on their appropriate technology transfer and entrepreneurship policies. Evidence would help policy-makers and funders judge whether individual universities are adopting sophisticated policies that will achieve appropriate impacts from academic entrepreneurship and technology transfer. It could also help deliver greater impact from collective technology transfer endeavours through more joined-up policy across a range of relevant areas.

Other forms of collaboration

108. Although we have focussed primarily on spatial systems developments, we believe that developing links with non-university bodies focussed on particular technology sectors also clearly has benefit. One example given by our membership was NHS Innovation Hubs. Some of these have now closed where they duplicated technology transfer capacity of other players (including universities), but some have developed unique NHS specialisms that add value to others, which have made them embedded in systems. Another is the Catapult network. It is important that collaborations do add value, rather than duplicate and/or add burden (given that universities are multi-disciplinary and will need to interface with many different networks).

109. We believe it would be useful for **HEFCE to continue to collect evidence as part of its HEIF strategies process on English universities' adoption of collaborative practices, comparing these with approaches overseas. HEFCE should also seek evidence that shared-services approaches in other countries actually do deliver increased benefits commensurate to public inputs, and adopt insights in future policy.**

Staff development, reward and recognition

110. University leadership can never succeed without the support and success of our staff, academic and professional. And this is particularly true in technology transfer where we are highly dependent on the entrepreneurial enthusiasm of academics and students, and the technical expertise of our professional staffs**. Our third important conclusion is that there is much good work within universities and across the sector in staff development in technology transfer, and this needs to be continued.**

Academics and students

111. For many academics, particularly in applied disciplines, engagement and impact are part of core scholarship, and others recognise the important synergies between KE and research and teaching practice. Technology transfer can be a source of new research ideas, provides opportunities for experiential learning, and is often great fun. Greater attention by funders and policy-makers to impact has improved the climate for this wider range of scholarship, and universities are continuing to identify ways to improve incentives and support for impact contributions.

112. Universities have to establish policies for academic entrepreneurship that work for the academic body as a whole, reflecting that there are multiple academic priorities and different disciplines/researchers will pursue different routes to impact. This will include policies on equity stakes taken in spin-outs, as well as policies on how returns from royalties and equity may be shared between academics, departments and the universities (and returns claimed by any research funders). Policies may also include the university taking equity in lieu of other services and support for spinning out, or making other arrangements to help company formation, student, graduate and academic entrepreneurship and the like.

113. Universities will vary significantly in these policies due to differences in:

- The priority placed on entrepreneurship in impact routes
- Resources and maturity of technology transfer professional capacity
- Discipline/technology sector mix
- Eco-system – places and partners.

Universities that excel in this area but already have very developed eco-systems (MIT and Stanford) may have few formal policies to support entrepreneurship. Other universities may do little because this form of exploitation is not suitable for their discipline/technology strengths. Standardisation of any sort is implausible, and **this is a matter of university leadership and strategy, which should be captured in the institutional statements we propose and improved by the evidence enhancement we propose on eco-systems.**

114. University policies on how they reward academic-inventors (their employees) will be agreed formally with the academic body in various ways, and hence should be available within the university as part of good human resource management. The charge is sometimes made that universities lack consistency and transparency in their policies on spin-outs. However, flexibility in policies may be good human resource management, with individual members of staff expecting a good employer to be sensitive to particular circumstances or conditions. Particular funders or investors may also require variations in university policies to meet their priorities.

115. One aspect to entrepreneurship is mentoring support for academic and student entrepreneurs, which universities secure in a range of ways – through the technology transfer unit, with their business school, with local entrepreneurs/eco-system, with alumni, with other universities, and through specific national and local schemes. Universities use a great range of resources to support staff and student entrepreneurship, from HEIF (over £30M over 2011-2015[49]), Research Councils, learned societies, regional and European funding and donor/alumni contributions. Managing conflicts of interest in mentoring, particularly in relation to students, is important, and we welcome the lead taken by the Royal Academy of Engineering in this area, which should be adopted more broadly, including in internal university schemes.

116. Research Consulting note that there is relatively little good practice material relevant to linkages of academic entrepreneurship and technology transfer practice. We welcome that HEFCE/universities are considering further deep-dive investigation of the enterprise/entrepreneurship dimension to the KE framework. **We task HEFCE with working with universities to develop a mechanism for recognition of university performance in supporting entrepreneurs, especially at earlier stages of their career.** Subject to available data, this might be suitable for an indicator in the KE framework benchmarking set. HEFCE should sound out the interest of other funders in this development.

Technology transfer professionals/practitioners

117. We noted previously in this report the availability in the UK of high-quality materials for technology transfer practice from UKIPO and PraxisUnico. PraxisUnico’s extensive training programme was originally developed in conjunction with leading-edge US experts, and has been praised in a number of independent reviews[50]. Universities also speak highly of UKIPO support.

118. On top of formal resources, networking is valuable to develop soft skills and a common understanding of what ‘good’ looks like using qualitative insights, as well as

metrics. The annual PraxisUnico conference is an important event for networking, **and policy-makers and funders could do more to promote the event as a must-attend for all practitioners. It would be valuable if the PraxisUnico annual event could be developed along the lines of AUTM in the USA, drawing in more overseas and private sector practitioners.** Funders might do more to help the profile of this event. The links between professional practitioners in the UK and the USA has been very valuable to this review, and **we recommend that these links are continued, either through system-wide links (PraxisUnico and AUTM) or through relationships between individual universities on either side of the Atlantic.**

119. There is a **strong community of practice in university technology transfer, and this community might do more to help less experienced or smaller scale technology transfer units to develop appropriately.** This might take the form of a pool of specialised mentors from whom smaller technology transfer units might gain advice. It could take the form of reflective practice reviews whereby a set of technology transfer professional peers work with a particular technology transfer unit to give feedback. Technology transfer office/unit reviews, which are good practice in the USA, can have developmental effects both ways. This might build upon approaches being explored across Europe[51].

120. **We propose that universities, through PraxisUnico (with the support of UUK), should explore whether sector differentiated technology transfer practice could be developed further, working with national agencies – the learned societies, Research Councils and Innovate UK – with expertise in sectors/disciplines.**

121. We have stressed throughout this report the importance of continuing innovative, reflective and evaluative practice. **Funders can and should support practitioner bodies in these behaviours, and the development of the KE framework provides an opportunity for this.** For example, we understand that US universities through AUTM are exploring publication of anonymised deal information to increase transparency in technology transfer, and sector-differentiated practice. This may be useful in UK and PraxisUnico should be supported to explore this.

Recommendations and next steps

122. Our first main recommendation is that university leadership should be asked to submit a statement on research commercialisation to funders to demonstrate how we lead technology transfer. There is a burden in doing this, though we think it is worthwhile as a means to allay any concerns about our commitment to the impact agenda. Universities will anyway want to engage with these critical agendas going into the new arrangements for UKRI and the OfS. **As a next step on this recommendation, we propose that UUK should be consulted on the issue of burden, format and approach to this recommendation. HEFCE should also**

consult other relevant funders to determine their support for this recommendation.

123. We also propose that **UUK should be asked to discuss with the LFHE how to support governors, leaders and managers in the impact agenda broadly.**

124. Second, we propose concerted efforts to improve evidence about the inter-play of universities with the development of their entrepreneurial eco-systems, including innovative finance models. We believe that funding for pilots could be valuable, if combined with appropriate evaluative and shared-learning approaches. This could be relevant to joint working between UKRI and OfS in future. Short of funding projects, national agencies could do more together to invest in research, evaluation and networking to support improved evidence and understanding of these topics. This should include support and development to policy-makers and funders to help them adopt appropriate approaches to policy development, building on evaluative evidence, including from overseas. Evidence helps to examine the policies of universities like MIT and Stanford in an informed way, and hence to draw appropriate lessons for the UK. It should include evidence and insight that engages university leadership, as well as academic communities and professional practitioners. As a next step, **we task HEFCE to discuss with other national agencies shared interests in advancing this agenda.**

125. Third, we propose that we need to continue our current approaches to development and support of our academics, students and professional staff in technology transfer and entrepreneurialism. **Some of this will be taken forward anyway through HEFCE's/universities' work on the KE framework programme, including potential benchmarking of support to academic entrepreneurs. University bodies led by PraxisUnico should be asked to explore with learned societies and other national agencies with sector/discipline insights how sector-differentiated good practice might be developed further. We ask that HEFCE draw the attention of wider funders and stakeholders to our recommendations, to sound out their interest and support.**

End note – why technology transfer will always be the subject of vigorous debate

126. Comparing our review with that of the US National Academies in 2010[52], virtually every issue, complaint and challenge that we encountered in this review was also a problem in the US system – and has been a continuing subjects for debate since Bayh Dole in 1980. There was one area of divergence: we are more comfortable in the UK with the role of universities in impact, and see commercialisation – jobs and growth – as an inevitable part of our societal contribution. UK universities are more phlegmatic about handling inevitable conflicts of interest.

127. The 2014 MIT study of entrepreneurial universities concluded that technology transfer is intrinsically a challenging area, at the point of maximum tension between grass roots activism of faculty entrepreneurship and the university-led mission to drive institutional contributions to innovation. The US National Academies[53] concluded "These critics of the status quo recognise and articulate an often overlooked truth – not everyone involved in the technology transfer process has the same goals ... making success difficult to achieve". The UK Intellectual Asset Management guide[54] similarly concluded that the "potential for conflict in the IP landscape is large".

128. We reflected in our group on the many different participants in the technology transfer process, and their differing perspectives:

- University governing bodies: Governors/charitable trustees may bring a new and helpful perspective to technology transfer, for example if they have industry experience. However, governors may also see significant potential risks from technology transfer, and also few benefits for the core purposes of the charity. The upshot may be to seek increased controls in order to address risks more effectively. This can lead to constriction on the entrepreneurial culture of the university, increased costs of bureaucracy without any likely commensurate increase in benefit, and a slower overall exploitation process. At one extreme, success may be regarded as doing no technology transfer at all. Finance directors or university legal advisers could take a similar view. On the other hand, governing bodies could have members who are highly entrepreneurial and may believe that their university could and should make more significant amounts of money from IP exploitation and spin-out companies.

- Universities/senior management: Supportive leadership and management will make technology transfer more attractive and efficient. Academics interested in technology transfer feel more supported overall to pursue entrepreneurship (such as through workload management), and see the central administration, including technology transfer professional staff, as furthering their individual motivations. However, because technology transfer costs and returns are highly skewed, most decisions will be contentious - either for the academic-inventor who feels they should gain significantly from the return on their invention, or for the wider academic body, most of whom will never be involved in technology transfer and hence do not see any reason to subsidise technology transfer operations. Hence it is unlikely that senior management will have the unqualified support of the entire academic body for any technology transfer decision. University management will often not know what 'good' looks like in technology transfer due to its technical complexity. Senior management will be highly reliant on the competence of their technology transfer professional staff to manage a range of unusual, erratic and potentially contentious risks. Success may be avoiding major complaints, navigating out of major resource disputes or risk issues, and having a few examples of apparent success to promote the university. Impact case studies from the REF may be particularly valuable for senior management in understanding the long-term benefits of the successful technology transfer their institution undertakes.

- Academics: Academics are motivated to further their research, teaching and discipline more broadly including in many cases pursuing the desire to commercialise the outcomes of their work. In some cases academics may be specifically motivated by personal financial gain and may have a specific, although not necessarily accurate, view of the value of the IP. Most academics will generally see the point of university-wide policies that reflect that university assets, costs and returns must be shared across all academics and departments. However, this will be harder to accept in the case of a perceived or real technology transfer 'blockbuster' where the academic may understandably feel that they should gain disproportionate benefit. Academics who want to be entrepreneurs will be driven by passion and extreme enthusiasm. They may see the university as their employer as a constraint in a range of ways, including rationing time through workload planning, rationing access to resources and support and intruding in relation to burdensome (if necessary) due diligence. They may therefore be wary of central administration, and may not believe intrinsically that the university technology transfer unit, even if trying to be helpful, is on their side. It may therefore be seen to be desirable to avoid university intrusion and policies by exploiting any personal links they can find.

- Early career researchers and students: These may have similar motivations to academics, but with an additional strong imperative, to find ways to make a career for themselves longer term from their entrepreneurship.

- Investors: Investing in early-stage technology is a risky activity and hence investors understandably will want to reduce their risk as much possible, while increasing their likely returns. The academic-inventor may be an important component in the value of the investment, and the investor will wish to engage and excite the academic-inventor in the commercial possibilities (real or otherwise) from exploitation. The university may be less important to the investor, and is likely to be perceived as a constraint, though this will depend on whether there is a long-term relationship with the institution. Success is matching risk and reward from the investor's perspective.

- Technology transfer staff: The challenge for technology transfer professionals is that as the experts on the technical details, they are likely to have to manage all the tensions above. Technology transfer staff are the sources of support for university management in managing risks of various sorts and setting university-wide policies. They need to both support academic and student entrepreneurs, and also act as the face of the university – rationing resources, turning down academics/students eager to commercialise ideas they believe in, and managing risks. Technology transfer units will need to make careful judgements on which exploitation routes are most likely to deliver impact, and to negotiate with academics, investors and funders, and advise senior management accordingly.

Most technology transfer units are likely to turn down the majority of inventions presented to them by academics due to pressures on resources. Success across all dimensions may be unattainable. Technology transfer units provide an essential professional service in universities to manage many technical features without which universities could not operate effectively and securely. However, the odds are stacked against technology transfer staff being popular.

129. Our review aims to put the UK ahead of the best in the world in technology transfer. Even if we succeed, debate and challenge will not go away. If anything debate and challenge may increase. This is the nature of entrepreneurialism.

Annex A: McMillan review of good practice in technology transfer: membership and terms of reference

Professor Trevor McMillan, Vice-Chancellor, Keele University (Chair)
Alan Aubrey, Chief Executive Officer, IP Group plc
Professor Steve Beaumont, Vice Principal Emeritus, Glasgow University (suggested by Royal Academy of Engineering)
Dr Dave Bembo, Deputy Director and Head of Research Development, Research and Innovation Services, Cardiff University
Tomas Coates-Ulrichsen, Research Fellow, Centre for Science, Technology and Innovation (CSTI), Cambridge University
Professor David Gann, Vice-Provost (Development and Innovation), Imperial College
Dr Sarah Jackson, Director of Research, Partnerships and Innovation, Liverpool University
Dr Angela Miller, Senior Business Consultant, Wellcome Trust (previously St Georges Medical School)
Dr Sue O'Hare, PraxisUnico, ex-Chair (previously City and London Metropolitan universities)
Dr Tony Raven, Chief Executive, Cambridge Enterprise, University of Cambridge
Professor Tom Stephenson, Pro-Vice-Chancellor Research and Innovation, Cranfield University
David Sweeney, HEFCE Director (Research, Education and Knowledge Exchange)
Dr Joanne Whittaker, Head of Intellectual Property Commercialisation, Loughborough University
Greg Wade, Higher Education Policy Adviser, Universities UK (observer)
Alice Frost and Rachel Tyrrell, HEFCE (secretaries)

a) To consider UK/England performance in technology transfer, against international comparisons and across the UK sector. Are there specific challenges or opportunities in university technology transfer in this country that require greater attention to be paid to driving up performance, and to continuous improvement/efficiency and effectiveness?

b) To describe which university strategies, policies, procedures and functions contribute significantly to technology transfer performance; and to consider whether there are any key issues that need to be addressed to achieve performance improvement. The group is asked particularly to consider the effective handling of spin-out companies, with focus on handling academic (and student)-university equity shares.

c) To consider the current state of good practice in university technology transfer.

d) To report to HEFCE with conclusions on the above and recommendations on what more could and should be done, particularly related to development of the KE framework. The main focus for conclusions and recommendations will be to HEFCE and to universities themselves/Universities UK, but the group may wish to set these in the context of wider conclusions for a greater range of stakeholders.

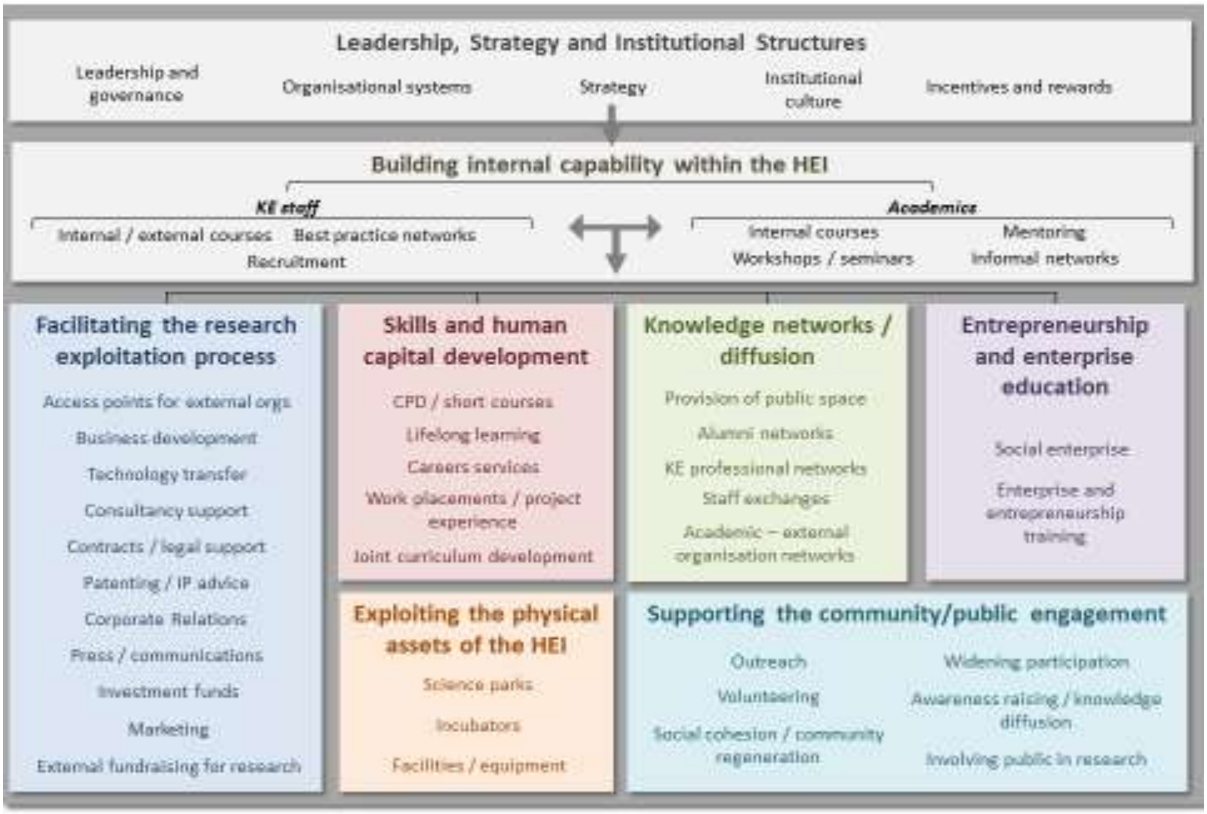
Annex B: Description of the KE framework programme

1. The Government tasked HEFCE in the 2014 Science and Innovation Strategy, in subsequent HEFCE grant letters, and most recently in the HE White Paper 'Success as a Knowledge Economy: teaching excellence, social mobility and student choice'[55], to devise a KE performance framework:

   "Government protection of research funding has helped HEFCE to maintain Higher Education Innovation Funding (HEIF) which underpins knowledge exchange and tech transfer capabilities. HEFCE is continuing to develop and implement a framework to benchmark KE performance across the HE sector, encouraging the sharing of innovation and entrepreneurial expertise, and supporting the professionalization of knowledge exchange skills." (Success as a Knowledge Economy, BIS, May 2016)

2. HEFCE's work on the framework is informed by past evaluations of HEIF and research studies on KE from PACEC consultants and Cambridge University's Centre for Business Research (CBR)[56]. Diagram AA illustrates the high-level schematic for KE capacity/capabilities developed by PACEC/CBR, which has informed policy and funding data collection for HEIF since.

Diagram AA Institutional competence/capacity framework



T Coates-Ulrichsen, Centre for Science, Technology and Innovation, University of Cambridge

3. Diagram AA reflects that there are many different routes to impact, and different infrastructure units are needed to support different types of KE. Different types of KE need different mixes of academic, institutional and professional capability and capacity – technology transfer and public engagement will be done differently to be done well.

4. Unlike teaching and research, KE involves both economic and non-economic activities, as defined by the EC under State aid legislation. This means that public funding presently may not be used to support some forms of KE, or can only be so used in line with State aid regulations. In the latest Research and Development and Innovation (R&D&I) Framework (effective from 1 July 2014), the EC clarifies that knowledge transfer capacity and development of capabilities within the university are non-economic activities and hence can be supported through public funds. This fits with the HEFCE policy approach to KE, with HEIF supporting the capacity/infrastructure elements (such as technology transfer or corporate/business partnerships units) and the development of capabilities in leadership and management and academics, and not subsidising KE that should be paid for by users.

5. The KE framework aims to support universities in higher performance in all the forms of KE that they choose to do. It aims to support a culture of continuous improvement in universities, to help universities achieve greater efficiency and effectiveness and improve quality and standards across the sector. The framework should also help explain the wide scope of KE, and inter-connections between different types of KE, but also highlight the specialist knowledge, skills and competencies needed to do different types of KE well. In technology transfer, as an example, there is an international scheme for Registered Technology Transfer Professional (RTTP) designation, which recognizes the accomplishments, roles, skills, knowledge, and deal-making expertise of technology transfer professionals. There are less formalised approaches in other areas of KE professional practice.

6. The KE framework is not intended to incentivise all HEIs to do all forms of KE. Indeed, the KE framework should help an institution to identify the KE areas which are its priorities (due to its mission, partnerships and underlying research/technology and teaching capabilities), and to determine whether it has strength in these. This may help develop KE institutional strategy through informing decisions on where to focus resources, as well as helping develop KE professional practice.

7. HEFCE commissioned two studies to inform development of the framework. Reports from Research Consulting on common and transferable good practice materials and IP Pragmatics on performance indicators/benchmarking are to be published in September 2016. HEFCE will set out next steps on the framework in the autumn, and will take forward the work with HE sector bodies.

Annex C: History and overview of legal and other arrangements for ownership and exploitation of IP in universities

1. The 2014 UKIPO/Government/funders/universities' 'Intellectual Asset Management for Universities' guide outlined that 'knowledge' underpins most university activities, including teaching, research and KE. Universities should take a broad approach to understanding and managing the knowledge they hold – their intellectual assets. Intellectual assets may include exploitation of existing IP (technology transfer), IP developed in research projects and collaborations (and course materials) and softer know-how, such as in consultancies or unpaid advice.

2. Universities need to manage their intellectual assets in order to deliver their core activities, as well as to exploit these for societal and economic benefit. Universities need to retain rights that enable them to teach and to continue avenues of research. Formal approaches to IP sit within wider KE policies/strategies, and then wider university mission and strategy encompassing research, teaching and KE.

3. This review focusses narrowly on technology transfer. However, policy on technology transfer, and on wider research commercialisation, needs to be understood in the context of issues overall in ownership and management of university IP, discussed further in this Annex.

<u>History</u>

4. Until 1987, IP arising from publicly funded research was owned by the Government and exploited through a national monopoly body, the National Economic Development Council, which became the British Technology Group (BTG) as a private body in 1992. BTG was concerned primarily with exploitation of existing IP through technology transfer. This was similar to the USA, where government departments owned IP in work funded in universities or small and medium sized enterprises (SMEs) until the 1980 Bayh Dole Act; and departments either exploited IP through their own arrangements or gave universities (or SMEs) a wide and diverse range of licences to exploit.

5. The decision by the Conservative Prime Minister in 1987, Margaret Thatcher, to hand IP over to universities was motivated by a view that universities and entrepreneurs should be brought closer together. (Thatcher also took an interest in encouraging venture capital through the tax system.) Both the USA and the UK took the view that centralisation of IP through government ownership was overly complex and unwieldy, with universities, academics and partners nearer the ground being much more likely to exploit the full potential of the knowledge base. UK universities were required to

put in place (through research grant terms of the Research Councils) exploitation arrangements, as a condition of the transfer of IP ownership.

6. The Bayh Dole Act sets out some terms and conditions on exploitation of IP by US universities. This includes requirements on use of revenues: that revenue should cover the costs of exploitation, returns to inventors, and contributions back to teaching and research. It also asks universities to consider, particularly, exploitation that benefits the American economy, and SMEs. It also provides for ‘step in’ rights for government departments if they feel that universities are not being effective in exploitation. Universities have responsibilities to monitor that terms and conditions of Bayh Dole are met.

7. UK universities have then had over 30 years of experience of managing their own research commercialisation. There have not been steps by Government or public funders related to technology transfer since 1987 of the order of magnitude of the end of the BTG monopoly. However, government policy related to the wider agendas of seeking greater impacts from research, and teaching, has continued to develop, which has also provided positive support for technology transfer.

8. The 1992 White Paper ‘Realising our Potential’[57] set out the importance of policy reflecting a non-linear model of exploitation, with iterative engagement between academe and business/users. HEFCE initiated its third stream of funding for KE, which included support of technology transfer, in 1999. There were a number of major steps by HM Treasury and the Science Budget to develop commercialisation further in the early 2000s. This included support for HEIF, building on the HEFCE third stream approach, as well as some pump-priming for proof of concept through the University Challenge Seed Fund and entrepreneurship through the Science Enterprise Challenge Fund.

9. Science Budget policy from 2000 also included government support to improve the quality of university technology transfer practice through grants to support a training programme from Praxis and a community of practice through Unico (and support for the wider KE professional community through the Association for University Research and Industry Links (AURIL)). The Government’s support for engagement between Cambridge and MIT through the Cambridge MIT Institute (CMI) helped enable development of training and practice in this country to be informed by US leading-edge expertise. Dr Lita Nelsen, Head of MIT’s Technology Licensing Office, was a founder of the Praxis training programme alongside Dr David Secher. Praxis and Unico merged as PraxisUnico in 2009 in order to better support and develop the professional community. PraxisUnico is a founding member of the global alliance of technology/knowledge transfer professional bodies, Alliance of Technology Transfer Professionals (ATTP) which drives global, professional standards. The university sector itself has made developments initiated by Government sustainable, and developed these further.

Current IP policies/positions of UK funders

10. The UK Research Councils (RCUK) emphasise the importance of focussing on all intellectual assets flowing from research, and not solely IP rights, given that softer modes of IP exploitation, such as know-how, can have greater impact. The Research Councils also fund a wider set of organisations than universities.

11. RCUK have a policy, ‘Impact through knowledge exchange: RCUK position and expectations’ (http://www.rcuk.ac.uk/documents/innovation/keposition-pdf/), which recognises that in most cases ownership of IP, and responsibility for its application, rests with the organisation generating those intellectual assets. The Research Councils also set out exploitation conditions in ‘Terms and Conditions of Research Council fEC Grants’ http://www.rcuk.ac.uk/documents/documents/TermsandConditionsofResearchCouncilfECGrants-pdf/.

12. RCUK policies set out the expectation that universities (or other research organisations in receipt of funding) will identify and manage appropriately all the intellectual assets associated with research activity. Universities should have in place a strategy for KE relevant to the institution’s mission, areas of research and user communities. The main purpose of intellectual asset management should be to deliver the most benefit to society and the economy. The RCUK statement recognises a wide range of different KE mechanisms/routes to impact, including free dissemination/publication. The Research Councils may on occasion exercise rights over IP which will be set out in additional conditions; they expect collaboration arrangements to be put in place to handle intellectual assets in joint work; and they expect appropriate reward policies for researchers. The statement does not make explicit reference to how KE should be funded, but sets out a commitment for Research Councils to work together to provide accessible and appropriate KE mechanisms.

13. HEFCE has no policies on IP, as HEFCE research funding may be used in conjunction with that of other funders, and hence different IP terms related to funding streams in the same project would impede exploitation. HEFCE also recognises that IP management usually incurs a cost and returns are very uncertain and hence does not burden universities overly with monitoring IP. HEFCE requires a KE strategy from universities in receipt of HEIF funding, and assesses these as being fit for the purpose of funding. The REF also takes account of approaches taken by universities to supporting and furthering impact, through the impact template element to REF.

14. Other research funders, such as research charities, usually confer ownership of IP on universities (or other funded organisations) but also attach specific terms and conditions related to owning IP or ways to exploit it. Research charities, for example, are likely to have policies that require that some set proportion of income from

royalties or equity should be returned to the charity. This reflects that, similarly to universities, charities need to demonstrate that they use any proceeds from commercialisation for the public benefits relevant to the charity's purposes. Charity terms require that all those engaged in funded research are subject to employment terms of the universities so that the university can be responsible for meeting the terms and conditions of the grant.

15. Provision for IP in work jointly sponsored with industry (collaborative and contract research, research capital infrastructure) will be set out in specific agreements: this is subject of the Lambert toolkit (https://www.gov.uk/guidance/lambert-toolkit) Innovate UK require a collaboration agreement, based on an example collaboration agreement on this website, to be agreed by all partners for its competition funding.

16. The study for HEFCE by Research Consulting on good practices summarises other templates and models, for example the Development of a Simplified Consortium Agreement (DESCA) 2020 model agreement for the EC.

17. Most public and other funding for research, teaching, KE/enterprise will be granted to the university, with a view to the university being responsible for adherence to the terms and conditions of grant, monitoring and reporting. It is through the centralisation of IP in the university that funders can secure accountability for, and evidence of, the benefits delivered from their funding. Responsibilities are placed on universities to put in place strategies and management to maximise societal impacts from knowledge/research/IP. The management by the university of the pool of collective IP of academics, researchers and students enables effective exploitation because most technologies are developed through collaborations of various sorts. It is also the responsibility of the university to monitor the specific contributions of academics, students and other research participants (such as consultants) to development of IP and hence ensure that rewards or recognition are distributed in line with stated policies, including in research collaborations. Given that research is highly collaborative, this is a significant task in itself.

18. Some funders (HEFCE, RCs) provide funding for KE, but otherwise universities have to support strategies and management through a range of funding streams (KE income, use of core teaching and research funds, other sources such as local enterprise partnerships (LEPs)). The university has to make maximum use of the IP portfolio overall, while ensuring that requirements of all funders/sponsors are addressed. The resource implications for universities in handling IP are significant, though they then benefit from greater flexibility, sensitivity to institutional conditions and delivery of wider value to the institution in taking forward impact routes. The trend generally in UK policy has been toward devolving more responsibilities down to universities, and cutting central bureaucracy.

IP policies within universities

19. The Government's 'Intellectual asset management for universities' guidance gives an overview of the complex legal issues and broad policies of universities. This includes ownership of IP generated by staff and treatment of IP of students and other types of staff (for example, consultants). Research is a highly collective activity, and hence a lot of the work of universities is overseeing handling of the rights of the many different participants in research.

Diagram CC Alternative options for university IP ownership

Tony Hickson, Imperial Innovations

20. Vesting ownership of IP in universities is now the norm worldwide. The main alternative approaches are either vesting in the Government/funders, or in individual academics (allowing academics to retain ownership of IP is often termed "professor's privilege" in Europe). We also examine in Annex D shared-service models for technology transfer, such as regional hub-and-spokes models.

21. The USA has never considered re-nationalising IP, though there is significant and on-going debate there about whether academic-inventors should take a lead role, or at least be able to select between institutional technology transfer offices (so the university unit is not a monopoly supplier).

22. We give some of the histories of IP exploitation in Europe and Japan in Annex D. These countries have changed their approaches to be more in line with Anglo-Saxon models of the USA, UK and Australia in recent decades. They have moved from models involving government or academic ownership towards university ownership of IP (with shared hub-and-spokes models as part of this trajectory). Largely only Sweden retains the 'professor's privilege' form of academic-inventor ownership of IP.

23. We have examined no countries with national government ownership of university IP.

24. Changes in ownership of IP have implications not just for technology transfer, but also for handling research agreements and the much greater proportion of IP which is exploited through collaborative and contract research or in dual use (university and business) research infrastructure (such as the UK Research Partnerships Investment Fund in the UK). If universities do not own IP, then they will not be able to enter into agreements with research sponsors, such as industry, but all this would need to be handled by whoever owns IP – Government or individual academics.

25. It seems that change in policies on IP ownership in most countries is being driven primarily by drivers of increasing the autonomy of universities, seeking income diversification and involving universities in innovation systems, rather than enterprise-entrepreneurship. The innovation agenda rather the enterprise agenda is driving change.

26. Handling all university research contracting centrally in the UK would require a massive central bureaucracy and would clearly be unworkable. It would also lead to fragmentation of IP. Government cannot be responsible for IP developed from EC, charity, industry and university own funded research IP, and hence there would be division of ownership of IP between Government and universities, making the system less flexible and most likely reducing exploitation due to complexity.

27. The 2010 US National Academies review drew attention to the major problems for innovation posed by ownership of IP by academic faculty. Exploitation of IP would be significantly impeded by disputes between academics and between academics and students (and within and across different universities) because most exploitable IP comes out of research collaborations, and commercial value is associated with combinations of technologies. Even if all academics and students were likely to agree, the process of providing assurance to investors and industry that all rights to exploit were secure would be daunting in the extreme.

28. Both the USA (National Academies) and Europe (EC) concluded that there was little evidence that professor's privilege could be more effective than university ownership of IP in terms of technology transfer/entrepreneurship. This is not just about the role of the technology transfer unit, but also about the university taking responsibility for supporting academic entrepreneurs more broadly, such as in workload management, bidding for enterprise scheme support and tapping into external investment funds.

29. The OECD looked at the case for taking the professor's privilege approach and allowing academics to source technology transfer support outside of their own university (recommended by the Kauffman Foundation in the USA to increase competition and hence quality). The OECD noted[58] more cons than pros over free agency: "concerns include limitations on adjusting TTO performance through competition, the potential capacity constraints of external university TTOs, regional and local economic development issues, overlapping interests and unclear pay-out schemes".

30. There has been though some evidence to the contrary. A recent study of the effects of abolishing professor's privilege in Norway in favour of university ownership showed a significant decrease in academic entrepreneurial activities such as patenting and spin-out formation[59]. Similarly there has been a drop in the formation of spin-out companies in Japan since 2000 when IP ownership was transferred from Government/academic control to universities. Further examination is needed on detailed and long-term impacts of policy changes. For example, university ownership of IP may lead to a focus on fewer, larger-impact interventions, which may deliver greater long-term value, with the decline in start-up companies being of the form of personal consultancies and the like.

31. There are clear arguments and evidence toward university ownership of IP. This is primarily driven by increased interest worldwide in the inter-linked forces of increasing university autonomy, diversifying funding and involving universities in innovation systems.

32. There are also arguments and evidence toward university ownership of IP to advance the enterprise/entrepreneurship agenda, though this is less clear cut.

33. There is clearly a need for close attention to support and incentives for individual academic and student entrepreneurship. There is also a need to monitor and evaluate the university role in technology transfer as appropriately supportive of the entrepreneurial ambitions of staff and students, to deliver best outcomes overall.

Annex D: Overseas and UK models for collaboration and shared services for technology transfer

1. KE by its nature must involve collaboration with economic and societal partners external to universities. This Annex considers collaboration between universities to deliver technology transfer.

2. Since technology transfer is significantly focussed on commercial acumen and private finance, there is a logic that many universities look to private sector partners in technology transfer collaboration (for example, IP Group), rather than initially/specifically each other. Private sector partnerships though also involve inter-university collaboration.

3. There is a great range of other types of cross-university collaboration in research and KE. Major research centres, research collaborations and centres of research excellence may put in place shared arrangements for exploitation of the IP generated in the research collaboration. This is logical since these will create shared IP.

4. We note the great difficulty in making international comparisons of collaborative activity given different terminologies for technology transfer and wider KE used in different countries. This makes it hard to identify initiatives that are specifically focussed on technology transfer. The nature and extent of technology transfer collaboration in any country may also be shaped by wider differences – for example, the shape/structure of the university system or regional/local economic development. Many countries examined are federal, and university systems may be funded at state/regional level, with regional economic development implications.

Overseas models: Technology transfer alliances (hub-and-spokes models)

5. The OECD looked at new approaches to research commercialisation in 2013[60] in the light of global concerns that rates of innovation/commercialisation were dropping globally. One area investigated was new bridging/intermediation technology transfer structures, including 'technology transfer alliances (hub-and-spokes models)'. These tackle the perceived problem that mid-range universities have limited ability to generate income to cover the expenses of complex/specialist technology transfer operations. They may also address the issue of pooling IP pipelines to increase critical mass in commercialisable technologies.

6. The OECD noted that there are arguments pro and con technology transfer collaborative models, and no evidenced conclusions yet on what works. The theory is that hub-and-spokes models "allow the bundling of inventions across universities, lower operation costs, and access to personnel with superior commercialisation expertise". However "it may lead to higher co-ordination/communication costs, competition amongst institutions, and capacity constraints of TTO personnel"[61].

7. The EC concluded in its KT guidelines (2007)[62] that there may be arguments for shared services and critical mass due to both creating a larger IP pipeline and providing opportunities for greater industry-sector specialisation in a larger unit. But the EC commented that “independent TTOs tend to have the disadvantage of less intensive relations with the researchers at different PROs (public research organisations).”

8. We examine some specific examples of inter-university technology transfer shared-services models below.

Continental models (France/Germany)

9. Technology transfer collaborations in continental Europe (and Japan) form part of wider systems changes in these countries. Changes include making universities more autonomous from the state so that they can own and be accountable for assets, including IP; and moving from a focus on mission-oriented research centres to more distributed innovation systems, with greater private sector and university involvement.

10. Continental (and Japanese) changes have been made since 2000 and hence these are fairly embryonic developments (compared to the USA where the system has been developing for 50-60+ years). There is significant expert literature critiquing many of the changes made and new programmes and vehicles being introduced by governments. This reflects the complexity of innovation systems theory and policy-making, and the need to make experiments, evaluate and develop over time. Many countries are inevitably challenged by political changes that make this kind of long-term policy implementation cycle difficult. The approaches described below are therefore not necessarily evidenced yet as working.

<u>France – Societies d’acceleration du transfer de technologies (SATTs)</u>

11. As part of developing an innovation system model, the French Government introduced a new legal framework for research and innovation in 1999-2002 which included giving universities rights to own and exploit IP. SATTs – tech transfer acceleration companies – are part of a major ‘Investments in the Future’ programme begun in 2009 (€47bn). SATTs are aimed at strengthening technology transfer in a large French university system that is only just developing IP competence.

12. There are now 14 regional SATTs with 400 staff and budgets in the range of €36-78M; 95% of SATTs budgets are spent on proof of concept/technology financing – essentially de-risking technologies for the market, and particularly SMEs. SATTs are private companies, wholly owned subsidiaries of the public research organisations in a territory, with central government oversight. The aims of SATTs balance making a return on investment with local economic development. The services provides by SATTs are:

- Mandatory – SATTs have to deliver exclusive IP management and licensing, sold to providers at market price, plus providing investment. Proof of concept investment money is provided by the Government interest free. A strong role is given to external/private sector consultants to increase commercial savvy in universities and research institutes and to focus on 'market pull' not 'tech push'. The aim is for SATTs to break even over eight-10 years, becoming sustainable through licensing revenues. SATTs get 80-100% of revenues up to break-even of a spin-off company and 40-60% after.
- Voluntary – SATTs can also provide business development, R&D contract management, capability mapping and incubation. The aim is for SATTs to break even on these services over a three to five year horizon.

13. The French are still exploring/evaluating the value of the SATTs model. Issues include:
    - Subsidiarity – what do you do at what level?
    - Some universities still operate their own technology transfer units which work in close conjunction with their academics (for example, the École Polytechnique) even though they are in a SATT region, leading to tensions between system participants.
    - France continues to have large public research entities across hundreds of sites such as INSERM, CEA, INRIA, CNRS, which have their own technology transfer units both on individual sites and drawn together nationally.
    - How do SATTs fit into wider local/regional, national and European innovation systems? SATTs represent a top-down, national approach but then how is local/regional government involved to avoid duplication?

<u>Germany – Regional patent agencies (RPAs)</u>

14. Germany shifted from ownership of IP by academics (the professor's privilege approach described in Annex C) to a university-owned IP system in 2002, with additional resources put into the university system to increase and strengthen capacity to manage IP effectively. Each federal state invested some public money in at least one regional patent agency (RPA) with a view to supporting individual universities. RPAs may serve both universities and research institutes. However, many universities still operate their own technology transfer units in addition to the RPAs. Major agencies like Max Planck have technology transfer units of their own, including both centrally and in individual institutes, as well as linking technology transfer units nationally.

15. One of the most successful RPAs is Ipal GmbH in Berlin, which is owned by the regional Berlin bank, funded by the Federal State of Berlin and involves Berlin universities. Ipal GmbH is a for profit company which aims to generate revenue from licensing, royalties and equity share, but also has economic development goals of furthering technology development and supporting entrepreneurship. It provides a range of services from IP protection, technology development to financing. Services

are provided not just for universities, but also SMEs, commercial technology and patent agents.

16. Humboldt University is one example of a university that is linked into Ipal. Humboldt has an IP office of its own but the main role of the IP office is to liaise with Ipal on evaluations of patent applications, and all patenting and licensing matters are conducted by Ipal. The IP office is responsible for communicating all views and policies of the university and the academics to Ipal. Experts comment that interest in, and rates of, commercialisation by academics at Humboldt are not notably high, and Ipal turns down the bulk of patents from the university. Ipal is primarily commercially focussed and hence not interested in matters that are important to universities and academics, such as long-term research potential, entrepreneurial interests of academic and wider university entrepreneurial benefits.

America/Australia – University-led development

17. The USA, Australia and UK share similar university systems with much higher degrees of autonomy than in Europe and with greater private sector links and entrepreneurial roles. Collaborations in these countries have been formed by the universities themselves (or as part of their natural structures – for example, state university systems), rather than by national policy intervention. US models pre-date the USA Bayh Dole Act and reflect that American universities have been part of economic development since the 19th century (flowing from the USA Morrell/Hatch Acts that were focussed on the period of post US civil war re-construction). The examples we discuss below look at technology transfer units that have been developing since the 1930s. The main issues in the US system about technology transfer related to university matters, such as university leadership commitment, resourcing, close links between technology transfer professional staff and academics to achieve culture change.

<u>University of California system</u>

18. The University of California (UC) system is a state/public university system with 10 constituent parts (for example UC Berkley) plus a federal laboratory. UC is probably the largest research/TT organisation in the world, with $2.9bn research expenditure. It was established originally as part of the Land Grant movement in the 19th century, with an overtly applied mission. UC conducted technology transfer activity first in the 1920s, filed its first patent in 1934 and formalised IP policy for UC along the lines of, but in advance of, Bayh Dole, in 1963.

19. UC started with a central technology transfer office to handle IP across all its campuses which enabled it to build a sustainable model through pooling licensing revenue, and the scale enabled it to put in place specific industry/sector licensing groups. UC technology transfer operating costs are now $14.3M, plus $13.9M on legal expenses.

20. Over time, UC has shifted its approach with more technology transfer activity undertaken within the individual campuses, and with technology transfer units in each campus. (The UC footprint is vast anyway: the central UC technology transfer unit is at San Francisco, which is 500 miles from, for example, the campus at UC San Diego.) The first campus to establish its own technology transfer capacity was Berkeley in 1990, and other campuses have followed. The local technology transfer units deliver the interface with the researchers, with research funders, licensees and regional business organisations. The central UC technology transfer unit now handles primarily data collection/ICT, overall policy, legal oversight and risk management.

21. UC has concluded that decentralisation has been important to provide proximity of technology transfer professional staff with the academics. The embedding and development of technology transfer needs to involve culture change, including in faculty, and this is best developed through close working of academics and professional staff.

22. Outside commentators note that negotiations with UC are difficult due to it being a massive, risk-averse organisation. Some of the centralised technology transfer policy/legal work is dealing with the organisation's own bureaucracy.

<u>USA – North Carolina Technology Development Initiative</u>

23. The North Carolina Technology Development Initiative (NCTDI) was a short-term development project supported through a two-year National Science Foundation award to the University of North Carolina (UNC) System. Its aim was to explore a novel approach to the university/venture capital/incubator partnership model. North Carolina is the site of a well-respected economic development infrastructure – the Research Triangle science park.

24. The partners to NCTDI included the UNC system campuses, the North Carolina regional development agency, the Research Triangle science park and venture capitalists.

25. The project aimed to explore technology transfer in a multi-institutional setting to find new models – defining technology transfer policies and practices, training academics, linking universities with state agencies and venture capital networks. It focussed on methods to optimize the opportunities for each UNC campus to work with the NC State science and technology apparatus to manage IP for regional/local economic development.

26. A project director worked to the Office of the President of the UNC system to deliver the project. The project took different forms at the individual campuses. At UNC Charlotte the focus was on strengthening the corporate relations strategy through putting in place a campus-wide corporate relations team. At UNC Greensboro it focussed on developing the campus's entrepreneurship centre further. At UNC

Chapel Hill the project developed an alumni circle to support innovation, leading to an innovation roadmap. The project involved a diagnostic of different campus challenges with some campuses having input problems (for example, the amount of research funding secured and hence volume of research outputs to be commercialised) and some activity problems (for example, campuses with no entrepreneurship programmes). This reflected the very significant differentiation between campuses in terms of their underlying research and teaching capabilities and hence appetites and approaches to entrepreneurship and innovation.

Australia – Uniquest

27. Uniquest was established in 1979 as the commercialisation division of the University of Queensland. It was incorporated in1984 as a wholly owned subsidiary of the university focussed solely on technology transfer. There were the following milestones in its development:
    - 1989 – Uniquest started to provide consultancy support.
    - 1994 – It created a research and consultancy division.
    - 2004 – It expanded into providing commercialisation training for academics and provided its first external technology transfer service provision, to University of Wollongong.
    - 2005 – It expanded to create a proof of concept programme.
    - By 2012, Uniquest had achieved revenues of A$100M.

28. In 2012, Uniquest expanded to service six other Australian universities/research institutes. This lasted only one year; in 2013, Uniquest was refocused and re-structured to support University of Queensland only. Expert view is that the arrangement whereby Uniquest provided services to other universities failed due to the perception of Queensland academics that Uniquest had taken its 'eye off the ball' in terms of dealing with its originating university and was spending too much time and effort focussing on others.

England/UK

29. Early rounds of HEIF focussed on supporting projects, to build shared understanding between HEFCE and universities of the range and types of KE, and their characteristics, pointing toward good practices and development of higher performance. Technology transfer featured in a few HEIF projects, though there was a greater number around other aspects to KE, such as industry links, student enterprise and international developments.

30. Building on early HEIF project rounds, HEFCE has continued to monitor and evaluate levels of collaboration between universities through expert examination of HEIF institutional strategies in overview reports to HEIF rounds 4 and 2011-15[63]. A challenge in measuring levels of collaboration, and the appropriateness of these levels to maximise efficiency and effectiveness, is the great range of types of KE collaboration, as well as the range of reasons to collaborate and hence forms that

collaboration may take (such as shared services, intermediary vehicles, links with existing networks like Catapult or discipline/research or technology sector hubs or marketing/raising demand vehicles), The main reasons for collaboration summarised by PACEC consultants from 2011-15 HEIF strategies[64] were:

- Sharing good practice
- Achieving economies of scale through sharing infrastructure, resources, and management
- Accessing complementary capabilities to provide a full service to academics, students and users
- Utilising regional/local infrastructure for KE; opening up new markets.

31. PACEC compiled evidence on collaboration in KE from HEIF strategies in the 2011-15 round of funding[65]. They concluded that there were relatively high levels of collaboration in KE – a median of 13 collaborations per HEI. This only covered collaborations focussed on partnering around KE capacity/infrastructure, and not collaborations focussed on research or between researchers, where there may be an accompanying approach to collaborating on exploitation (given that IP developed will be shared between universities in the collaboration anyway). PACEC concluded that current KE collaborations are particularly focussed on technology transfer and handling IP[66].

32. The 2013-14 HE-BCI survey reports 102 HEIs (64% of the sector) outsourcing filing of IPRs to a private sector provider of some sort (which may be additional to in-house filing). This is only a small subset of technology transfer/research commercialisation activity though.

33. There are a number of initiatives in Scotland, Wales and Northern Ireland to promote KE collaborations of various sorts. A particular focus in these collaborations is the economic characteristics of the particular nation, and linking universities with local/regional/national economic development capacity and with industry sectors/hubs. We found only one initiative – the Welsh IP Collaboration Project – that was specifically focussed on technology transfer.

Conclusions

34. The USA models and Australia are long lived (over 50 years) and mature. They tend to take the form of organic arrangements flowing out of the development of universities themselves (the UC system) or their partnerships with other universities (Uniquest in Australia). The trend in the USA and Australia over time has been toward more devolution of technology transfer capacity within institutions/specific campuses and greater differentiation of capacity, reflecting specific institutional strengths.

35. European and Japanese models come from countries that have made major and relatively recent (10-15 years) changes to their university systems, which have included changing responsibilities for IP ownership and exploitation. These countries

have invested in shared-services approaches as a means to strengthen university capacity in early years of taking responsibility for IP. These countries are still exploring whether these shared services work, and how various levels of subsidiarity should be organised. There are some signs already of universities developing their own institutional capacity in addition to the shared services, and greater differentiation of capacity to fit technology transfer with the particular university and regional/local eco-system.

36. The UK university system has much in common with the USA (a high degree of institutional autonomy), and collaborations on technology transfer in UK are probably most akin to those in the USA. The UK sits between US and Europe in terms of maturity of the IP/technology transfer system.

37. It is difficult to determine whether UK universities exhibit fewer or more collaborative characteristics than other countries'. A major barrier to drawing evidenced conclusions is the wide divergences in terms/nomenclatures, as well as differences of university and innovation systems, which make comparing like with like difficult.

38. There seems little evidence that collaborative approaches pursued anywhere work – though this is a matter of time and the need for evaluation, rather than any absolute judgement. Certainly there is clear evidence that the nature of universities – their focus on supporting their own staff and students, and sensitivity to their eco-systems – tends to work against collaborative/shared-services/commercial or government-sponsored approaches. Universities tend to duplicate and differentiate their technology transfer to fit their circumstances.

Abbreviations

ATTP – Alliance of Technology Transfer Professionals

AURIL – Association for University Research and Industry Links

AUTM – Association of University Technology Managers

BEIS – Department for Business, Energy and Industrial Strategy

BIS – Department for Business, Innovation and Skills

BTG – British Technology Group

DESCA – Development of Simplified Consortium Agreement

EC – European Commission

HE – higher education

HE-BCI – Higher Education Business and Community Inter-action survey

HEFCE – Higher Education Funding Council for England

HEI – higher education institution

HEIF – Higher Education Innovation Funding

KE – knowledge exchange

KPI – key performance indicator

KT – knowledge transfer

IP – intellectual property

IPR – intellectual property rights

LEP – local enterprise partnership

LFHE – Leadership Foundation for Higher Education

MIT – Massachusetts Institute of Technology

NCTDI – North Carolina Technology Development Initiative

NCUB – National Centre for Universities and Business

OECD – Organisation for Economic Co-operation and Development

OfS – Office for Students

R&D – research and development

RCs/RCUK – Research Councils UK

REF – Research Excellence Framework

RPA – regional patent agency

RTTP – Registered Technology Transfer Professional

SATT – Sociétés d’accélération du transfert de technologies

SME – small and medium-sized enterprise

TT – technology transfer

TTO – technology transfer office

UKIPO – UK Intellectual Property Office

UKRI – UK Research and Innovation

UUK – Universities UK

Endnotes

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1 HEIF 2011-15 institutional strategies available at http://www.hefce.ac.uk/kess/heif/

2 REF 2014: REF impact case studies available at http://impact.ref.ac.uk/CaseStudies/search1.aspx

3 PACEC “Strengthening the Contribution of English higher education institutions to the innovation system: knowledge exchange and HEIF funding”, HEFCE, 2012.

4 Higher Education Business and Community Inter-action (HE-BCI) survey available at http://www.hefce.ac.uk/kess/hebci/.

5 US evidence also suggests that technology transfer is very rarely income generating. See for example, National Academies “Managing university intellectual property in the national interest”, National Academies Press, 2010 ‘for a very large number [of universities] the costs incurred [from technology transfer] are a net drain on university resources’.

6 State aid issues in technology transfer covered in AURIL and PraxisUnico “State Aid in Research, Development and Innovation: a guide for universities” AURIL, 2016.

7 “Commission Recommendation on the management of IP in KT activities and Code of Practice for universities and other public research organisations” EC Research Policy 2008.

8 Cambridge Centre for Business Research/PACEC “The higher education knowledge exchange system in the United States”, HEFCE 2010 and Library House “Metrics for the Evaluation of KT activities at universities, Unico, 2009.

9 Cambridge Centre for Business Research/PACEC “The Intellectual Property Regime and its implications for knowledge exchange”, HEFCE, 2010.

10 OECD ‘Commercialising Public Research: New Trends and Strategies’ OECD, 2013

11 Cambridge Centre for Business Research/PACEC “The Intellectual Property Regime and its implications for knowledge exchange”, HEFCE, 2010.

12 For example, European Commission “Green paper on Innovation”, EC, 1995.

13 See for example, Jon Sandelin, Stanford OTL and Gilles Capart, EC “Models of, and Missions for, Transfer Offices from Public Research Organizations”, EC, 2004: ‘It is relatively more difficult to license out a university invention in Europe than in the US. The European market is much more fragmented ... and the density of technology-based companies is less important. Many licenses from European universities are actually executed with US groups, and do not benefit the European economy. The innovation model is comparatively more developed in certain European countries, notably the UK, Scandinavian countries, Netherlands and Belgium, than in the US. The potential benefits for the public and for the university will also be larger and more regional in character. The basic difference is that European universities have to be more directly involved in the innovation process than their US counterparts for achieving the same result.’

14 Coates-Ulrichsen, Hughes and Moore, HEFCE, 2014.

15 Discussion document Dr Lita Nelsen and Dr Katharine Ku “Are US university spin-out processes really better than those of UK universities?” for HEFCE available at

http://www.hefce.ac.uk/media/HEFCE,2014/Content/Knowledge,exchange,subjects,and,skills/Good,practice/UK-and-US-spin-outs-April-2016.pdf

16 See for example, National Academies 2010. See also Scott Shane “Academic Entrepreneurship: university spin-offs and wealth creation”, Edward Elgar Publishing, Northampton, MA USA, 2004 for summary of USA university practices on royalties.

17 Guarisco et al, 2008.

18 The main source of indicators on technology transfer and wider KE in the UK is the HEFCE/HESA Higher Education Business Community Inter-action (HE-BCI) survey, which is also provided to the EC for European comparisons. HEFCE also shares data with AUTM in America and the University Network for Innovation and Technology Transfer (UNITT) in Japan. HE-BCI was designed from its outset in 1999 to describe and measure the wide range of knowledge based interactions between universities, research and teaching and the economy and society. This approach to measuring the breadth of engagement is now regarded as best practice (for example, by OECD 2013).

19 National Academies, 2010.

20 National Academies, 2010.

21 Guarisco et al “Academic patenting in the UK: Evidence from the CID-Kleins Database”, EC, 6th Framework, 2008.

22 Patanalyse Ltd, Technologia Ltd “Patenting in the UK”, 2011.

23 National Centre for Universities and Business “The changing state of knowledge exchange”, NCUB, 2016.

24 NCUB 2016 provides information on the numbers of academics undertaking particular forms of KE activity. Engineering academics had the highest propensity to file a patent – 22%, compared with 15% in Biology, Chemistry and Veterinary Science. Engineering and Materials scientists were also most likely to spin-out a company – 8%, with 4% Biology and Chemistry. This has some similarity in patterns with Guarisco et al (2008) though Guarisco et al’s analyses are of 2004 activity so are now somewhat dated. As a proportion of the total professors in a particular field, academics in Chemical Sciences were most likely to be inventors (9.7%) followed by Engineering (5.2%), and Biological Sciences (4.5%). However, as a share of total academic inventors, just over a quarter came from Engineering (27.8%), 26% from Chemical Sciences, 18% from Biological Sciences and 18.9% from Medical Sciences.

25 See for example: National Academies 2010, NCUB 2016. REF 2014: REF impact case studies.

26: European Knowledge Transfer Report, 2013, EC Research and Innovation, 2013.

27 See also for comparisons of UK universities with overseas in Library House “Metrics for the Evaluation of Knowledge Transfer Activities at Universities” PraxisUnico, DIUS, RCUK, HEFCE, SFC, Library House, 2009: ‘The UK is actively involved in knowledge transfer activities and competitive with US and Canadian universities ...The UK appears to be competitive for its size. Although the absolute licensing values for US universities are generally higher, in other measures where the absolute value is less important, such as licensing income market share, and the importance of licensing income to the total research income, the UK performs competitively compared with the US and Canada. This also applies to the number of spin-outs formed.’

28 Coates-Ulrichsen, T., Moore, B., and Hughes, A., HEFCE, 2014.

29 OECD, 2013. In Europe, only 10% of universities account for 85% of the total income generated by inventions. In, USA 50% of the total licensing income came from only 6% of the institutions (12 institutions in total).

30For example – comparing Stanford and Oxford universities: Stanford has a total annual budget of £3.5 billion with only 7,000 undergraduate students, compared to Oxford University, with a £1.4 billion budget and 11,603 undergraduates. MIT Skoltech, 2014.

31 See for example, Zahara, S.A., Van de Velde, E. and Larraneta, B. “Knowledge conversion capability and the performance of corporate and university spin-offs”, Industrial and Corporate Change, Volume 16, Number 4.

32 OECD, 2013.

33 For example, annual HE-BCI surveys, PACEC 2012, NCUB 2016, IP Pragmatics “Review of UK proof of concept support” Innovate UK, 2016.

34 Innovate UK, 2016.

35 NCUB, 2016.

36 See for example, British Council: “Ownership structures in relation to IP reflect differing historical, legal and structural characteristics of the systems within which they operate. There are various ways in which policy can be formulated: most clear is in terms of patent law. However, other considerations include labour and contracting law and ownership clauses in the regulation of national R&D systems. Generally, government policy in this area is converging on vesting the rights with the individual institutions. There exists a large body of literature on the subject of IP protection. However, in our primary research, with the exception of Brazil, where the discussion is still live, debate seems to have moved on to other broader matters relating to the commercialisation of research. Across all four countries, the university TTOs/TLOs (Technology Transfer/Licensing Offices) were seen as potentially hindering the effective transfer and commercialisation of research, due to a range of reasons including: TLO/TTO staff having limited skillsets; the lack of a commercial mindset and culture; the number of staff; and a lack of understanding of the ‘bigger’ picture and potential of relationships with external businesses.”
http://www.britishcouncil.org.au/sites/default/files/ged_summary_report.pdf

37 Coates-Ulrichsen, T., Hughes, A., and Moore, B. “Measuring university-business links in the United States” HEFCE, 2014: The study noted that there was a very limited set of comparable data between the UK and the US. Most comparable data is in the area of technology transfer and research commercialisation, rather than wider knowledge exchange.

38 Herskowitz, O. and Butterfield, B. “Know thyself: how well do you understand your own IP strategy?”, Intellectual Asset Management, 2016.

39 NESTA, Manchester Institute of Innovation Research (MIoIR), 2012.

40 National Academies (2010) concluded that comparisons of performance would need to consider at least [though most evidence on below was not available]:

- Structural/contextual factors – university mission, historical reputation, geographical proximity to potential investors and industry partners, scale of research portfolio, existence of medical school or other niche areas or specialisations in research, public or private status of the institution, structure of faculty incentives for entrepreneurship.
- Technology transfer specific factors – technology transfer staff remuneration packages, age of the TTO, organizational structure, staffing and funding sources of TTOs, TTO relations with research faculty, links with centres of entrepreneurial education.

- Volume of TT – invention disclosures, patents grants, and applications, licenses and licensing income, spin-outs.

b) Quality and efficiency of TT – timeliness, extent of marketing outreach, character of relations with faculty and inventors and economic and societal impacts.

41 Dr R Graham "Creating university-based entrepreneurial eco-systems: evidence from emerging world leaders" MIT Skoltech Initiative, 2014.

42 See for example, MIoIR NESTA, 2012. The study describes an early comparative account (Heher, 2007) of licensing income as a percentage of research expenditure for the US, Canada, Australia and the UK. The MIoIR study notes "One important characteristic of the data noted was that it was highly skewed. Effectively most universities earned little licensing income with 95% of universities having returns of less than half respective averages, while 50% earn only very small amounts from technology transfer. ..in Australia, for example, the omission of a single equity transaction in 2000 resulted in a change in income earned by over 50%; while in 2001 and 2002, one university accounted for 66% of all income earned. In Canada, omission of two universities had a similar impact, while in Europe omitting two universities reduced income by 70%. The high variability induced by a few large transactions makes measuring and interpreting data for benchmarking purpose particularly difficult." Professor Paul Wellings in a 2008 review of technology transfer for DIUS noted from historic data that around 0.1% of US university licenses and 0.12% of UK licenses generated more than $1M. Spin-out performance was similarly highly skewed.

43 US policy and expert literature on technology transfer summarised in National Academies Press, 2010. UK expert literature summarised in MIoIR "The impact and effectiveness of support measures for exploiting intellectual property." (Part of the Compendium of evidence on the effectiveness of innovation policy.) NESTA, 2012.

44 HESA/HEFCE HE-BCI survey Part A data and Research Consulting "Knowledge exchange and commercialisation: The state of the profession in UK higher education", PraxisUnico, 2016.

45 Nelsen and Ku, HEFCE, 2016.

46 "Science and Innovation Audits: Call for Expressions of Interest" BEIS, July 2016

47 HM Treasury "Fixing the Foundations", 2016.

48 See for example discussion on golden share in "University technology transfer FAQs" 6U, 2016 available at http://www.hefce.ac.uk/media/HEFCE,2014/Content/Knowledge,exchange,subjects,and,skills/Good,practice/TT%20in%20the%20UK%20Paper.pdf.

49 HEIF 2011-15 strategies available at http://www.hefce.ac.uk/kess/heif/. PACEC "Strengthening the Contribution of English Higher Education Institutions to the Innovation System: Knowledge Exchange and HEIF Funding", HEFCE, 2012.

50 See for example, House of Commons Science and Technology Committee "Bridging the valley of death: improving the commercialisation of research" Eighth report of session 2012-13: "PraxisUnico provides training programmes and networking events to improve technology transfer skills across the whole of the university sector. It is a good example of a government sponsored programme that delivered necessary skills across a disparate sector. We recommend that the Government should consider it as a model for the delivery of a coherent set of skills across the whole of Government procurement."

51 Such as through ASTP-Proton – http://www.astp-proton.eu.

52 National Academies, 2010.

53 National Academies, 2010.

54 UKIPO, 2014.

55 BIS, 2016.

56 PACEC and Cambridge Centre for Business Research "Evaluation of the effectiveness and role of HEFCE/OSI third stream funding", HEFCE, 2009.

57 Cabinet Office, 1993.

58 OECD 2013.

59 Available at http://www.nber.org/digest/may16/w22057.html

60 OECD 2013.

61 OECD 2013.

62 EC KT guidelines 2007.

63 PACEC "Higher Education Innovation Fund round 4 institutional strategies. Overview and commentary", HEFCE, 2008 and PACEC, 2012.

64 PACEC, 2008 and PACEC, 2012.

65 PACEC, 2008 and 2012.

66 PACEC, 2012: 75% of HEIs reported in their HEIF 2011-15 strategies that they were seeking collaboration and shared services to improve KE efficiency; greater shift in helping visibility and access to IP. ''The HEIF 2011-15 strategies underline an increased trend towards shared services to exploit IP between groups of HEIs or the complete outsourcing of IP-related commercialisation services. In the latter, some HEIs are outsourcing their requirements to other universities. For example, both Cranfield University and Aston University have outsourced their IP exploitation process to other universities (Imperial Innovations and Isis Innovation of Oxford respectively) arguing that this has led to efficiency and value for money gains. Other HEIs are outsourcing their IP exploitation requirements to private sector firms.'